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2006

2006 ANNUAL REPORT

INER Longtan

Institute of Nuclear Energy Research, Longtan

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Contents

Enhancing Collective Strength in Face of Challenges; Employing Unique Creativity in Pursuit of Excellence

Director-General

For us, 2006 was a significant year that we have strived aggressively to pursue changes and make progresses in an environment full of challenges. A mechanism has been started to make the reforming transformation of our organization, INER, not only to arduously build up a more competitive body in conformity with an "Incorporated Institute " in the near future, but to actively care about the demands of our nation's economic development, to substantially expand our R&D capacities and capabilities accumulated over the years, as well as to positively expect ourselves to play more powerful and influential roles in the mainstream of the nation's key developments with respect to scientific technologies and its industrialization.

Creative in scientific technologies R&D

In the areas of scientific technologies R&D, we have integrated our research resources and formulated into three key technology centers, i.e., The Nuclear Safety Technology Center, The Environmental and Energy Technology Center, and The Radiation Application Technology Center, to respectively promote the development of technologies in five main domains. As results, breakthrough progresses have appeared due to some fruitful achievements in this year. The key indicators of the R&D performances, e.g., numbers of patents, research reports and journal papers, have not only reached our preset targets but even outgrown 42% as compared to those of the prior year. It created the new highest record in the history of INER. For each domain's specific advancing direction, in addition to strengthening the international competitiveness of technology, we have devoted ourselves to

connecting the basic research abilities of the academic organizations in the technology upstream and the marketing abilities of the application industries in the technology downstream. All these efforts were made with an attempt to establishing an intact development framework of the relevant industries in promoting the realization of technology industrialization.

The Nuclear Safety Technology Center is responsible for the technology development with respect to nuclear energy safety, spent fuel dry storage, and radioactive waste treatment and disposal. In this year, the major work achievements include: (a) Completion of the Safe Analysis Report (SAR) of spent fuel dry storage project, which has been submitted to and gained the approval from Taiwan Power Company (TPC); (b) Completion of the design of airtight steel casks for spent fuel dry storage project, which has been set for fabrication bid; (c) Establishment of a "High Performance Clustered Computing (HPCC)" hardware environment, which has been set up with 1,024 CPUs for calculations and simulations of key technologies and started as well as strengthened a new high speed calculation mechanism at INER. Following two successful projects at Chingshan and Kuosheng nuclear power plants, INER has earned another "Measurement Uncertainty Recapture (MUR)" project from Maanshan Nuclear Power Plant of TPC. INER's consistent promotion in the operations and maintenance (O&M) program has laid a sound foundation for the industrialization of the nuclear energy technology in our country.

The Environmental and Energy Technology Center is responsible for the technology development relating to environmental protections, such as the plasma treatment of contaminated materials and the development of new energy sources including the researches on renewable energy and clean energy. These research topics are closely related to the most important problems that influence human survival and development in this century. These are the key items of the science and technology developments in our

country as well. INER also has participated in two national projects, i.e. " Renewable Energy-a key project of science and technology" and "National Nanotechnology Project", which indicates the high expectations from the Central Government to fully exploit our R&D capabilities. In 2006, the major achievements include: (a) Both group III-V solar cell and cellulose-based bioethanol technologies have reached their preliminary verification phases in system integrations, and have gained much attention from the industrial circle; (b) In the case of technology transfer, a new code of practice for screening business partners has been introduced. The revenue from loyalty has the best performance over the years. (c) INER's plasma melting demonstration plant has finished its burning tests and the license application has been filed. It is expected that the operation license will be granted soon. This should be beneficial for the promotions of the environmental protection and resource recycling industries.

In addition, INER's Decontamination Center had already finished its hot tests. More than 100 barrels of low-level radioactive wastes have been treated. These have become harmless wastes that can be released to the general environment. This facility is currently in its routine operations for the transfer process. It can be put into formal operations as soon as the "Operation Report" is approved by the Fuel Cycle and Material Administration. As to the decommissioning work of the suspended nuclear facilities in the Institute, 20 component units have already been done and accomplished so far. This work has lasted for nearly four years. The accumulated practical experiences and technologies on the planning, the safety evaluation and the operation of decontamination and decommission (D&D) has set up a solid foundation for promoting the clean-up industry of nuclear facility.

The Radiation Application Technology Center is responsible for the technology developments concerning radiopharmaceuticals. Its mission is to serve the welfare of our people by studying and developing advanced radioactive medicines. In this year, the important works are: Implementing technology application and promotion; Promoting nuclear medicine

technology authorization; Drafting the code of practice on starting a spin-off enterprise; and Promoting the development of related downstream industries by accelerating the commercialization of mature technologies. INER is expected to complete the establishment of its radiopharmaceutical bureau soon. It will make an intact system for the radiopharmaceutical production and marketing in the Institute. After having set up its own system, it will positively contribute to the acceleration of INER's technology industrialization in this field; Radiopharmaceutical "MIBI" has already obtained the drug permit from the Department of Health (DOH) and will be formally put into the market soon. Two more drugs, i.e. "INER Tc-99m TRODAT-1 Imaging Agent" and "INER In-111-Pentetreotide Injection", have obtained a gold medal and a bronze medal award, respectively, in the " Medical R&D Contest" held by both the DOH and the Ministry of Economy (MOE). Moreover, their research papers also received the outstanding research award from the Executive Yuan. The research performance is really excellent.

The biggest change we have made in the technology research is to escape from doing the planning only from the R&D point of view and passively carrying out the research tasks. Now we can actively grasp the needs for the nation's development and rigorously carry out our R&D projects in terms of the market demands. In this way, the external cooperation channels and the resources circulation connections have been established. In this year, both the promotion of tactical alliances with the industries and the use of "Mutual Fund" for joint research programs with the academia have given rise to fruitful results. All these wonderful achievements are also presented in this annual report.

Transmutative and innovative in operations and management

In order to promoting the physique of INER for a better shape in competitiveness, in addition to the R&D activities, we have diligently adjusted our business operation and management strategies to meet the actual

needs of the internal transformation and the challenges of the ever-changing environment of the external. In 2006, we have devoted to: (1) Constantly minimizing the internal interfaces to reduce costs in communications, raising the administration efficiencies, activating the effective use of resources, enforcing the joint-project strategy, and offering an instant and omni-directional scheme for solving problems. (2) Molding a new organization culture to progressively convert the existing mission-oriented work attitude into a market-oriented one, and to recognize that the operational environment under the knowledge economy the competitions and collaborations among the industry, academy and research entities are becoming more and more intensive. Under such circumstances, the only way out is to change the culture of this organization, and to offer "high quality" and "low cost" products continuously. This is the only effective means for the sustainable operations of the Institute. Based on the outcome of ballots, "specialty", "innovation", and "safety" were voted by our colleagues to be the key values of INER. (3) Extending the influences to the outside world. INER intends to strive for the leadership and has held several international conferences on relevant R&D programs, such as Solid Oxide Fuel Cell (SOFC), Direct Methanol Fuel Cell (DMFC), Atomic Energy Forum, East Asia Radioactive Waste Management Forum, Quantitative Risk Assessment Seminar, etc. Both domestic and international experts were invited to participate in these conferences to exchange experience and knowledge with our colleagues so as to expand our visions of the professional domains and increase more cooperative opportunities and links. (4) Establishing cooperative channels for personnel training and sending the young new bloods overseas to famous organizations and universities, including RMA Company and Johns Hopkins University in the United States, Juelich Research Center in Germany, etc., for short-term trainings. INER has started up a new practice to cultivate our new bloods to be world-class researchers. In the mean time, our institute has broadened the scopes to recruit international talents.

In addition to the entire management aspect, each project as well as each work unit is encouraged to effectively carrying out the spirits of the PDCA

cycle in management. It is believed that only through constant adjustment and strengthening of our organization can we be well equipped in the pursuit of being outstanding.

Responsive to challenges in the future

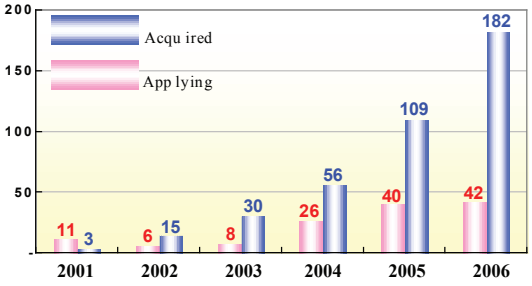
We will continue to actively strive in the following three directions: (1) Strengthening our core technologies as well as establishing professional laboratories, focusing on integrating the R&D resources of the Institute, following closely to the evolutional paces of the cutting-edge technologies, and developing those technologies which can combine the natural resources and the industrial advantages of our country. (2) Deepening the computerized "e" management, fully utilizing the ever-growing "e" management tools, finding out the weaknesses of our management, simplifying the processes of the management, and improving the work efficiencies. (3) Constructing a free work environment that international talents are able to give full plays to their creativities. INER is about to stride into more R&D fields requiring originalities and creativities in the future. It is necessary to invite a variety of world-class experts and engineers to join our research programs. Therefore, to construct an internationalized, English-friendly work environment is a particular subject that INER must seriously face with.

Introduction of the Institute of Nuclear Energy Research (INER)

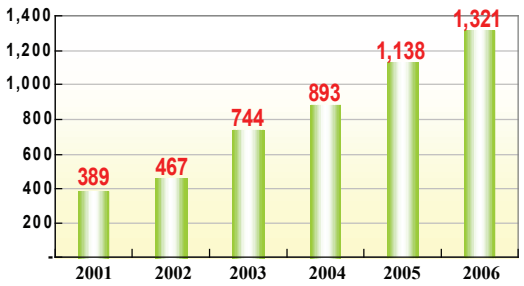
In accordance with the current requirements of governmental reform as well as an endeavor for sustainable development, the Institute of Nuclear Energy Research (INER) established three technology centers in July 2002. The three technology centers, namely, Nuclear Safety Technology Center, Environmental and Energy Technology Center, and Radiation Application Technology Center operate in close matrix with the existing eleven functional divisions. In addition, all research activities of INER are streamlined into five technical groups including enhancement of nuclear safety and control technologies, radiation biomedicine R&D and applications, R&D of radioactive waste treatment and disposal technologies, R&D of plasma technology and applications, and new & renewable energy source technology development and applications. INER's mission is to enhance its R&D capabilities and to promote R&D achievements to local industries for the welfare of the general public.

By the relentless efforts by the three Centers, the quality and the quantity of patents, research reports, international journal papers, and revenue from technical services have significantly enhanced and increased during the year. Also, the effort in CO_2 reduction has received significant results (see Table 1 and Table 2). In addition, there was no occupational accident at INER for the last three years and the occupational accident rate per 1,000 persons was much less than the national average value for the last six years. This result indicates the well-keeping on safety within the whole workplace at INER. These achievements have certainly founded a solid base for INER in the effort toward becoming a world-class competitive research institution.

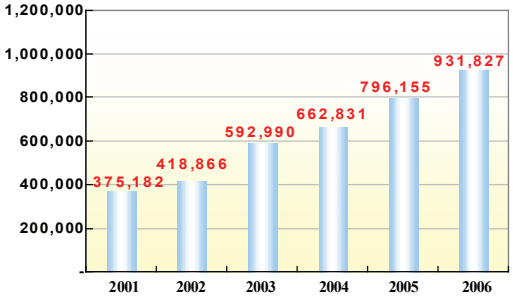
■ Patent/event



■ Research Report /article



■ Technical Service Income/1,000NTD



■ International Journal / article

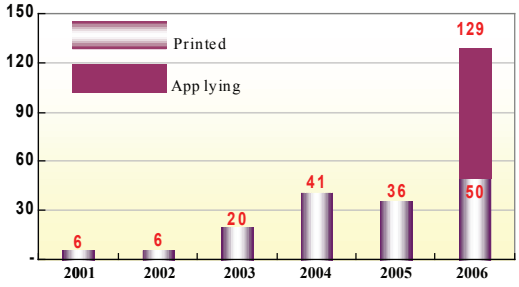
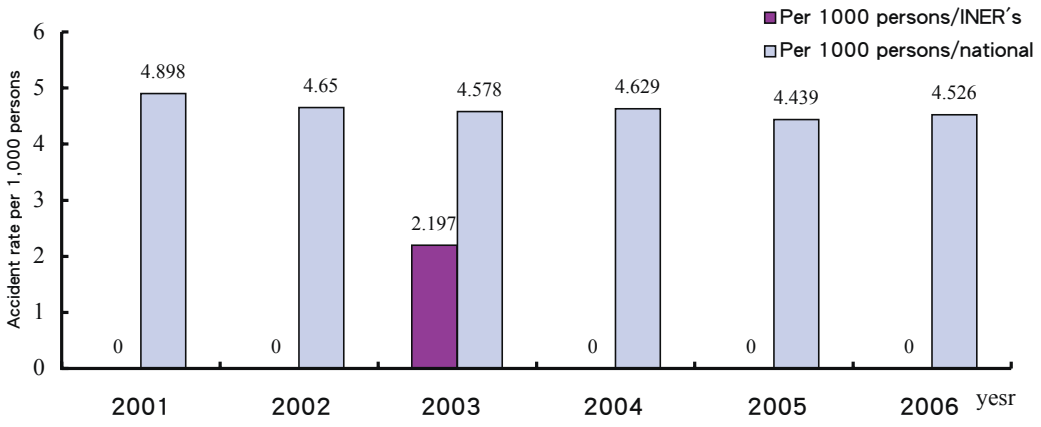


Table1. CO_2 Emissions of INER from 2004 to 2006

Year	Electricity -CO_2(Ton)	Water -CO_2(Ton)	Gasoline -CO_2(Ton)	Diesel -CO_2(Ton)	Paper -CO_2(Ton)	CO_2 Emissions (Ton)
2004	17,530	178	77	123	32	17,941
2005	17,529	179	89	527	29	18,354
2006	16,315	167	79	734	37	17,332

Table2. CO_2 Emissions Reduction by Renewable Energy in INER

Year	Electricity Generation Units of INER	Planned Capacity (kW)	Installed Capacity (kW)	Availability	Electricity Generation Projection (kW/hr)	Reduction CO_2 (Ton)
2006	Wind power	0	25	0.2	43,800	30
	PV	0	1.2	0.21	2,208	2
					Total Reduction: 32	
2007	Wind power	25	50	0.2	87,600	60
	PV	105	106.2	0.21	195,366	133
					Total Reduction: 193	
2008	Wind power	150	200	0.2	350,400	238
	PV	1,000	1,106.2	0.21	2,034,966	1,384
					Total Reduction: 1,622	



The occupational accident rate over the last 6 years

Note:

1. The occupational accident rate per 1000 persons includes injuries, disabled injuries and deaths (not includes those caused by traffic accidents.)
2. The average occupational accident rate per 1000 persons of INER over the past 6 years is 0.366.
3. The average occupational accident rate per 1000 persons of the nation over the past 6 years is 4.62 (based on the statistical data of 'Occupational Injuries Ratio per Thousandth under Labor Insurance in Taiwan-Fukien Area,' Bureau of Labor Insurance.)
4. The occupational accident rate per 1000 persons = (No. of accidents/No.of INER's total staffs) x 1000; INER has a total of 455 staffs.
5. Based on the record of INER's occupational accidents reported to the 'Northern Region Inspection Office of the Council of Labor Affairs,' there was only one death accident for the TRR case of the Engineering Division occurred on September 18, 2003. Since then, there was no other occupational accident happened. The average occupational accident rate per 1000 persons of INER over the past 6 years is 0.366, much lower than that of the national average of 4.62.

Nuclear Safety Technology

The Nuclear Safety Technology Center (NSTC) visions itself to be a capable and unbiased technical center, a technical arbitrator at national laboratory level of excellency, and a reliable research institution that contributes to enhancing the public confidence on nuclear safety. NSTC thus sets goals at developing world-level nuclear safety technologies, establishing independent equipment qualification capability and getting ready to transfer related technologies to the industrial sector. In 2006, NSTC submitted 28 patents applications, published 47 international journal papers and received business revenue for about NT$ 540,000,000 and technical licensing fee at NT$ 2,000,000. Comparing with previous years, each of these performance indicators reflected substantial progress.

NSTC attained various technical achievements in fiscal year 2006, with typical examples briefly described as below. Chinshan NPP's license renewal application documents were finished and a peer review to follow soon. Finishing the Safety Analysis Report (SAR) of the spent fuel dry storage project of Chinshan NPP was within schedule and received Taipower approval. The Measurement Uncertainty Recapture (MUR) engineering analysis of the Kuosheng NPP has received approval by Taipower. The feasibility evaluation report of the MUR for Chinshan NPP is in the Taipower reviewing stage. The MUR contract for Maanshan NPP has also been awarded to NSTC. All simulation systems for safety analysis have been integrated into the SIMPORT platform, including 18 and 16 simulated systems for Kuosheng NPP and Lungmen NPP respectively. NSTC established the electrical power portion of an energy model for economic analysis, which is available for benefit analyses of nuclear and clean coal power generation. NSTC set up a high performance cluster computer with performance better than 4.0 TeraFlops to improve simulation capability. NSTC replaced the guide tubes for the in-core detector system of Maanshan NPP and sets a pioneer record of applying domestic maintenance technique to the internal of nuclear reactors. NSTC established the performance demonstration technique for manual ultrasonic testing of dissimilar metal

weld and held the first examination. Distributed Control and Information System (DCIS) received recommendations in an OECD/NEA hosted Computer Based Systems Important to Safety (COMPSIS) conference, for offering failure analysis methods of safety related computer systems for NPPs. The Probabilistic Risk Assessment (PRA) team was awarded a contract by the Chinese Petroleum Corp (CPC) for the risk evaluation of a LNG storage tank system. It is the first PRA contract for NSTC on non-nuclear applications.

In radiation safety, NSTC completed a mammography x-ray dose calibration system and quality assurance criteria as technical bases to implement control on medical exposures by the Competent Authority. A web-based GIS radiological bomb preparedness information integration management system capable of strengthening decision quality was established, along with a scenario analysis for radiological bombs. The results were incorporated with the information management system and adopted to support the 2006 Won-An 29 drill by the Taoyuan County government. The national traceability system for environmental sample radioactive analyses were established, together with the validation of fabrication technology for 7 standard reference samples. Eleven calibration services of dosimetry and neutron measurements were successfully adopted into the Key Comparison Database (KCDB) of the Bureau International des Poids et Mesures (BIPM) for the global Mutual Recognition Arrangement (MRA), after being reviewed by four regional metrology organizations and the Asia Pacific Metrology Programme (APMP). These achievement have advanced Taiwan's calibration and measurement capabilities to a world-class standard.

In waste management, NSTC established the Eastern Asia Forum on Radwaste Management (EAFORM) as a communication platform among Taiwan, Japan, Korea and the US, and hosted the first EAFORM international symposium in 2006. NSTC also implemented the first phase of technology transfer on final-disposal site analysis and safety assessment for low-level radioactive waste through the arrangement of an Industrial Cooperation Project (ICP). The project produced a whole-system safety-assessment code

for low-level radioactive waste disposal which is ready to be used for the safety assessments of a tunnel type or a shallow-surface type of disposal sites.

Environment and Energy Technology

The solid and concrete goals of the Environment and Energy Technology Center (EETC) are as follows: relevant researches of the environment and energy, demonstration of the new energy system, and development of the decommissioning and radioactive waste disposal technologies. In 2006, we have 96 patents claimed, 476 reports released and 51 papers foreign periodicals submitted. The income of ETTC in 2006 is 168.766 million NT$, and the royalty is 6,664 thousand NT$.

In 2006, EETC's performance is classified into the following four portions: the environmental plasma, decommissioning and radioactive waste, new energy, and other portion. In the aspect of the environmental plasma, we accomplished items are: the standard manufacturing procedure for the porous light lava resources product, and the study and technology assessment for the manufacturing procedure for the ore textile fiber. We planned valuable metal recycling procedure from electronics industrial waste by plasma melting. The preliminary result shows that about 80% of the valuable metal can be recycled. Also, we accomplished the design, manufacturing and preliminary functional test of the non-transfer type of the 600 kW steam direct current plasma torch system; completed the activity trial and application for the license of the low radioactive plasma melting facility. In April of 2006, we had our technology of the direct current plasma torch system transferred to Taiwan Plasma Company, authorization granted for six years. Taiwan Plasma Company established a spin-off company, and at present it has obtained the first order. Processing time of the new approach of plasma immersing injection of nitride mold is five times less than the traditional nitride processing method. Along with the plasma coating bi-function, it effectively promotes the ability of abrasion and anti-corrosion.

In the aspect of the decommissioning and radioactive waste, last year we

collected 14 cans of the fuel pool uranium powder and stored temporarily. There were 44 greater than class C waste barrels produced in 2006, including the fuel pool sampling rods, inner and outer guide tubes, fuel handling baskets, fuel stacks, and other miscellaneous waste. Also, we completed the preliminary assessment of using pipes to remove the waste resin to TRR basement for following stability process, and improved the construction of delay slot vault by year's end. The "Micro power Reactor Cease Operation Safety Management Plan" and the "Micro Power Reactor Decommissioning Plan" were approved by Nuclear Safety Council and Fuel Cycle and Materials Administration (FCMA) respectively for ready to examine; established the stability process facility in the hot cell of TRR fuel and uranium powder; applied for the protection box of the spent fuel for temporary storage; completed stability process of single TRR fuel; planned the decommissioning and dismantling work of the transuranium experimental facility of building 016; finished the cutting, dismantling, packaging and transporting operating of the Unit 21 large-scale transuranium glove box. Also, the the dismantling detailed operational procedure of the Unit 20 large-scale transuranium glove boxes were written, reviewed and ready to examine. Plans of "releasing the waste concrete" and "releasing the waste metal" were passed the FCMA's review, and according to this review, we will apply for the release of TRR dismantled concrete and existing extremely low radwaste metal.

In the aspect of the new energy, we developed the active sunlight sensor with precision 0.2~0.5 degree, and installed it with its controller on the pioneer 5 kW tracking system for testing; completed the design and bid invitation for 5 kW concentration photovoltaic power demo system, including the solar cell modules, frames, prop structures, and the foundation, etc., and installed the system by the side of building 013 in the end of 2006. In 2006, we completed the design and assembly of 1kW SOFC power system; developed the 10x10 cm^2 SOFC unit battery and now it is under the electrical testing; completed the development of SOFC unit battery by plasma spurt spread with power density approximately 100 mW/cm^2; completed the SOFC module assembly of three cells stacking module with output power

approximately 25W; completed the 20/25W DMFC system of 1,000 hours continuously operating test, and have demonstrated that this system is in accord with world standards.

In the aspect of large-scale seminar activities, in March 17~18, 2006, we and the biochemistry science and technology department of Taiwan University worked together to host the seminar of "the development and usage of biomass energy," inviting four renewable energy experts from England and attendants including approximately 150 domestic experts. We held the international seminar of, June 6~8, 2006, "The 2006 Taiwan SOFC Workshop," and there was a large attendance numbered approximately 140 people with nine overseas speakers. Not only do our visions broaden and technical levels largely elevate, but SOFC international cooperation opportunities promote as well. In addition, we held the seminar of "2006 Taiwan Small Fuel Cells Symposium," in June 27~28, demonstrated our achievements of research and development of DMFC fuel cell, and our success was affirmed. Participants of 350 people to this seminar mostly come from industries, help construct a cooperation bridge between industries and INER.

In the aspect of project deployment and strategy planning, we proposed and approved to establish two priority plans: "1MW HCPV demonstration system" and "scale-up cellulose-to-ethanol advanced mass production research" in 2006; drafted "the national energy development strategy plan," approximately 10 colleagues participated in and had worked on weekends for 4 months. This draft has provided the reference for future energy plan.

In the aspect of importing technical cooperation, we worked with American national laboratory LANL to develop the non-destructive measuring technology for a stable process of TRR spent fuel. Participated in the German national laboratory Jülich for the SOFC cells stack assembly and testing, and researched on direct methyl alcohol fuel cell. We also cooperated with Italian Acta Corporation to evaluate the characteristics of Acta Corporation fuel cell; signed the cooperation contract with American

PolyFuel Corporation to evaluate the characteristics of methyl alcohol fuel cell thin film of PolyFuel Corporation. In addition to working with many overseas companies on DMFC, we signed the contract with domestics companies, such as Southern Asia Plastics Co., Ating Corporation, Asia Vital Components Co. etc., and establish the joint venture to develop commercial products in synchronization with international technology. In May 6~17, 2006, we and delegates from industries attended the 4th International Conference on Solar Concentrators for the Generation of Electricity (ICSC-4), and sought for the cooperation opportunities with international famous III - V solar cell manufacturing companies: Spectrolab, Emcore and Fraunhofer ISE, in order to develop the concentration photovoltaic power project.

In the aspect of giving support to the supervisory authority, we helped AEC for an urgently receiving a source of remote healing and treatment machine from Jen-sen; worked on behalf of AEC to receive the damaged source after BaoYan company caught fire, promoting the image and implementing the nuclear-free homeland commission; identified and analyzed 30 samples out of 43 items for the radioactive abnormal fromm different domestics steel companies, such as: Dragon Steel, Tung Ho, Feng Hsin, etc.

In the aspect of obtaining rewards, we acquired the first-class prize in the category of science and technology from Executive Yuan, for an outstanding research on “Establishing Deactivation Technique and its Application to the Decontamination and Deactivate Reuse Project for the TRR & Fuel Recirculation Experimental Facility.” Also, we won the prize for an outstanding paper named “Thermal Stress Analysis of Solid Oxide Fuel Cell Testing Components” in the 1st national hydrogen energy and fuel cell symposium and the hydrogen energy forum of Cross Strait Tri-Regional. Moreover, we cooperated with Rong-Jih company to develop a manufacturing method for the patent of aqueous extracts lava cast stone, and acquired the bronze medal in 2006 Taipei International Invention and Technology Exchange.

Radiation Application Technology

The purpose and orientation of development for the Radiation Application Technology Center (RATC) of INER can be described below: Short term: improving the reliability of the middle-sized cyclotron operation. Middle term: cultivating domestic nuclear medicine industry and including bio-tech as our important developing industry to follow the acts of "Challenge 2008 National Developing Key Plans", and "Two Trillion, Two Star". Long term: developing new nuclear medicine, and irradiation therapeutic technology for both diagnosis, and therapeutic demands, and the nuclear medicines to be developed now are MoAb, and Peptides; elevating research ability, increasing the profit, and becoming one of the center of nuclear medicine research, and manufacture in Pan-Asia Pacific Basin.

Accordingly, RATC has applied patents for 14 items, acquired 5 patents, published 196 internal reports, 28 papers in international journal, 2 papers in domestic journal, 28 papers for conference, and received NTD 3,100,000 as the technology authorizing.

As technology developing, twelve items of technology has been established which are listed below:

(1) After an amplifier with 70 kw has been installed, the proton flux has been upgraded up to 800μA. Adding a quadruple ion source output elevated the output efficiency from 5% to 20%. The ^{124}I producing target is modified with Tellurium-Alluminum sintered material which is able to provide the 30μAh proton flux irradiation. All these actions have increased the efficiency and capacity of middle-sized cyclotron tremendously; (2) The technology of synthesis and identification for bombesin peptide has been established, which includes the bombesin labeled with radioactive isotopes, and quality control analysis. As the field of pharmaceutical dynamics, the prostate cancer animal model has been established. Accordingly, the micro SPECT/CT, and micro PET image technology has been built up. All these accomplishments have highly promoted the ability of pharmaceutical therapeutic evaluation, and nuclear medical technology for INER; (3) The genetic drug-Tc-99m-MIBI had

been registered, and its drug-permission-license has been awarded at Dec. 05, 2006; (4) The pre-clinical image system and the image processing technology have been set up. This work makes the pre-clinical animal study easier, and shortens the time, and cost for drug developing; (5) The permission license for calibration sealed source of Co-57, and Ge-68 has been acquired from Health Bureau; (6) Cu-64 is successful produced from cyclotron. As well known, the Cu-64 is a bifunctional isotope which can be applied in both diagnosis, and therapeutic; (7) The chelating technology of HYNIC and SOTA with protein is finely developed; (8) The evaluation report for second clinical stage of Kit for gastric empting measurement has been finished; (9) The nano technology for enveloping Re-188 in liposome as cancer-therapeutic medicine has been well established. Also, the biodistribution, pharmacokinetics, and therapeutic evaluation of the medicine have been finished; (10) The INER-developed micro-PET/CT bifunctional image system has been undertaken test-run; (11) The synthesis technology for Norepinephrine transporter molecular tracing reagent - I-123-MIPP has been well developed; (12) The image analysis and cellular transporter molecular image analysis evaluation for anti-depression therapeutic effect with small animal model of cerebral anti-depression drug for decreasing the bonding ratio of serotonin, and its transporter have been set up.

As INER's contribution to the society, the concrete facts are catalogued as following: (1) Stably supply INER Thallium (II) Chlordie (Tl-201) injection reagent, and INER Gallium citrate (Ga-67) injection reagent etc. more than ten varieties of high quality nuclear medicine. All the reagents supplied not only help the physicians in clinical diagnosis, but also in research. The patients taking the reagents had gone up to 27,000 person times. Amongst, the INER dopamine transporter image reagent has been provided to National Taiwan University Hospital etc. 23 hospitals as the diagnosis drug for Parkinson's disease which strongly reflect the contribution of INER to the society; (2) Develop new anti-tumor drugs; Panbiotic Octreotide injection reagent (Permission License of Health Bureau No G841704654), targeting therapeutic anti-tumor drug - Lipo-Dox-Oct have been synthesized. The

mass-production, biological activity, cellular toxicity test, animal tumor model, and their therapeutic evaluation of all these drugs have been established, and INER is putting all these drugs to the market aggressively.

As publishing, and awards, the following events can give evidence for INER's efforts this year: (1) INER dopamine transporter image reagent acquired the "Excellent Award" in Technology from Extraordinary Research Award of Executive Yuan, and the only "Golden Medal" from the Fifth Pharmaceutical Technical Research Developing Award; (2) In-111-Pentetreotide acquired "Copper Medal" from the Fifth Pharmaceutical Technical Research Developing Award; (3) RAC of INER held a reporter's meeting at Mar. 27, 2006 to publish the research in the cardiomuscular infusion injection image reagent-^{99m}Tc-Sestamibi. The research acquires two US patents, and is patent transferred to US pharmaceutical company; (4) INER held an international conference- 2006 Taiwan Atomic Energy Conference during Apr. 27-Apr. 28, 2006 (in the field of radiation development and application). The speakers were from Germany, Japan, and Taiwan, and more than 180 attendants were present for the conference.

As domestic cooperations, the followings are worthy of mentioning: (1) The final-stage cooperation case of the Pre-clinical Pharmacokinetic Study for E, and E-K Protein Pharmaceutical has been finished with Biotech Center; (2) The cooperation case of the Pre-clinical Pharmacokinetic Study for Human Monoclonal Antibody GNX-7 has been completed with Glyconex Inc., Taiwan; (3) The cooperation case of the Pre-clinical Biodistribution Study for Protein Medicine IFN/IFN-Fc has been continuing with Biotech Center; (4) The cooperation case of the Pre-clinical Study for Radio-Pharmaceutic As_2O_3 has been continuing with Biopharm Company, Ltd; (5) The cooperation case of the Material Modification with Radiation for High Quality Poly Acrylo Nitrile (PAN) as Raw Material in Carbon Fiber Application Research which is requested by Tong-Hwa Synthetic Fiber Co. has been completed; (6) The cooperation case of the Radiation Engineering Applied in Thermo-Reversible Electric Resistant Plastic Polymer which is requested by Polytronics Technology Corporation has been completed.

As international cooperations, members of Hamamatsu Photonics K.K., Japan visited INER to attend the research of PET instrument system, cerebral neurological function pharmaceutical development, and radiological image detector etc., also to give speeches at the Atomic Energy Conference. The other international cooperation event is that INER has signed the contract of providing Tc-99m TRODAT-1 with St. Paul Hospital, Brazil.

Research Fields

- Development of Safety and Regulation Technologies for Nuclear Power
- Development and Applications of Nuclear Facilities Decommission and Radioactive Waste Deposition
- Development and Applications of New Energy Technologies
- Development and Applications of Environmental Plasma Technologies
- Research and Applications of Nuclear Medicine and Radiation Biology

Development of Safety and Regulation Technologies for Nuclear Power

■Hung-Fa Shyu, Yin-Pang Ma

As a domestic leader in nuclear technology research, the Institute of Nuclear Energy Research (INER) has established international credibility in many areas, such as root cause analysis of fuel failure, safety analysis of digital instrumentation, risk monitoring system and severe accident analysis. Furthermore, the INER has demonstrated competitive capability in the areas of reactor core loading design, safety analysis, thermal performance analysis and monitoring, fuel inspection, nuclear grade item dedication, NDT performance demonstration and simulator upgrade. The strong ability to compete internationally has prevented the technological and commercial monopoly by foreign companies. In addition, the INER has set up regulation related technologies and provided technical supports to the Atomic Energy Council (AEC) directly. The strategic plan of the Center is to develop in-house technologies together with ones imported from abroad, and seek strategic technological alliances with both overseas and domestic organizations. After setting up technological capabilities, the Center will, in the short term, actively make contribution to the domestic nuclear circle, including the Taiwan Power Company and the AEC. In the long term, the Center plans to establish a nuclear service industry in the form of business incubation, patent authorization or technical transfer depending on market demands and scopes. The following provides a detailed description in areas of operation and maintenance services, dry storage, PRA applications, digital control and instrumentation, core management and safety analysis, national radiation standards, fuel cladding aging as well as final disposal of nuclear wastes.

The Development of O&M Technology for Nuclear Power

■Shih-Kuei Chen

The Institute of Nuclear Energy Research (INER) has been in the development of operation and maintenance (O&M) technology for nuclear power plant for many years. The matured core technologies include, core management, safety analysis, probabilistic risk assessment, severe accident analysis, commercial grade items dedication, digital instrument and control, simulator upgrade, fuel inspection and root cause analysis, authorized nuclear in-service inspection, non-destructive inspection and performance demonstration, radiation protection analysis, material degradation and life assessment, motor operated valve (MOV) functional inspections and assessments, etc. These technologies have been applied to domestic nuclear power plants (NPP) successfully. These capabilities have prevented technological and commercial monopoly in Taiwan by foreign vendors. With these technical bases, INER has been able to take on large projects, such as the Measurement Uncertainty Recapture (MUR) power uprate for the three operational NPPs and the license renewal for Chinshan NPP. The scope of O&M that INER can offer has been increased dramatically over the last three years, from 100 million NTD in 2003 to about 600 million NTD in 2006, taking share about one fifth of the total Taipower outsourcing NPP O&M work. INER is now starting a project with Taipower's sponsor ship on dissimilar metal overlay welding technology, that is expected to be accomplished in two years. Also, INER is the planning for technology transfer of In Vessel Visual Inspection from a renown organization in hope to establish a reliable domestic capability. In year 2006, major maintenance related work includes:

- MOV inspection and assessment for Maanshan NPP end of cycle (EOC) 16; thirty valves have been inspected for unit 1 and 2, respectively.
- Replacing guide tubes for the movable in-core detection system (MIDS) during Maanshan NPP EOC16; tube cutting machine has been developed and seven tubes for each unit have been successfully cut and replaced.

■Ultrasonic inspection performance demonstration: seven out of nine personnel from Taipower passed the capability demonstration test for carbon, stainless steel or dissimilar metal pipe weld.

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Installation of Spent Nuclear Fuel Dry Storage Facility for Chin-Shan Nuclear Power Plant

■Ding-I Lee

In July 2005, INER was entrusted by the Taiwan Power Company (TPC) with the project of "Installation of Spent Nuclear Fuel Dry Storage Facility for Chin-Shan Nuclear Power Plant." According to the contract signed by both parties, the duration of this project is about six and a half years ending in February 2012. The contract requires INER to design a dry storage system that meets the characteristics of the spent fuel to be stored and the conditions of the storage site, to submit a safety analysis reports (SAR), to assist in the licensing for construction and operation, to build up a concrete cask storage facility capable of storing at least 1,366 spent fuel assemblies and to provide for the handling, loading and transportation.

In the past 18 months, almost all tasks has been completed as scheduled, except that the licensing review for the safety analysis reports (SAR) was delayed for a couple months. Major work accomplished for contract in 2006 included: submitting various engineering documents, transferring technology by off-job training courses, modifying the NAC-UMS system (transfer cask and lifting yoke) to meet the loading weight and space limitations in the plant, adding additional shielding on the outer surface of the concrete cask to meet the dose limit requirements at site boundary, accomplishing SAR which was approved by the TPC on Sept. 22 2006 and submitted to the Competent Authority for licensing review on Oct. 14 2006, and implementing the Transportable Storage Canister (TSC) procurement for which a contract was signed with a local vendor on Dec. 29 2006.

In 2007, the important tasks to be performed include: licensing for the construction permit, procurement of a transfer cask, concrete pad, concrete casks, operational services with auxiliary equipments, preparing the operational procedures, and the manufacturing of TSC. Based on the past experience incorporated by technology transfer, INER is confident of completing the project satisfactorily on schedule.

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Appliction of Probabilistic/Quantitative Risk Assessment Technique on Liquefied Natural Gas Tank Systems

■Tsu-Mu Kao

Probabilistic/Quantitative Risk Assessment (PRA/QRA) is a technique, which can be used to identify hazard scenarios, to quantify the frequencies of hazard scenarios and to evaluate the consequence and risk of the associated hazard scenarios. It had been used in the fields of nuclear power plants, aerospace industry and the development of military equipments for many years. The technology has demonstrated its effectiveness in helping managers to make decision on the base of associated risk information and to optimize the resource taking full consideration between safety and operation requirements.

According to the Act 132 entitled, “Safety Inspection Rules for Dangerous Machines and Equipments”, the Liquefied Natural Gas (LNG) tank is a specific facility for the storage of high-pressure gas and an internal inspection should be implemented by the end of a 15 year period. The first three LNG tanks in Taiwan in operation from 1990 till 2006 have exceeded the time limit for an internal inspection as required by law. Since INER has accumulated over 24 years’ matured PRA experience on nuclear power plants, the Council of Labor Affairs (CLA) encourages utilities to implement quantitative risk assessment on LNG tank systems as an alternative to the required internal surveillance inspection. The INER has helped the Chinese

Petroleum Corp. (CPC) to obtain the permission from CLA of extending one additional year to perform the required internal LNG tank periodic inspection for the CPC phase-one 3 LNG tanks in March 2006. The CLA may grant the CPC longer period of extension, depending on the final result of the quantitative risk assessment of the LNG tank systems. The CPC expects to save more than one billion New Taiwan Dollars of both direct and indirect costs with the exemption of periodic inspections of LNG tanks.

Based on the preliminary QRA for Yuan-An phase-one LNG tanks, that the primary initiating events source of LNG tank system attribute to the leakage of auxiliary piping of the LNG tank systems. The ratio of initiating events caused by the leakage of LNG tank membrane is lower than 1% within the period of ten years. The LNG tank membrane is not the major source of initiating events.

From the view point of risk, the probability of leakage on LNG tank membrane will grow with time. However, due to the small amount of LNG leakage and the small impact area, the contribution of initiating events caused by LNG tank membrane failure on the F-N (Frequency-Number of Fatalities) curve of Individual Risk and Societal Risk is minor. The operating risk of the LNG receiving terminal will not be significantly affected with respect to the exemption of internal inspections on LNG tank membrane.

Research Team:
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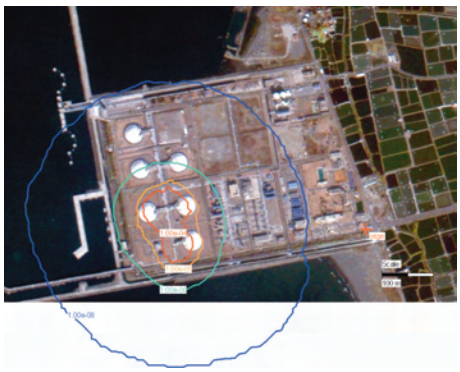
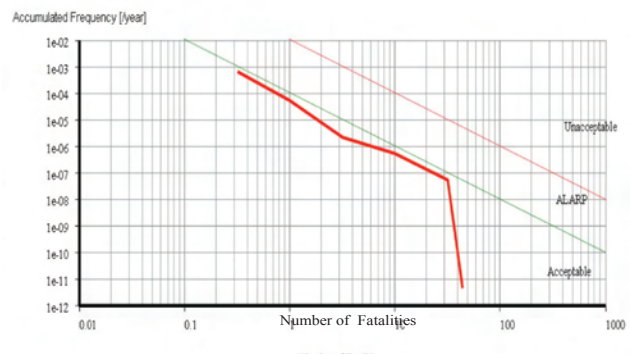


▲Individual risk caused by LNG tank systems.



▲Societal Risk F-N curve due to LNG tank systems.
(ALARP：As Low As Reasonably Practical)

Development and Application of Digital Instrumentation and Control System Technology for Nuclear Power Plants

■Ming-Huei Chen

The application of digital instrumentation and control (I&C) system in nuclear power plants is an unavoidable trend due to the rapid progress of electronic and computer technology. However, there are still many safety concerned topics related to nuclear regulations including software quality and reliability, common mode failure assessments, human factors engineering, commercial grade item dedication, hardware/software qualification, and cyber security issues, etc. In order to build up the localized technology infrastructure, INER continues its efforts in the research and applications of the nuclear digital I&C system technology. Moreover, INER continues to join the COMPSIS (Exchange of Operating Experience Concerning Computerized Systems Important to Safety at Nuclear Power Plants) international cooperation program hosted by OECD/NEA, and to discuss with NRC regarding to future cooperation on software reliability topics. The major achievements in technology development include: (1) Development of software fault-injection test bed with PCTran-ABWR dynamic simulation model. (2) Development of human workload and man-machine interface performance measurement methodology, and assess the differences regarding the maintenance task between digital and conventional I&C systems. (3) Development of network application architecture and measurement/ diagnostic tools for plant-wide I&C systems. (4) Perform the functional test of INER programmable logic controllers and applied in reactor water level indication system. The major achievements in technology applications include: (1) Technology support to Taipower Company on factory acceptance validation tests of DCIS system (Distributed Control and Information System) and perform parallel verification of RTIF system (Reactor Trip and Isolation Function) software safety analysis for Lungmen project. (2) As regard to the digital upgrade of operating nuclear power plants, INER support the Kuosheng feedwater control system retrofit and Maanshan BOP retrofit projects including the tasks of safety evaluation, software V&V,

Instrumentation uncertainty analysis and simulator modification.

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▲Software fault-injection simulation test bed for digital I&C system.

Nuclear Fuel Management and Safety Analysis

■Lain-Su Kao

Under the projects related to Nuclear Fuel Management, the analysis capabilities for calculating the refueling shutdown margin during fuel shuffling, and for evaluating the decrement of shutdown margin resulted from the rupture of Boron filled control rods, of the Kuosheng nuclear power plant, have been established. The latter can provide a control suggestion for emplacing the ruptured control rods, to discover the potential risk, and ensure the operational safety. In the future, both capabilities can be extended to applications for Chinshan and Lungmen nuclear power plants. The analysis models for a plurality of control rods have been established for the Chinshan nuclear power plant. The model can be used to confirm the differences of absorption capabilities among all kinds of control rods, and

thus effectively reduce the uncertainty in the prediction of cold critical and substantially reduce the standard deviation of the prediction. The accuracy can be increased by almost 100%. For example, in designing the core loading pattern for Chinshan unit 2 cycle 22, it was found that the fuel vendor made an obvious error in the modeling of Marathon control rod. The quality of independent verification has been improved. In addition, in performing the parallel design of core loading patterns for Chinshan unit 2 cycle 22 and Maanshan unit 1 cycle 17, it was found that the independent and domestic design of core loading patterns can only make a little improvement over the vendors' design, and thus indirectly achieved the objectives in implementing a double check. On the other hand, when fuel failure was found during the Kuosheng unit 2 cycle 18, the core loading pattern after replacing the failed fuels can be promptly verified. This enables the reactor to get restarted, and the root-cause for fuel failure to be studied quickly. In safety analysis area, the TITRAM (TPC/INER TRansient Analysis Methods) stage 1 project completed four Topical Reports (TRs) for the Kuosheng Nuclear Power Plant (NPP) and received licensing approval by the Atomic Energy Council (AEC). Three more TRs for Chinshan NPP were also reviewed and approved in stage 2. This project established a model for licensing review of the independent safety analysis methodology developed by TPC and INER. For the first time, Safety Evaluation Reports (SERs) were issued by AEC for TRs submitted by domestic organizations, instead of foreign vendors. The ATWS (Anticipated Transient without Scram) analysis TR for Kuosheng NPP has been adopted in the Reload Licensing Analysis by vendor. The current assignments for Chinshan and Kuosheng MUR PU were completed. Further applications for the Chinshan, Kuosheng and Maanshan NPPs can be expected in the future based on the technical support by the TITRAM team. In addition, the self-developed RELAP5-3D/K code for LOCA analysis has been successfully adopted and purchased by a National Lab. in the U.S.A. The engineering simulator of the Kuosheng NPP has been developed and integrated with sixteen sub-systems. The product of this project can be used to support the evaluation of operational parameters in the future projects of SPU and EPU.

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Hydride Reorientation Behavior in Zircaloy-4 Fuel Cladding

■Chu Hou-Chin

The mechanical properties of Zircaloy fuel cladding can be adversely affected by the presence of hydrides, especially when they are oriented along the radial direction of the tubing (i.e. radial hydride). It is reported that Zircaloy-2 tube containing radial hydrides of more than 50 ppm hydrogen exhibited no macroscopic ductility. In order to retain sufficient ductility to keep its integrity during reactor service, Zircaloy fuel cladding tube is manufactured to ensure that only circumferential hydride platelets are developed due to hydrogen pickup from the waterside corrosion reaction. However, radial hydrides can be formed when a specimen is cooled down under stress from temperatures at which a fraction of hydrides is dissolved. As a result of the larger hoop stress and higher hydrogen concentration attendant with fuel cladding at higher burnups, the stress reorientation of hydrides is very likely to happen under some conditions during spent fuel dry storage or reactor operation.

In this work, the effect of radial hydrides on the mechanical properties of stress-relief annealed Zircaloy-4 cladding was studied. Specimens were firstly hydrided to different target hydrogen levels between 100 and 600 wt.ppm and then thermally cycled in an autoclave under a constant hoop stress to form radial hydrides by a hydride reorientation process. The effect of radial hydrides on the axial properties of the cladding was insignificant. On the other hand, the cladding ductility measurements decreased as its radial hydride content increased when the specimen was tested in plane

strain tension. A reference hydrogen concentration for radial hydrides in the cladding was defined for assessing the fuel cladding integrity based on a criterion of the tensile strength 600 MPa. The reference hydrogen concentration increased with the specimen (bulk) hydrogen concentration to a maximum of ~90 wt.ppm at the bulk concentration ~ 300 wt.ppm H and then decreased towards higher concentrations.

The formation of radial hydrides in Zircaloy-4 cladding was also studied. Based on the experimental data, a thermodynamic model was proposed to elucidate the stress reorientation behavior of hydrides in Zircaloy cladding. According to the model, the bounds of stress and temperature to stress reorientation of hydride precipitates were developed. The threshold stress for hydrides to reorientation, not a fixed value, was a function of solution temperature and specimen hydrogen concentration.

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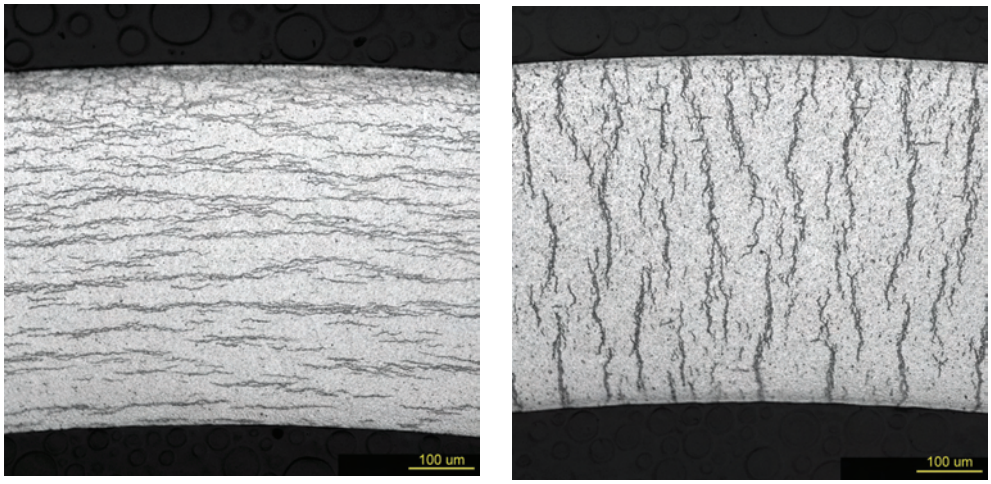
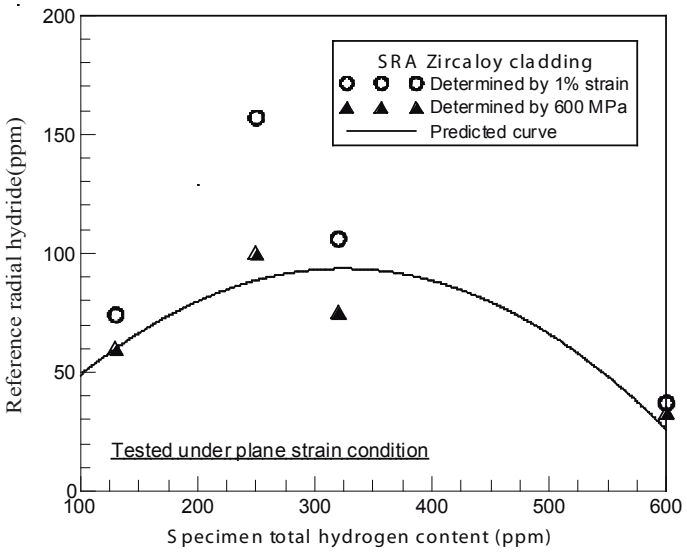
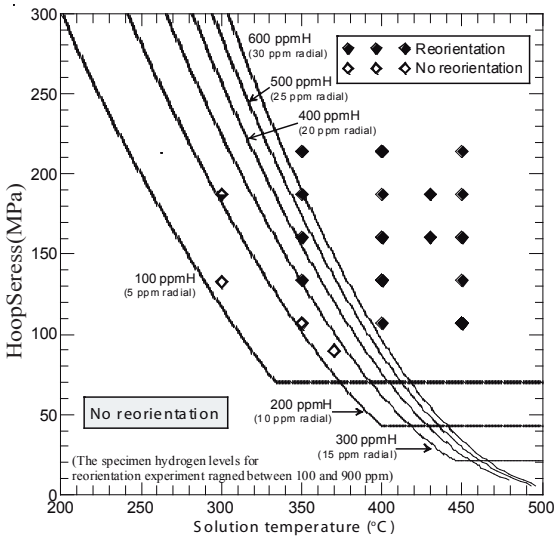


(a)as-hydrided (b) after 8 cycles of thermal treatment

▲Micrographs showing reorientation of hydrides in Zircaloy-4 cladding.



▲Estimation of the reference radial hydride concentration as a function of specimen total hydrogen concentration.



▲Applied hoop stress for hydride reorientation as a function of isothermal solution temperature and specimen hydrogen concentration. The hydrogen concentration in parenthesis is to define the resolution of radial hydrides observable for each hydrogen level.

National Ionizing Radiation Standards in Taiwan

■Ming-Chen Yuan

Starting from 1993, the INER took the entrustment of the Bureau of Standards, Metrology and Inspection, Ministry of Economic Affairs, to construct the National Radiation Standard Laboratory (NRSL) to establish and maintain the nation's highest ionizing radiation standards, ensure the consistency of national standards and international standards, deliver national measurements standards in the country through the TAF system, facilitate the applications of atomic energy in radiation therapy, radiation protection, environmental protection, radiation processing and nuclear power generation as well as the safety of these applications.

In 2006, NRSL improved existing standards and developed new systems to fulfill the needs of environmental monitoring and protection by completing the CIEMAT/NIST technology establishment, environmental level gamma

emission radioactivity calibration technology which made the traceability of radioactivity standards covering not only gamma emission radionuclides but also pure beta emission radionuclides, extending the calibration strength from MBq downward to kBq. To meet the needs of domestic radiation processing industry and radiotherapy, NRSL undertook the establishment of high dose measurement technology and Ir-192 brachytherapy source dosimetry standard. Both were to be completed in 2008 and anticipated to promote dose assessment accuracy of radiation processing for domestic biotherapy, electronic and polymer materials and ensure the radiation safety in brachytherapy.

In 2006, NRSL earned to be the host of the comparison of the absorbed dose to water for Co-60, participated in the I-131, Ba-133 and Co-60 air kerma key comparisons organized by the BIPM and the EUROMET.RI(I)-S3 comparison organized by the EUROMET. INER was doing well and had very good agreement with the international reference values. Moreover, NRSL has been devoted to the global MRA (mutual recognition arrangement) and successfully entered 78 calibration services items in radioactivity in February 2005 and 11 calibration services in dosimetry and neutron measurement in October 2006 into the KCDB of the BIPM after being reviewed by 4 regional metrology bodies (APMP, EUROMET, COOMET, and SIM) and the BIPM and six years' efforts. Till now, all the NRSL's CMC (calibration and measurement capabilities) tables have been entered into the KCDB of the BIPM. The fact showed that our calibration and measurement capabilities have been officially recognized by all the global professional organizations.

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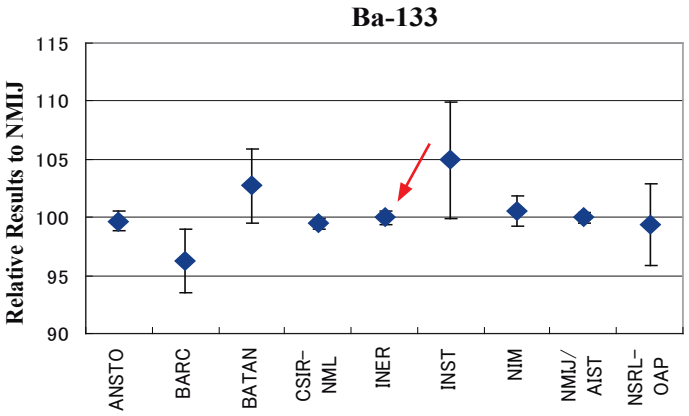
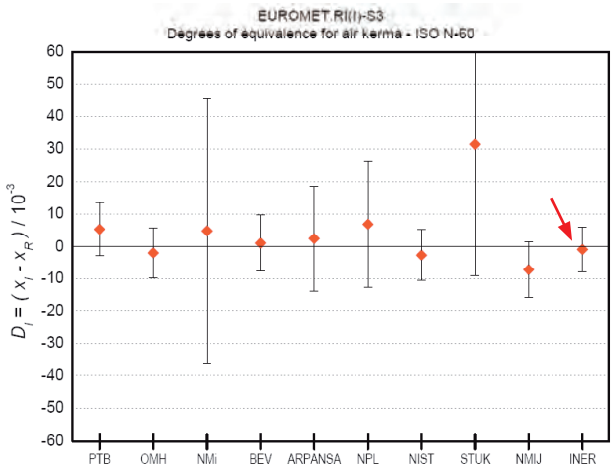


▲The Asia-Pacific Ba-133 activity key comparison result for National Radiation Standard Laboratory.



▲The comparison result of EUROMET.RI(I)-S3 X-ray air kerma rate measurement for National Radiation Standard Laboratory.

GIS and Wireless Transmission System Applied to RDD Emergency Preparedness and Respondent

■Hsin-Fa Fang , Chung-Hsin Lu

Wireless network, satellite navigation, and GIS have been popular technical application recently. INER has combined environmental radiation detection with GIS, worked on wireless data transmission years ago. Real-time, spatial, and mobile system was the goal of this project.

The integration of environmental detection with GIS has been a major trend. It can not only indicate detecting points on the geographic map, but also store data systemically in the database for further analysis. Base on the promotion of wireless network, INER has invested much efforts in wireless protocol and the connection of detecting instruments with PDA to achieve the acquiring data, wireless transmission, and detectors positioning via GPS automatically.

For the RDD emergency response drill item of Wan-An Exercise in 2006, INER cooperated with GIS Research Center at Feng Chia University

to develop Web-GIS information integration system. Car camera was also applied to transmit live video via streaming technology. Mobile meteorological station carried easily by car was established to collect weather parameters that could be applied to public radiation dose estimation.

The latest technology applied to RDD emergency will be expended to all of the nuclear accident preparedness and respondent. To shorten the response time, to receive real-time information, and to assist decision-making were the objective of this work.

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▲The System schme of RDD emergency Preparedness and respondent.

Proficiency Testing Programs and Traceability System on Environmental and Low-intermediate Radioactivity Levels

■Jeng-Jong Wang

The results of analytical measurements play an important role in our daily lives. Analytical data may be the basis upon which economic, legal or environmental management decisions are made, and they are essential in international trade, environmental protection, safe transportation, law enforcement, consumer safety and the preservation of human health. As an incorrect decision can be extremely costly and detrimental, it is essential that such measurements are accurate, reliable, cost effective and defensible. In addition, measurements performed by laboratories located worldwide should yield traceable and comparable results.

It is now widely recognized that for a laboratory to produce consistently reliable data it must implement an appropriate program of quality assurance measures. Among such measures is the need for the laboratory to demonstrate that its analytical systems are under statistical control, that it uses methods of analysis that are validated, that its results are "fit-for-purpose," and that it participates in proficiency testing exercises. The competence of laboratories is demonstrated in accreditation processes following the ISO/IEC 17025 and in the frame of accreditation systems, the use of reference materials, both for quality control and proficiency testing, has therefore increased in recent years.

Proficiency testing is a method for regularly assessing the accuracy of the analytical data produced by the laboratories of particular measurements. In radioactivity analysis, proficiency testing usually comprises the distribution of effectively homogenous portions of the test material to each participant for analysis as an unknown. The laboratories conduct the test under routine conditions, and report the result to the organizer by a deadline. The results generated in proficiency testing should be used for the purpose of a continuing assessment of the technical competence of the participating laboratories. Participation in proficiency testing exercises also provides

laboratories with an objective means of assessing and documenting the reliability of the data they are producing.

The duty of National Radiation Standard Laboratory (NRSL) is keeping the primary standards of radiation and the traceability of radiation measurement in Taiwan. In 2006, NRSL, cooperated with Taiwan Accreditation Foundation, held the proficiency testing program on environmental and low-intermediate radioactivity levels. Seven kinds of spiked samples, including water, soil, tea leaf, milk powder, air filter, synthetic urine and synthetic feces, were used for the environmental proficiency testing program; the participants are all the environmental monitoring laboratories. Besides, three kinds of standards, including water, gas and air filter, were used for the low-intermediate activity proficiency testing program; the participants are the nuclear power plants, environmental restoration and waste management laboratories. All the analytical results accompanying with the uncertainties of each participating laboratory were reported to the NRSL, and which were collected and evaluated to assess the performance of the participating laboratories. The evaluation showed that all the analysis results were "Acceptable". It reveals that all the participating laboratories had good proficiency in radioactivity measurement on samples of environmental and low-intermediate levels and well QA/QC management in routine practices.

Research Team:
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▲Proficiency testing samples (Environmental).

▲Proficiency testing samples (Fe-55, Sr-89, Sr-90).

Development and Applications of Nuclear Facilities Decommission and Radioactive Waste Deposition

■Wen-Shou Chuang

In accordance with the current trend as well as the future demand, nuclear facility decommissioning and radwaste volume reduction technologies have become the top priority in Atomic Energy Council's development strategy. These technologies also become the major INER R&D targets to fulfill the ultimate goal of improving environmental quality and reducing related social cost. The main work items include (1) conducting INER's nuclear facility decommissioning to achieve the goal of deregulation and reuse of facilities and advancing related planning and execution capabilities, (2) progressively developing technologies for radwaste decontamination, volume reduction, treatment, and storage in order to improve low-level radwaste management and reduce the amount of radwaste produced. Nuclear facility decommissioning requires highly integrated and multi-disciplined technologies. Notonly that decontamination provides an effective way to reduce human dosage during operation, it is also crucial in reducing the amount of radwaste produced. A complete management plan is essential to regulate the radwastes produced during decommissioning since measures of waste volume reduction, including its treatment, transport, and storage, have a significant impact on the environment. Free-release of radwastes after careful cleaning has become the international trend in radwaste management. Over the years, INER has devoted efforts in developing nuclear facility decommissioning and radwaste treatment technologies. It is hoped that these technologies can be applied to the large-scale nuclear facility decommissioning in the future. The R&D projects conducted in 2006 include the establishment of volume reduction technology to treat NPP's control rod blade, the establishment of D-to-C (Dose rate to Curie) classification technology for low-level radwastes in the Lan-Yu storage site, root-cause diagnosis for the deterioration of solidified low-level radwastes, operation of the High-Efficiency Solidification System (HEST) in Kuosheng NPP of Taipower, the development of clean-

up technologies for high-activity wastes in TRR spent fuel pool, the development of stabilization process for TRR metal uranium spent fuel, the development of dismantling technologies for trans-uranium contaminated facilities, the study of dose assessment technology for waste clearance, and the establishment and operation of decontamination facility for metal scraps from decommissioning.

Study on Volume Reduction of Control Rod Blade of Nuclear Power Plant

■Jung-Chun Hsieh

Used control rods at Taipower's Nuclear Power Plant are currently hanged with box-hangers on the poolside. This practice not only occupies valuable pool space, but also imposes restrictions on the operation of the fuel exchange platform. A volume reduction process for used control rods in Chinshan Nuclear Power Plant was developed.

The machine for control rod volume reduction consists of a cutting unit and a compacting unit which operates at the poolside. Due to the fact that this process was designed for operation at a depth of 6 to 12 meters underwater, a PL control and underwater monitoring camera system was provided. The cutting unit, which is intended to cut off the low-radiation limiter head, comprises a control system, up-down guide structure & driving system, loading structure, gravity balancing block, cutting device, hydraulic fluid supply, X-Y table, and control rod rotating devices. The compacting unit in the shape of a rectangular tube structure (4.357 meters in length) is designed to compress the cross shape control rod blade into a flat sheet with 3~5 cm in thickness. On one side of the compacting unit there are 7 water cylinders with maximum operation pressure at is 4,000 psi. They are used to compress the control rod blade after removing the limiter head. On the opposite side of the water cylinders, 5 air cylinders with output pressure at

100 psi are equipped. Their functions include taking the control rod into the compressing cavity, positioning it during the compressing process, and returning the compressing mold back to its original position.

For operation safety, various analyses were performed with the cutting unit and the compacting unit, including seismic analysis, floor loading analysis, structures analysis, and system analysis. The results demonstrated that the machine meet all design requirements and posing no safety concerns.

Research Team:
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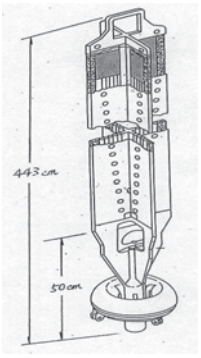
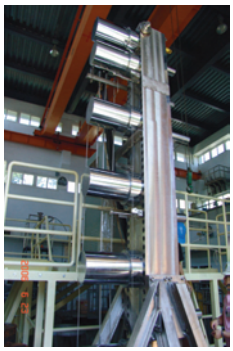
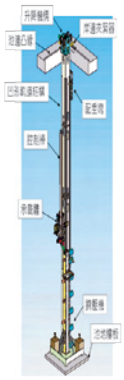


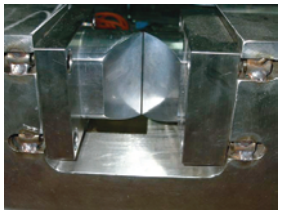
▲Control rod blade and limiter head.



▲Schematic structure of the cutting unit.



▲Assembled compacting unit.



▲Compressing the control rod blade.

▲Compressed control rod blade.

▲C-shaped cutting device.

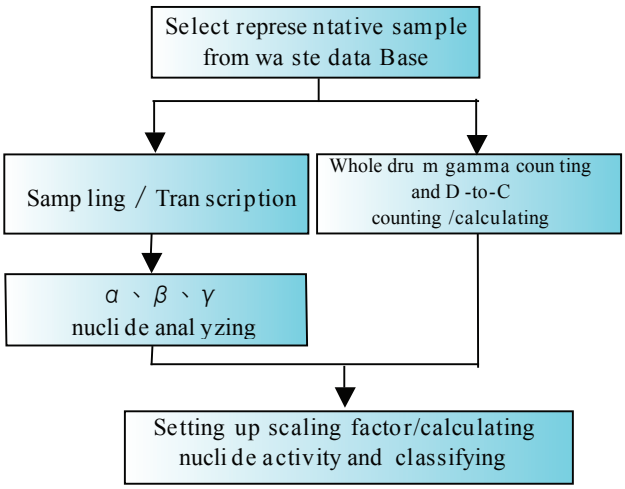
Establishment of the Low-Level Radwaste Classification using Dose-to-Curie Technique at the Lan-Yu Temporary Storage Site

■Tser-Min Chang

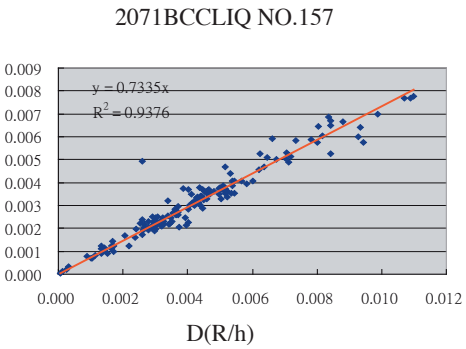
The Fuel Cycle and Materials Administration (FCMA) promulgated the "Supplementary Regulation for Classification of Low Radioactive Wastes", as well as the "Regulation for Disposing of Low Radioactive Wastes and its Facility Safety Management" in July 17, 1997 and September 10, 2003 respectively. The latter regulation states that for low-level radioactive waste delivering to a final land disposal site, each waste drum must specify its nuclide activity and be classified into four classes: A, B, C or greater than C.

The Taipower Co. has requested INER to conduct low-level radwaste nuclides database and classification methods since Dec. 1998. The flow chart for establishing nuclide database is illustrated in Fig. 1. This method has been applied to the classification of 5381 drums while inspecting the trenches of 8-2 and 13-2 in the Lan-Yu storage site. Except some unknown waste streams, 99% of the drums have been classified. Taking concentrated liquid wastes produced at Kuosheng Nuclear Power Plant in 1982 as an example (refer to figure 2), the development of D-to-C technique greatly simplifies the measuring procedure. For instance, with the help of D-to-C technique, only 10% of the drums need to undergo whole-drum gamma counting. The activities for the rest of the drums can be calculated by simply measuring the surface dose rate. This not only provides great savings on measurement costs (~ 150 million dollars), but also reduces human dosage during operation.

Research Team:
Jwn-Yung King, Tser-Min Chang, Tsao-Chih Lang, Shih-Kang Chang, Wang Tsung-Yuan, Ching-Ho Yang, Hwa-Jou Wei.



▲Fig.1 The flow chart for establishing nuclide.



▲Fig.2 The relationship of dose rate to activity for 2071BCCLIQ waste stream.

Root-Cause Diagnosis for the Deterioration of Solidified Low-Level Radwaste

■Yih-Ping Chen

Low-level radwaste must be well-stabilized before being transported to the final disposal site. Cementation is one of the most typical ways to stabilize low-level radwaste. However, bulging or cracking will usually occur after solidified waste has been stored for a period of time. In order to preempt the problem and provide appropriate treatment for the solidified waste, the root-cause or mechanism of deterioration must be explored and identified. INER devotes to gain insights into the issue and developed procedures as follows: (a) Collects representative samples of solidified waste according to a comprehensive sampling plan; (b) Collects samples at three different degrees of deterioration, namely minor, moderate and serious, respectively from the same bulk. Further examines samples by analytical instruments such as the Scanning Electron Microscopy (SEM) for recognition of molecular structure patterns, the Energy Dispersive X-ray Spectrometer (EDS) for detection of sample compositions, the X-Ray Powder Diffractometer (XRD) for compound identification, the Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES) for composition determination, and the Ion Chromatography (IC) for ascertainment of different anion species; (c) Makes

judgements on the trigger for the degeneration on base of results analyzed. Our analyses indicate that the gradual formation of ettringite [$Ca_6Al_2(SO_4)_3(OH)_{12}.26H_2O$] that contains sulfate contributes to the deterioration of solidified waste. Specifically, the low-density ettringite produced from sodium sulfate reacts with some components in the cement and causes local swelling of the solidified waste, which consequently result in bulging and cracking. To avoid this phenomenon, it is necessary to eliminate sodium sulfate prior to cementation or to apply the High Efficiency Solidification Technology together with the solidified agent developed by INER.

Research Team:
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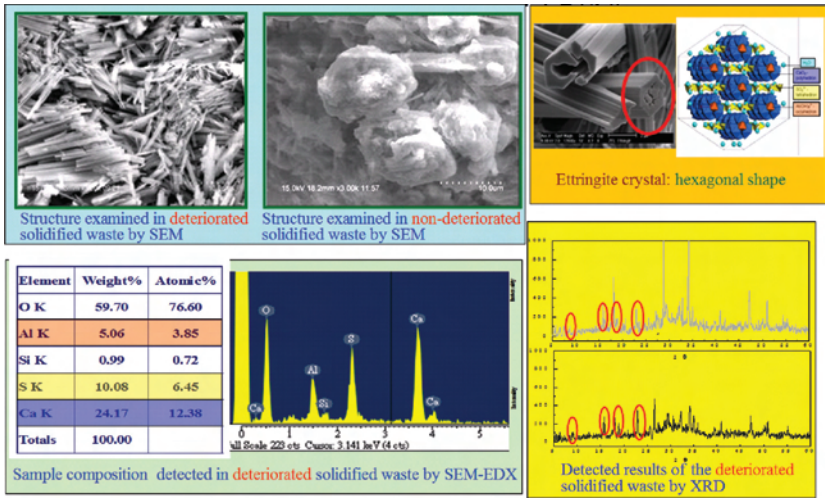

▲Formation of ettringite leads to deterioration of solidified low-level radwaste.

Performance of BWR High-Efficiency Solidification System at Kuosheng NPS of Taipower

■Ching-Tsuen Huang

Kuosheng nuclear power station (NPS) of Taipower employs boiling-water reactor (BWR) to generate electricity. In routine operation, however, it inevitably produces different sorts of wet low-level radwastes, such as sodium sulfate, spent powder-type and bead-type ion-exchange resin,

and sludge. These waste must be solidified into a stable form to meet the quality requirement for final disposal. Typically, the radwaste is solidified by cementation. However, the conventional process not only produces poor volume reduction efficiency, the quality of the solidified the product is also unsatisfactory. For this reason, INER has developed a High Efficiency Solidification Technology (BWRHEST) aiming at reducing the volume of radwaste produced by BWR nuclear power stations, as well as, to maintaining good solidification quality. Taking advantage of the waste characteristics, a strategy-"using waste to solidify waste," was adopted to significantly reduce the volume of solidified waste. This technology has not only received patents from a number of countries, such as Taiwan, U.S.A. and EU, it. also won a Silver Medal from National Inventions and Creations of Taiwan in 2004. In Dec., 2002, INER was granted a contract by Taipower to implement BWRHEST in the Kuosheng NPS. The design work was commenced in Dec., 2003 and the system test run after construction was completed in Dec., 2005. Subsequently, the system obtained operation permission from the Fuel Cycle and Materials Administration (FCMA) in May of 2006. As of the end of 2006, 107 drums of solidified waste have been produce with a volume reduction factor of 2.8 times as oppose to that of cementation. The system design emphasizes on features, of reliability, safety, operation flexibility and ease of maintenance. For instance, the system allows for conducting a remote and automatically controlled operation by using human-machine-interface (HMI) and programmable logic control (PLC). In an effort to reduce the individual dose received by operators, some friendly considerations such as dust prevention, simplification of QA work, and automatic sampling were also included. The successful commercial application of the system was demonstrated by the outstanding waste volume reduction efficiency of over 60%, outperformed the cement solidification system previously used in Kuosheng NPS. The quality of solidified waste produced is also superior to that of cementation as well as the regulatory criteria. Besides, the individual dose received by operators is significantly lowered. The solidification for wet radwaste at Kuosheng NPS has thus been significantly improved.

Research Team:
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▲Main control panel and computer with automatic PLC.

▲High-Efficiency Solidification System in Kuosheng NPS of Taipower.

▲Facility for containing solidified waste and conveying drums.

Development of Clean-up Techniques for High-activity Waste in TRR Spent Fuel Pool

■Ling-Huan Chiao

As designed for the storage of TRR spent fuel and high activity radioactive waste, the TRR spent fuel pool contains spent fuel basket, experimental tray rod cladding, irradiation sample rod cladding, spent fuel rack and filter can. In addition, there are estimated 140 kg of uranium as oxidized sludge/powder spread over the whole pool bottom.

Upon receiving a work permit from AEC, INER started to develop effective techniques for each type of waste in the clean-up of high activity radioactive waste in the pool. For metallic wastes, INER has established an integrated technique including underwater sectioning, underwater ultrasonic cleaning, shielded drying and transportation that can be performed in a relatively small working space. All of the claddings, spent fuel racks and filter cans, sum up to about 8.1 metric ton, have been cleaned up at a reasonably low collective dose to the work staff. As for uranium sludge/powder spread over the whole spent fuel pool, it is difficult to be retrieved due to its physical form as very fine uranium compound particles with high activity. Several alternatives

are assessed to collect the sludge/powder. Factors to be evaluated include collection efficiency, secondary waste production, collective dose minimization required, handling labor, device maintenance and financial investment etc. INER developed a precipitation collection process and has successfully used it to retrieve 18 cans of uranium sludge/powder.

The process development and the implementation efforts have demonstrated a capability to clean up high activity radioactive waste that brings both safety and economical benefits to our society. This accumulated technical capability will be an important corner stone in meeting the future decommissioning of our domestic nuclear power plants.

Research Team:
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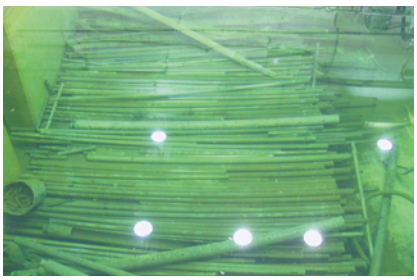
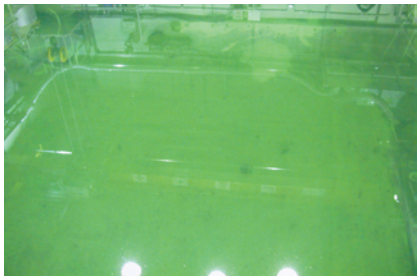
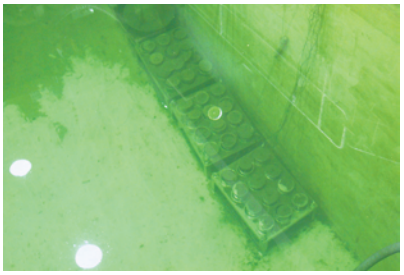


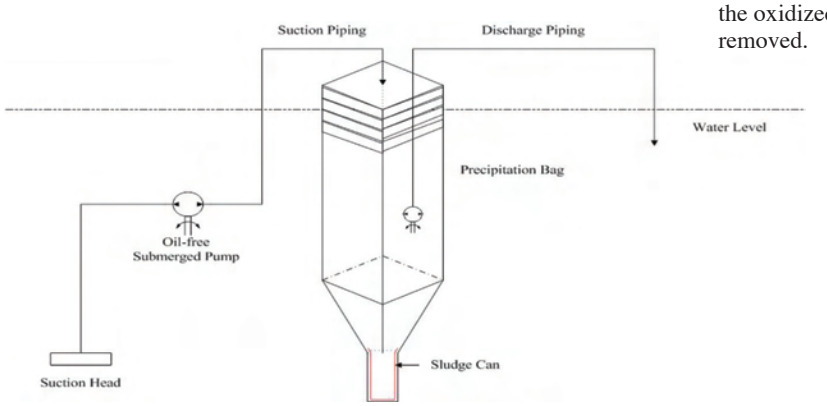
▲Flow tubes and claddings originally stored.



▲Flow tubes and claddings have been removed in spent fuel pool.



▲Sharp contrast at the bottom of spent fuel pool for areas before and after the oxidized uranium sludge being removed.



▲Oxidized uranium sludge/powder collection device.

Development of Stabilization Process for TRR Metal Uranium Spent Fuel

Jia-Baau Wang

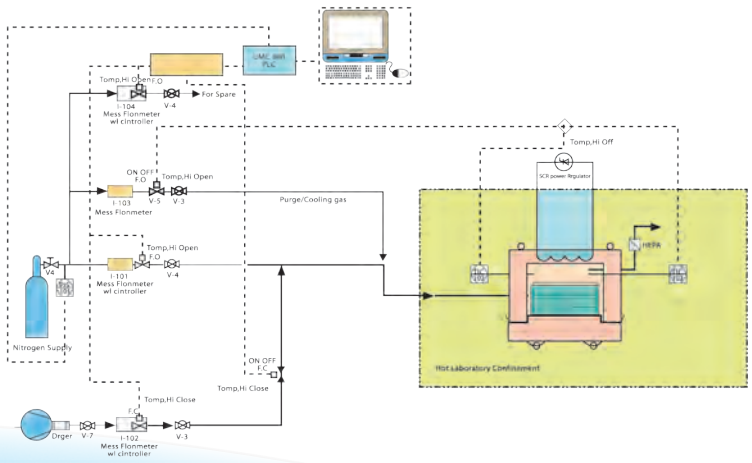
Most of the spent uranium fuels accumulated during the operation of Taiwan Research Reactor (TRR) have been retarned to the National Laboratories in the United States. Nevertheless, there are still some fuel canisters left in TRR's fuel pool waiting to be disposed of. These canisters contain deformed/broken fuel rods as well as filter cartridges once used for fuel pool clean-up. To conform with the schedule for TRR decommission, these fuel canisters have to be removed from the fuel pool and disposed of safely. Uranium metal reacts spontaneously with oxygen when stored in ambient atmosphere, which consequently raises safety issues for long-term storage. Considering that there is only a limited quantity of spent uranium metal fuel and the risk of chemical reaction during storage must be eliminated. Evaluation shows that the most feasible course of action is to convert the uranium metal to a stable oxide form, such as U_3O_8 and dry-stored in the existing horizontal shielded storage casks.

By utilizing the existing hot cell facility in INER, a stabilization process for converting spent uranium fuel to uranium oxide has been developed and set up in the hot cell. The stabilized uranium oxide will be stored in the horizontal shield storage cask for dry storage while awaiting final disposal. Stabilization of spent uranium metal fuel not only ensures storage safety but also simplifies the requirements needed for final disposal facility in the future.

The stabilization process is developed in accordance with INER's circumstances and requirements, and therefore is specific and unique. The process consists of (1) removing the spent fuel canister by a transfer cask to the hotcell; (2) taking out the fuel rods or filter cartridges from the fuel canister with subsequent sectioning and de-clading; (3) performing oxidation on sectioned/de-clad fuel rods or filter cartridges in a high temperature reactor with oxygen-controlled atmosphere to convert metal uranium into

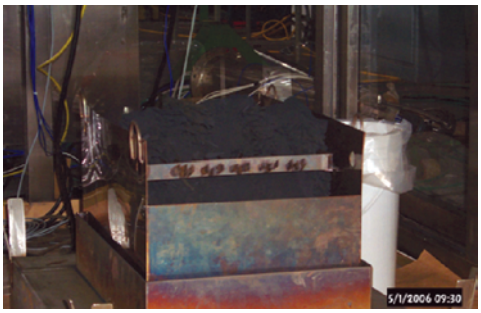
stable U_3O_8 which is in powder/flake form; (4) packing the stabilized product in stainless steel storage cans; and (5) loading the storage cans into the "horizontal shielded storage cask" for storage. The process was developed based on the chemical process study carried out with laboratory scale apparatuses. Together with the spent fuel handling designs in TRR fuel storage bay and hot cell facility, a complete TRR spent fuel stabilization process was established. The process was tested with unirradiated fresh TRR fuel rod in the simulated hot cell. The equipment and handling procedures were then modified based on the test results to improve the operability. After modification, the equipment has been installed in the hot cell for operation. A fuel canister containing one TRR fuel rod has been delivered to the hot cell for treatment. To consolidate the nuclear material accountability to meet safeguard requirements, non-destructive measuring techniques (plutonium canister counter, PCC) that include scanning PCC (SPCC) for in-pool fuel canister measurement and bottle PCC (BPCC) for can-packed stabilized product were developed in cooperation with Los Alamos National Laboratory of the United States. SPCC was completed and successfully applied for the measurement of fuel canisters stored in TRR spent fuel while BPCC is under development to be completed in the first quarter of 2007.

Research Team:
Jia-Baau Wang, Cheng-Si Tsao, Chung-Sheng Chen, Tian-Shi Zen, Ming-Chen Yuan, Ling-Huan Chiao, Shenq-Horng Lee, Horng-Bin Chen, Rong-Kae Lain, Ching-Shih Liu, Yaw-Hwa Shiu, Te-Wen Chu, Chun-Liang Lin, Wei-Ping Huang, Taing-Yi Lin, Yun-Hui Liu, Chan-Jung Hu, Shen-Yueh Tieng, Sheng-Yu Lin, Tsu-Han Cheng, Shan-Jung Chou, Cheng-Hsien Fang.



▲Process flow diagram of stabilization treatment.

▲De-clad fuel rods waiting for stabilization treatment.



▲Stabilized product, U_3O_8 powder/flake.

Development of Dismantling Techniques for Trans-Uranium Contaminated Facility

■Chung-Shin Lee

The decommissioning and cleaning of a Trans-Uranium contaminated facility at INER was implemented in a spam of four years (2004~2007). The program utilizes in-situ cutting, dismantling, boxing, transferring, and storage for the decommissioning of two sets of large-scale glove box (Unit 20,Unit 21) as well as five waste storage tanks (20V60, 20V30, 20V20, 20V10 and 20V40). The dismantling and cleaning technologies for Pu-239 contaminated large-scale laboratory facilities established by incorporating international experience as well as self-developed equipments suitable for local facilities. Other complementary measures such as special work procedures, safety measures, radiation protection, and medical care for α-radiation injury were established to fulfill the safety goal of decommissioning.

Important events occurred during the Unit 21 glove box decommissioning are summarized as followings:

July. 13: commence the decommissioning work after been approved.
Aug. 25: complete the tasks of dismantling, boxing, transferring and storage (25 working days).
Sept. 1: decontaminate nearby areas (5 working days).
Sept. 22: perform radiation monitoring and tracking for a consecutive 3 weeks.
Oct. 20: finish the dismantling of PC tent, negative-pressure ventilation

system, and other supporting facilities, after been approved by the Nuclear Safety Committee of INER.

Research Team:
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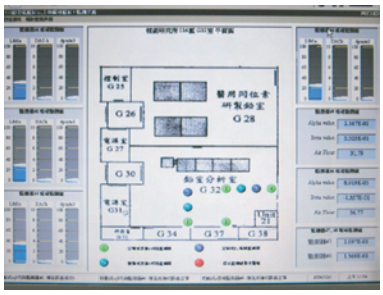
▲Unit 21 large-scale trans-uranium glove box.

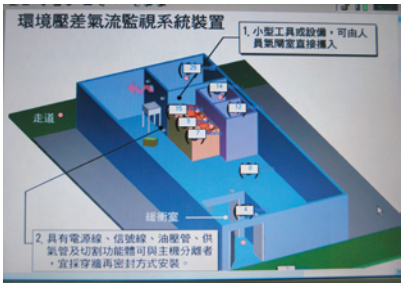
▲After decommissioning.

System for dismantling

▲PC tent and ventilation system.



▲Radiation detecting.



▲Negative pressure monitoring system.

▲Image recording system.

Dose Assessment Technology of Solid Waste Clearance

■Jyi-Lan Wuu

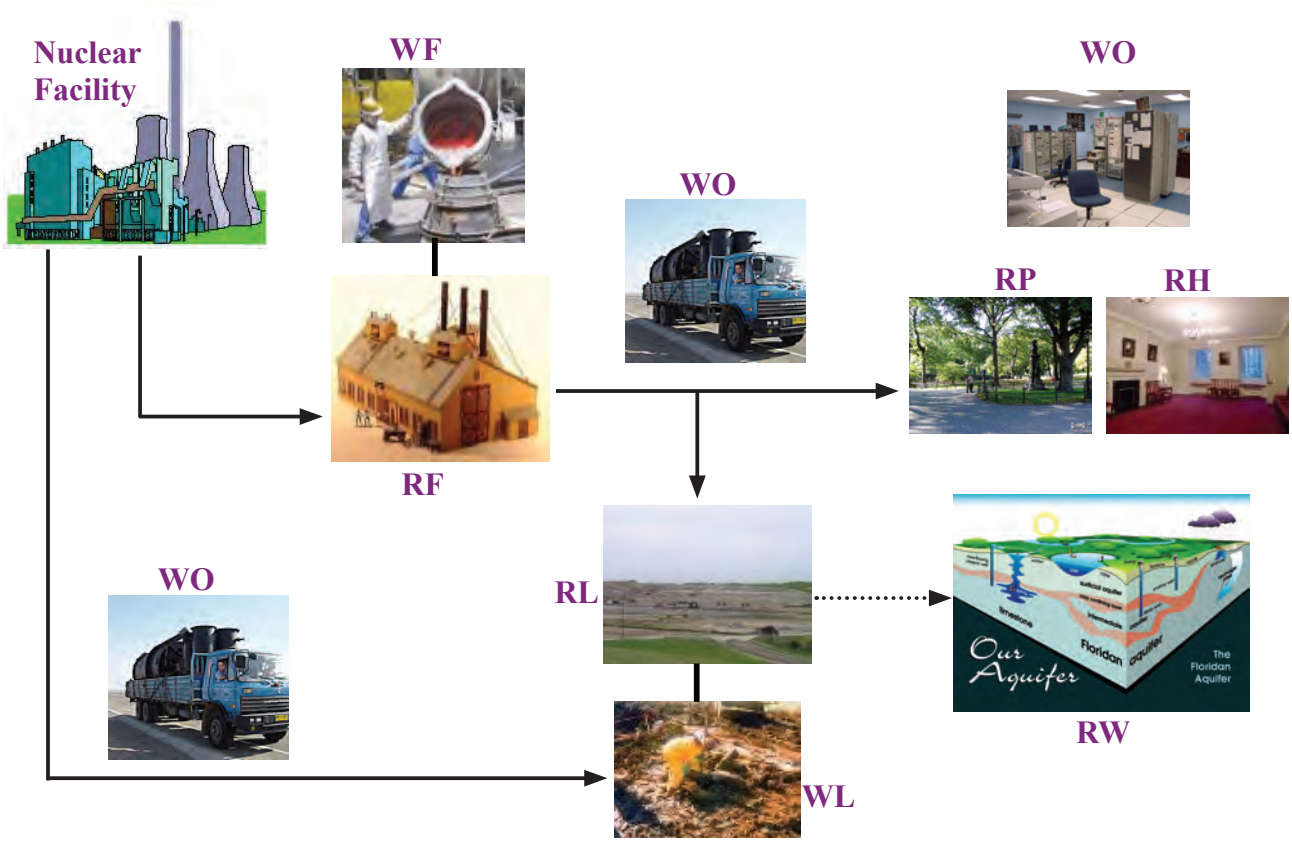
The Fuel Cycle and Materials Administration (FCMA) enacted the "Regulations on Clearance Level for Radioactive Waste Management" (the Regulation) on December 29 2004, referring to IAEA RS-G-1.7. Article 4 of the Regulation states that radioactive waste with activity or specific activity limit meeting the clearance level may apply for free release. Currently several release applications in Taiwan were based mainly on measurement results. Article 6 of the Regulation provides another approach to free release. Based on the radiation dose evaluation, radioactive waste with annual individual effective below 0.01 mSv and the collective below 1 person-Sv may submit, a radiation dose evaluation report and release plan to the competent authority for approval.

In reference to documents including IAEA Safety Report Series No. 44, 2005, NUREG-1640, European Commission RP series reports and RESRAD-RECYCLE programs, a new dose assessment code was implemented in INER with a main structure of exposure pathway referring to IAEA evaluation model. The exposure pathways include external exposure, inhalation exposure, ingestion exposure and skin exposure.

Twenty-five radionuclides and environmental parameters from Pingtung Plain (southern part of Taiwan) were selected to verify the suitability of the exposure scenario for domestic dose assessment. Some radionuclides were selected for each of the seven limit values specified in the Regulations. Since RL and water pathway scenarios involve hydrologicial, geological and dietary parameters, the results for IAEA and Pingtung Plain were obviously different. For the RL scenario, the dose of Pingtung Plain is about 1~2.5 times higher than that of the IAEA. For the water pathway scenario, the dose of Pingtung Plain is about 5~14 times higher than that of the IAEA. The variation comes from the different dietary dose. For other scenarios, there are no differences between both cases.

The radioactive wastes types and disposal process vary greatly with differences in site characteristics, national customs, diet, living habits and environmental parameters. The water pathway in Taiwan regions of is regarded as the key scenario. To identify these environmental parameters involves comprehensive hydrologic and geological investigations. In order to derive the doses caused by the release of radioactive wastes reasonably and conservatively, the collection of parameters in hydrology, geology, diet of various age groups and living habits of residents will be on important task of the future.

Research Team:
Jyi-Lan Wuu, Yi-Fong Kao, Ju-Lin Hsu.



WL: Worker on landfill or in other facility, WF: Worker in foundry,
WO: Other worker, RL: Resident near landfill or other facility, RF: Resident near foundry
RH: Resident in house constructed of contaminated material, RW: Water Pathway
RP: Resident near public place constructed with contaminated material
Scenarios of clearance dose assessment in Taiwan

Establishment and Operation of the Decontamination Facility for Metal Scraps from Decommissioning

■Tsong-Yang Wei

Taiwan Research Reactor (TRR) has completed its stage mission and shut down in 1989. In order to achieve the target of waste reduction, a decontamination facility has been constructed to treat the large amount of metal scraps generated from decommissioning. Typically, the decommissioning wastes consist of 70% metal wastes. By estimation, there are approximately 3000 barrels of metal wastes generated from facility decommissioning by the end of 2006. Together with the existing wastes in the warehouse, there will have 5000 barrels of metal wastes in total. For the goal of endorsing domestic decontamination technology and reducing the demand for waste storage, a decontamination facility was constructed, which adopts self-developed techniques incorporated with domestic industrial machines.

The decontamination facility including surface condition categorizing, chemical/electrochemical cleaning, blasting, wastewater treatment, decontamination agent regeneration, secondary waste treatment and solidification etc. has been successfully constructed in the end of 2005. From the beginning of 2006, a series of tests have being implemented to verify and improve the functions of the equipment. Most of the metal scraps can be categorized into different groups that fit the limitation of different decontamination method. However, part of the metal scraps need dismantling and cutting. These operations should be supported by other facility. The carbon steel waste is easy to clean in the phosphoric acid solution. The removal rates are 4.4μm/min and 1.2μm/min at 70°C and 50°C respectively. The stainless steel waste should be cleaned in the fluoroboric acid solution. Its operation cycle time is about 40 minutes. Meanwhile, operator and maintenance training have also been conducted. In order to achieve the goal of waste reduction by decontamination, a joint team consists of decontamination facility, radioactive waste treatment plant, metal melting plant, and free release measurement laboratory has also been organized. This

facility will treat metal scraps with a capacity of 2 to 3 tons per day. The experiences in construction and operation will serve as valuable references for the decommissioning of nuclear power plant in the future.

Research Team:
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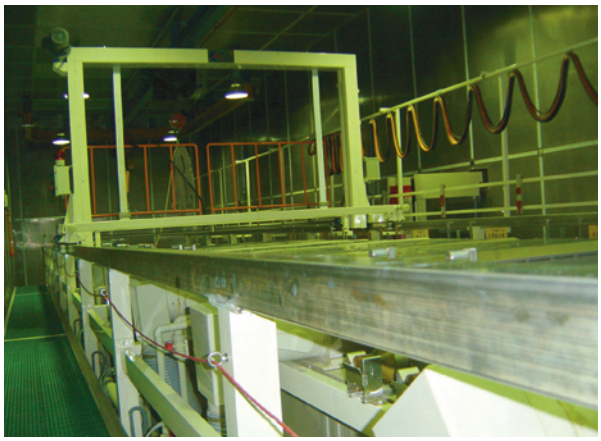
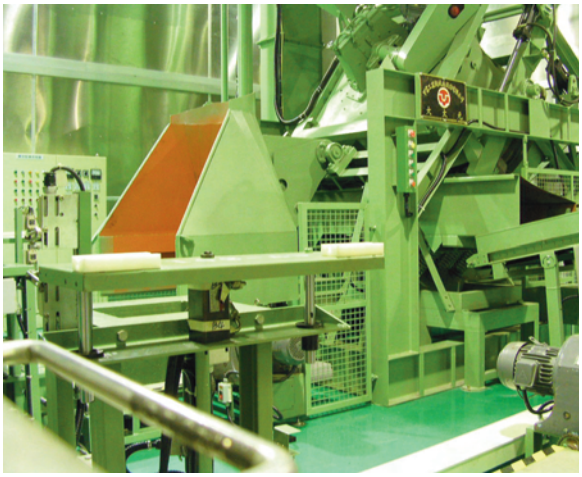
▲The operation of sorting equipment in decontamination facility.



▲The chemical/electrochemical cleaning equipment.



▲The overview of blasting decontamination device.

The Development of Radwaste Final Disposal Technologies

■Ching-Fang Shih, Fu-Lin Chang

Final disposal is the ultimate method to solve the problem of radioactive wastes arising from operation and decommissioning of the nuclear power plants, and medical and industrial applications, and research activity. The main objective in disposing radioactive waste is to protect people and the environment. This means isolating the waste so that the rate or concentration of any radionuclides returned to the biosphere is within acceptable limits. To achieve this, the radwaste is isolated by engineering barrier combined with natural barrier. Three crucial topics are studied in INER during 2006, namely: (1) technology development of performance and safety assessment of spent nuclear fuel final disposal, (2) technology development for safety assessment of low-level radioactive waste repository, and (3) establishment of the optimal concrete recipe for the construction of high integrity containers for final radwaste disposal.

Research Team:
Ching-Tsuen Huang, Wen-Shou Chuang, Ching-Fang Shih, Fu-Lin Chang, Shin-Jon Ju, Ben-Li Pen, Ling-Cheng Liu, Li-Min Chi, Li-Hao Wu, Ching-Tu Chang, Jum-Ding Lu, Neng-Chuan Tien, Chin-Lung Chen, Chen-Chang Lee, Po-Lin Wu, Ming-Chuan Kuo, Ren-Jie Lai, Ke-Wei Yan, Ching-Chang Chang, Chih-Ming Ma, Tseng-Chin Fu, Cheng-Yi Chen, Yu-Pei Chen, Cong-Zhang Tong, Hsien-I Lin, Hong-Tai Lue, Shui-Ying Tseng, Shu-Ju Chen, Kuei-Hua Lee.

Technology Development of Performance and Safety Assessment of Spent Nuclear Fuel Final Disposal

■Ching-Fang Shih

In accordance with the regulation for radioactive waste management, major tasks for spent nuclear fuel final disposal is to upkeep development on geoloyical investigation and assessment technologies for radwaste disposal, and to continue assessing applicable geological characterization of potential sites. As depicted in “Spent Nuclear Fuel Final Disposal 2006", the project duration from 2005 to 2055 is separated into five phases as "Characterization and Evaluation of the Potential Host Rock", "Candidate Site Selection and Approval", "Detailed Site Investigation and Test", "Repository Design and

Safety Analysis" and "Repository Construction" in sequence. An interim report named "SNFD Preliminary Technical Feasibility Assessment Report, SNFD-2009" is scheduled to be issued in 2009 and will serve the purpose of setting the foundation for future work plans. The current project for 2006 entitled "Spent Nuclear Fuel Long-term Disposal Program-Investigation and Evaluation of Potential Host Rocks Phase and Technology Development of the Performance/Safety Assessment" includes performance evaluation of near-field, far-field, biosphere, system integration, and database of disposal system. Conformance to regulation is the guide pole in the project implementation for site characterization, spent nuclear fuel characterization, and adopting international disposal experiences.

□ Near-field performance and safety assessment

For the near-field, multiple release pathway model for the vertical emplacement was accomplished by developing all axial/radial/tunnel transport pathways in the assessment program. The assessment model for the horizontal emplacement concept was established accordingly.

□ Far-field performance and safety assessment

Based on the conceptual model for radionuclide transport in geosphere, the far-field performance assessment model was accomplished for assessing geological radionuclide transport and groundwater flow in fracture rock. This will provide for analyzing the effects on radionuclide release rate for factors of groundwater velocity, including groundwater velocity in host rock, fracture spacing and aperture.

□ Biosphere radiation assessment

For the biosphere, in accordance with the radionuclide release scenario from drinking well into aquifer in BIOMASS 6/IAEA ERB1A/1B, the radiation dose assessment model was developed. By applying and analyzing the biosphere parameters, the radiation dose assessment for a hypothetical site was accomplished.

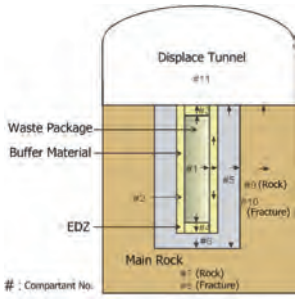
□ System integration of performance and safety assessment technologies

To construct an analysis model for the integrated system of performance/ safety assessment, data from site characterization and experimentation were analyzed and applied to the equivalent model the granitic host rock. Validation and integration was then implemented on the assessment model with data of the near-field, far-field and biosphere.

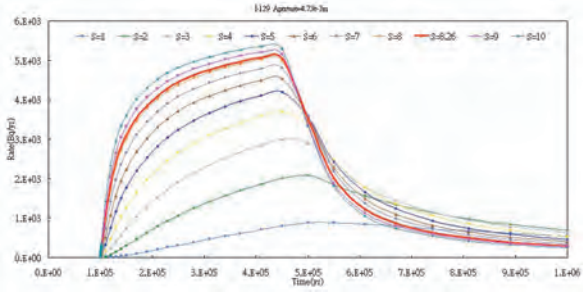
□ Development of an information system for performance and safety assessments

Tasks include completing system analysis of the spent fuel final disposal method, specifying specification and feasibility analysis of the related information system applying normalization technique for the entity model and the database, and accomplishing functional detail analysis and process flow design for database analysis and design, the query system and maintenance system.

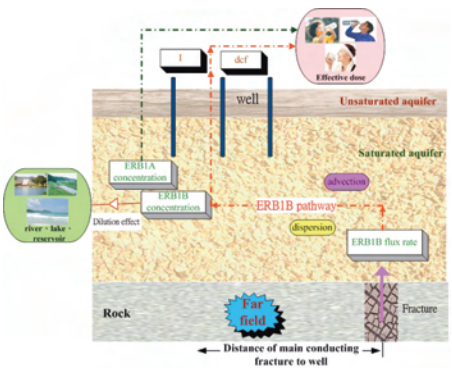
Research Team:
Ching-Tsuen Huang, Wen-Shou Chuang, Ching-Fang Shih, Fu-Lin Chang, Shin-Jon Ju, Ben-Li Pen, Ling-Cheng Liu, Li-Min Chi, Li-Hao Wu, Ching-Tu Chang, Jum-Ding Lu, Neng-Chuan Tien, Chin-Lung Chen, Chen-Chang Lee, Po-Lin Wu, Ming-Chuan Kuo, Ren-Jie Lai, Ke-Wei Yan, Ching-Chang Chang, Chih-Ming Ma, Tseng-Chin Fu, Cheng-Yi Chen, Yu-Pei Chen, Cong-Zhang Tong, Hsien-I Lin, Hong-Tai Lue, Shui-Ying Tseng, Shu-Ju Chen, Kuei-Hua Lee



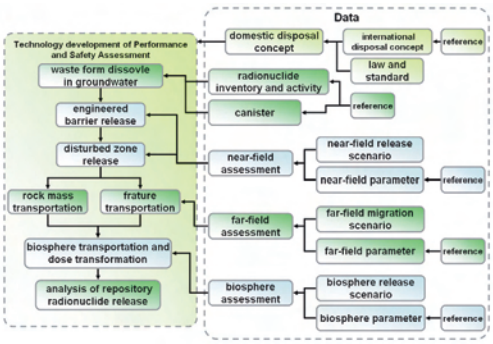
▲Conceptual model and nuclide release pathways in near field for disposal canister.



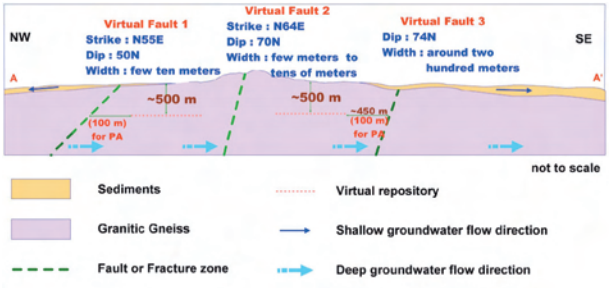
▲Release rate of I-129 for different spacing in far-field.



▲Conceptual model of radiation assessment of biosphere in a hypothetical site.



▲Final disposal system analysis for spent nuclear fuel.



▲Hydrogeologic model of a hypothetical repository.

Technology Development for Safety Assessment of Low-level Radioactive Waste Repository

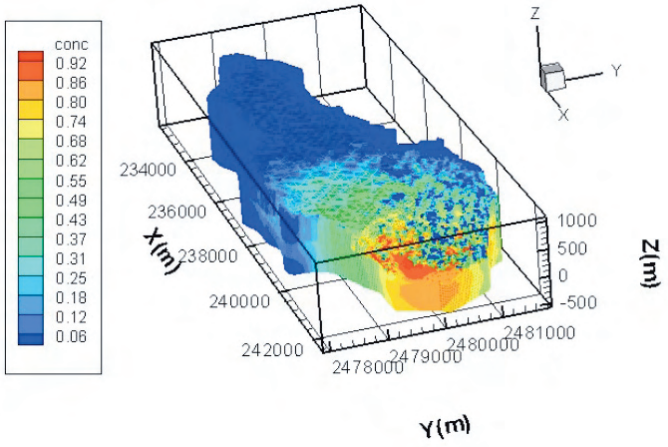
■Fu-Lin Chang

The Act for Establishing a Low-Level Radioactive Waste Final Disposal Site was promulgated on May 24, 2006. In accordance with the Act, INER continues it efforts in conducting R&D programs on safety assessment for low-level radioactive waste disposal.

During the year of 2006, probabilistic performance assessment models were constructed using software including HELP for infiltration calculation, FEHM for far-field nuclide transport calculation, AMBER for biosphere transport calculation, BLT-MS for near-field nuclide transport calculation, and GoldSim as a total system assessment platform. Preliminary performance assessment analyses were conducted for a near-surface disposal system and a mined cavern disposal system at two potential sites in Taiwan. Other R&D of INER includes the assessment of low-level radioactive waste characteristics, quantities, the development of waste acceptance criteria, and radiation monitoring at the potential disposal site, etc.

The overall R&D results can serve as references to benefit further activities, such as site selection, facility design, and license review. Substantial contribution in terms of enhancing repository safety, establishing realistic disposal scheduling and reaching overall project economy in the future are truthfully expected.

Research Team:
Ching-Tsuen Huang, Yih-Ping Chen, Chin-Chang Shen.



▲Result of 3D radionuclide transport simulation.

Studies on the Fabrication Technology of High Integrated Container for Radioactive Wastes

■Ching-Tsuen Huang

In order to enhance disposal safety of radwaste improve the volume efficiency of radwaste treatment as well as operational simplicity, a study on the fabrication of High Integrated Container (HIC) for radwastes was conducted at INER. The Container was designed to hold directly the radwastes that are under-qualified, hard-to-solidified or poor in solidification efficiency.

The lifetime of HIC must be at least 300 years. As a result, material selection and quality affirmation are particularly important. In addition to radwaste characteristics, environmental factors must also be considered in material selection. It has been known that HIC material comprises mainly of special alloys, such as the Ferralium 225 alloy reinforced concrete used by the Nuclear Packaging Co. of U.S., the Steel Fiber Polymer Impregnated Concrete (SFPIC) developed by the Chichibu cement Co. of Japan and the Steel Fiber Reinforced Concrete (SFRC) from the Sogifibre Co. of France.

The HIC material adopted in this study is the steel fiber reinforced concrete. In 2006, the concrete formulation was developed for the

construction of the HIC prototype. Several mechanical strength tests have been performed on the HIC prototype (Fig. 1) and the preliminary results are satisfactory.

In the follow-up study, we will continue to improve the HIC prototype by computer simulation for optimizing its mechanical strength. Evaluation on concrete durability as well as additional mechanical strength tests will also be carried out. Furthermore, the standard for concrete quality inspection will be established to serve as a reference for users or manufacturers in applying or reviewing HIC lifetime certification.

Research Team:
Ching-Tsuen Huang , Ching-Tu Chang, Yu-Pei Chen.

180^0

90^0

45^0

Development and Applications of New Energy Technologies

Chin-Jen Chang

Stable energy supply forms a strong support of a nation's economic growth. With less than 2% indigenous energy supplies and a low energy productivity comparing with those developed countries, the economic growth of our country will eventually face more and more rigorous challenges. Aside from that, the reduction of green house gas emissions has become a commitment of nations for the global environmental protection, but our carbon dioxide emission per capita has been long standing at higher value in the world. Recognizing the development and applications for both the technology of energy conservation and energy efficiency, and the technology of new and clean energy, are important aspects for benefiting our country's long term energy policy, the Environmental and Energy Technology Center of INER has been devoting in developing relevant technologies in recent years. During 2006, programs comprising research fields as wind energy, solar energy, biomass energy, fuel cell, nano-material, hydrogen storage, and clean coal technologies have performed. Ten out of these accomplishments are worthy of illustrating in this annual report. They are:

(1) The Development of High-concentration Photovoltaic Technology,
(2) The Technology Development for Cellulosic Ethanol,
(3) One kW Solid Oxide Fuel Cell Power Generation System,
(4) Field Emission Tests of the Carbon Nanotubes Applied to Excite the Fluorescent Thin Film Materials,
(5) Nanostructured SOFC Anode Fabricated by Plasma Spraying,
(6) Hydrogen Storage in Metal-Organic Frameworks (MOFs),
(7) The Current Status of DMFC Development at INER,
(8) Fabrication of a High Integrity Anode Substrate for Solid Oxide Fuel Cell - Membrane Electrode Assembly (SOFC-MEA),
(9) The Design of a High Efficiency 25-kW Commercial Wind Turbine, and
(10) Feasibility Study for the Development of Sustainable IGCC (SIGCC) Industry in Taiwan.

The Technological Development of the Concentration Solar Energy Power

■Hwa-Yun Shin

The concentration solar energy power system takes advantage of the concentration lens to focus sunlight onto a III-Vsolar cell with small size but high conversion efficiency. This technology reduces a large amount of quantities of solar cells being used, meeting the target of raising the efficiency and cutting down the cost. According to the analysis of U. S. Department of Energy, it indicates that the cost of III-Vconcentration solar energy power system can be 1US$/Wp as less as the cost of traditional power system. EMCORE reported in February of 2006 that the concentration solar energy power system will become one of the main streams of photovoltaic products for its high conversion efficiency comparing to silicon-based solar cells, and the market demand is up to 500MW in 2010.

On INER's research basis with successive efforts and continuous improvements, we accomplish the design and fabrication of InGaP/InGaAs/Ge triple-junction solar cell (TJSC) with conversion efficiency of 31%, and the manufacturing process of 4-inch TJSC with the highest yield above 80%. The triple-junction solar cells have been used in the 5kW concentration solar energy power system with 546x geometric concentration ratio and sunlight tracker system designed and made by domestic technology, The tracking accuracy is less than 0.5 degree. This pioneer system for the kW concentration solar energy power has been installed and exhibited at the side of INER building 013 in December of 2006. Furthermore, our HCPV team has developed a 1.2kW system with the module efficiency 22.45%, module highest output power 108W and system energy conversion efficiency 20.6% under 800W/m^2 DNI, in November of 2005.

Based on the results mentioned above, INER has applied 27 patents worldwide, and signed the contract of technology transfer with a domestic outstanding company for "the manufacturing process and measurement of the concentration InGaP/InGaAs/Ge TJSC". More than 20 large-scale

companies and research organizations came to the exhibition site of the 1.2kW concentration solar energy power system, and 8 companies had signed up the non-disclosed agreement last year. Currently, INER is discussing with industries interested in concentration module and sunlight tracking for technology transfer. and The work is anticipated to be conducted in 2007.

Research Team:
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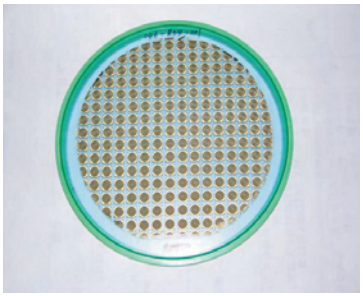
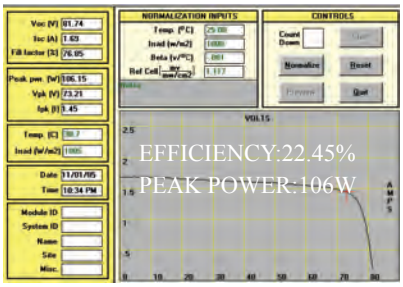
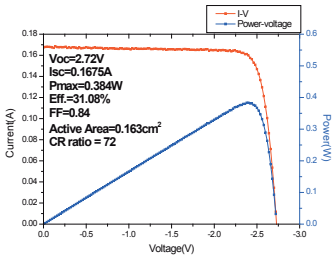


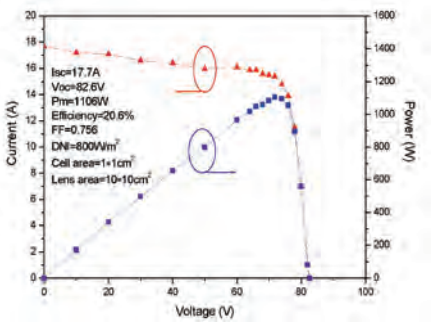
▲ Solar Cells on 4-inch Epi-wafer.



▲Module Efficiency of 1.2kW.



▲I-V Curve of the InGaP/InGaAs/Ge TJSC with Conversion Efficiency of 31%.



▲System Efficiency of 1.2kW.

▲5kW Concentration Solar Energy Power System.

▲Outdoors Experiment of Module with 546x Geometric Concentration Ratio.

Technology Development for Cellulosic Ethanol

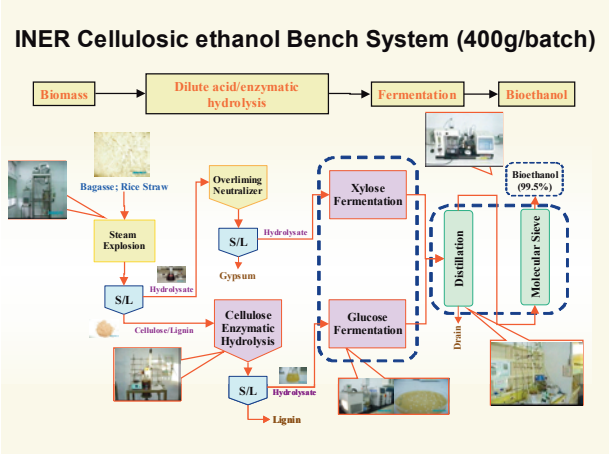
■Hsiao-Fang Pang

In recent years, countries of the world have started to produce biomass ethanol fuel as a long-term solution for international fuel and energy demands. The production technology of starch and sugar is pretty mature. However, considering the abundant supply of cellulose and avoiding consuming food production, countries have made large investments on the development and research of cellulosic ethanol technology to stand ahead. Hence, the Institute of Nuclear Energy Research (INER) has been aggressively working on the cellulosic ethanol technology in recent two years.

In 2006, we established a 400 g/batch cellulosic ethanol experiment system (Fig. 1), which was the first bench scale cellulosic ethanol research platform in Taiwan. The standard procedures of biomass composition analysis were also developed and applied to analyze the composition of biomass materials such as bagasse, rice straw, silvergrass, corn stover and sweet potato leaves. In this bench scale platform, we designed the pretreatment of dilute acid with steam explosion system (Fig. 2) using a high-temperature high-pressure reactor with a xylose conversion rate higher than 65%. We introduced cellulase from the Novozyme and Genencor and applied them in the cellulose hydrolysis of biomass materials like rice straw and bagasse. The hydrolysis efficiency obtained was higher than 60% with the enzyme loading in the range of 15-30 FPU/g cellulose. Besides, we established the optimal condition of glucose-fermenting strain, Saccharomyces cerevisiae, and xylose-fermenting strain, Candida shehatae, with respective ethanol conversion rates of 95% and 70%. These parameters from research results as mentioned above would be based for the design of another enlarged system. Furthermore, we cooperated with domestic universities to develop cellulose-to-ethanol technology. In addition to screen local cellulose- and polysaccharides-degrading microorganism, the joint research of cloning the genes that produce enzymes capable of digesting cellulose into the yeast chromosome by genetic engineering also plays a starting point for renewable energy research

and is anticipated to be a major scientific and technical development work in Taiwan.

Research Team:
Li-Fu Lin, Ming-Chao Kuo, Tai-Ming Chiu, Jia-Baau Wang, Men Lee-Chung, Wen-Song Hwang, Gia-Luen Guo, Wen-Hua Chen, Sheng-Hsin Chou, Chen Wen-Heng, Hwa-Jou Wei, Wei-Hsi Chen, Hsiao-Fang Pang.



▲Fig.1 400 g/batch cellulosic ethanol experiment system.

▲Fig.2 Steam explosion pretreatment unit.

1 kW Solid Oxide Fuel Cell Power Generation System

■Wei-Ping Huang

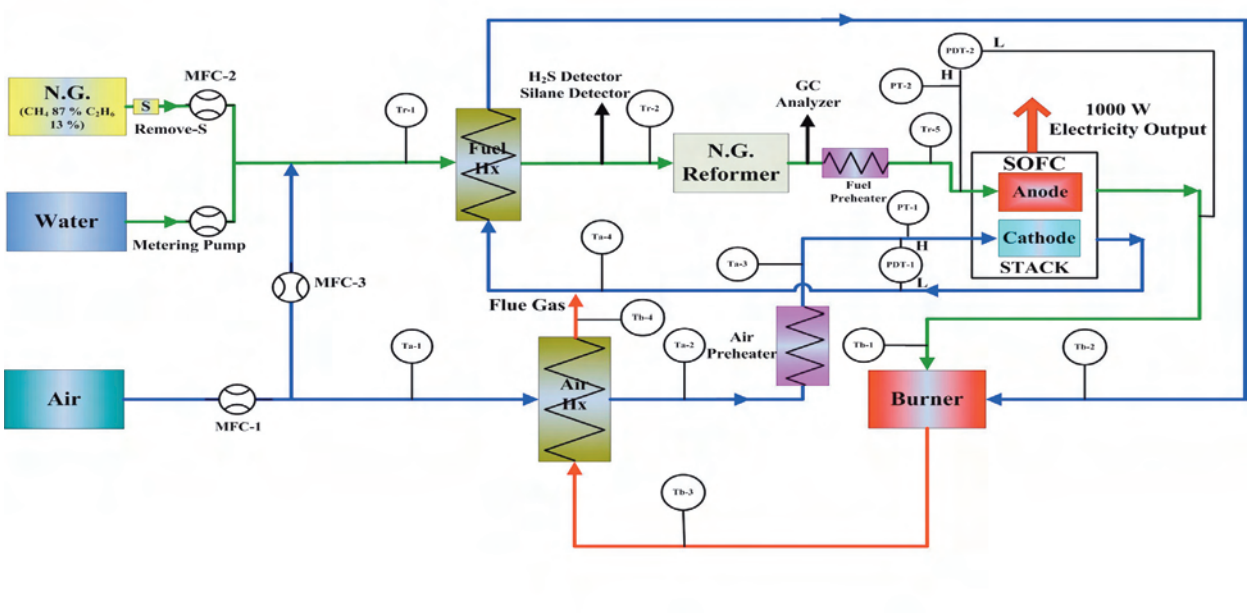
Globally, when fossil fuel is approaching depletion while the sensation of environmental protection keeps growing, development of new energy sources has become more urgent than ever before. The Solid Oxide Fuel Cell (SOFC) power generation system appears as a clean energy alternative, which is currently under competitive development among nations worldwide. The SOFC system, holding benefits of high energy conversion efficiency (40-60%), low emission of pollutant gases, multiple choices of supply fuels, makes possible the simultaneous achievement of domestic energy security, environmental protection and economical growth for the country. The SOFC system can either serve as a power base load nationwide, or independently supply for electricity demand in a community.

The main difference between SOFC and common batteries lies in the fact that a battery undergoes discharging till depletion, while SOFC keeps generating electricity if fuel continuously supplied.

The key component of a SOFC power generation system (Fig. 1) is a multi-cell stack, which is situated in an above 700 °C space and fueled with hydrogen gas, produced by a reformer from natural gas or biomass ethanol. Hydrogen and fresh air are blown separately on the anode and cathode sides of a cell respectively to generate electricity via electrochemical reactions through cell layers. The exhaust air, since still at high temperature, is introduced to heat up pre-reformed fuel, so to promote power efficiency. The exhaust fuel is directed to a sequential burner where it is mixed with the exhausted air and consumed, resulting in 1000 °C high temperature for further utilization. The low-voltage DC power generated from SOFC, after being modulated to 110/220 volt AC, can be coupled to the power grid for residential use.

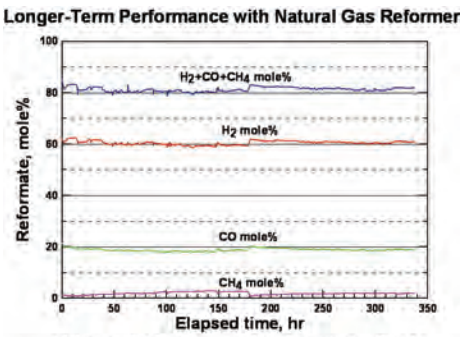
INER has devoted to R&D of the SOFC since 2003. In 2006, INER signed a cooperation contract with HTceramix Co. of Switzerland to build a primitive 1 kW SOFC power generation validation system (Fig. 2). This system utilizes a 1 kW planar type SOFC stack as the electricity generating unit and natural gas as fuel. For the time being, the functional test of the system with dummy stack is on going. The performance test of the natural gas reformer is shown as Fig.3 The system temperature control test is shown as Fig.4 It is projected a 720-hour continuous operation test can be finished in June 2007, initiating a new phase of alternative energy development in our country.

Research Team:
Chien-Hsiung Lee, Wei-Ping Huang, Wen-Tang Hong, Yu-Ching Tsai, Hung-Yu Wang, Tsye-Shing Lee, Dustin Lee, Ming-Dar Lin, Chen-Po Lai, Chung-Lin Lee, Shu-Ling Chiu.

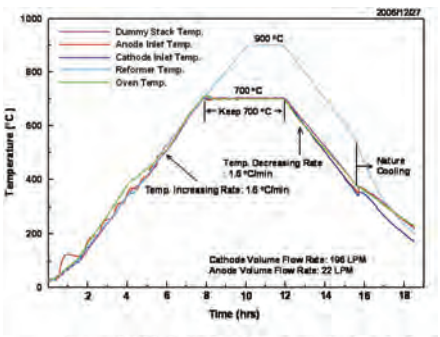


▲Fig.1 1kW SOFC bop fest flow diagram.

◀Fig.2 The 1kW SOFC power generation validation system at INER.



▲Fig.3 Reformer perormance test.



▲Fig.4 SOFC system temperature control.

Field Emission Tests of the Carbon Nanotubes Applied to Excite the Fluorescent Thin Film Materials

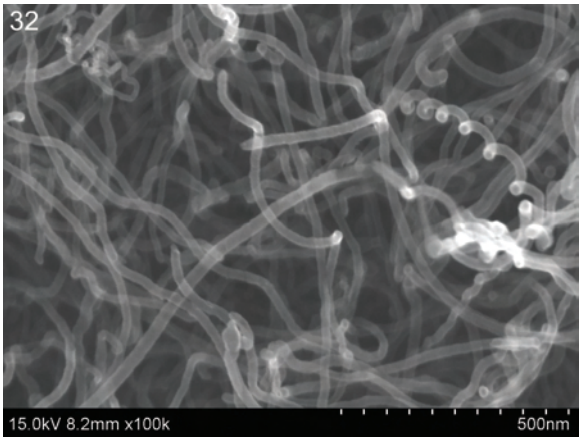
■Wei-Ping Huang

Since carbon nanotubes (CNTs) were first discovered by Dr. Iijima in 1991, its outstanding physical and chemical properties have attracted large number of attention, and opened a new technology on nanoscale materials. Due to its excellent field emission behavior, flat panel display and microelectronic devices would be the most promising applications of CNTs.

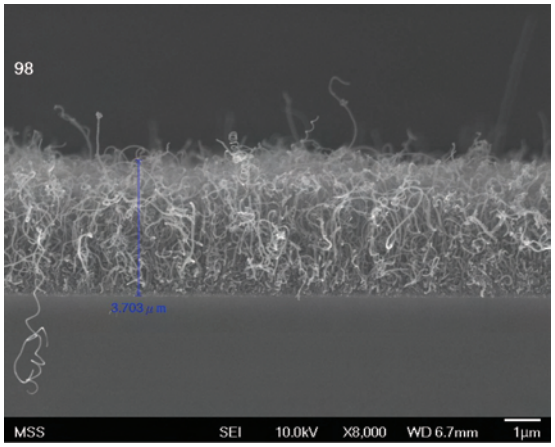
In this research, CNTs were synthesized in a home-made atmosphere pressure chemical vapor deposition (APCVD) system in INER. C_2H_2 and NH_3 were used as reaction gases, and Ti/Ni metal layers as catalysts. By varying experimental parameters such as gas flow rate, thickness of catalyst layer, and deposition temperature, random-orientated CNTs with a length of over 10 μm and a diameter of approximately 30 nm were synthesized on n-type silicon wafers at 800°C (Fig. 1). Furthermore, vertically-aligned CNTs were successfully synthesized by applying a strong external magnetic field during the deposition processes (Fig. 2). Field emission tests could be realized by using patterned CNTs made by semiconductor processes as electron emission cathode and white phosphors as anode. The results revealed that the electron emission began and the luminescence started under the threshold electric field of 8 V/μm (Fig. 3). As the electric field strength increased, the current density increased, that is, luminescence became more intense.

The preliminary results show that the CNTs are suitable excitation sources for exciting the fluorescent material. Combine the CNTs with the silicon quantum dots fluorescent thin films developed in INER, the fabrication of the CNTs flat lamps as shown in Fig. 4 is in progress.

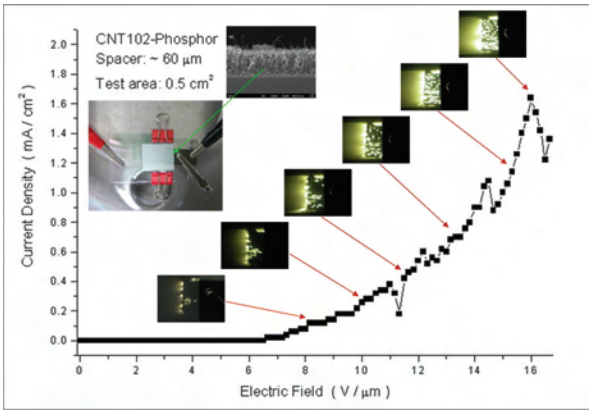
Research Team:
Tsun-Neng Yang, Shan-Ming Lan, Chien-Te Ku, Wei-Yang Ma, Chin-Chen Chiang.



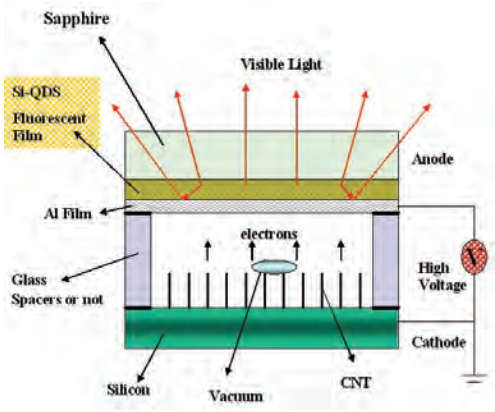
▲Fig.1 SEM images of the random-orientated CNTs fabricated in APCVD before applying magnetic field.



▲Fig.2 SEM images of the vertically-aligned CNTs fabricated in APCVD after applying magnetic field.



▲Fig.3 Field emission tests of the CNTs.



▲Fig.4 Schematic representation of the CNTs flat lamp.

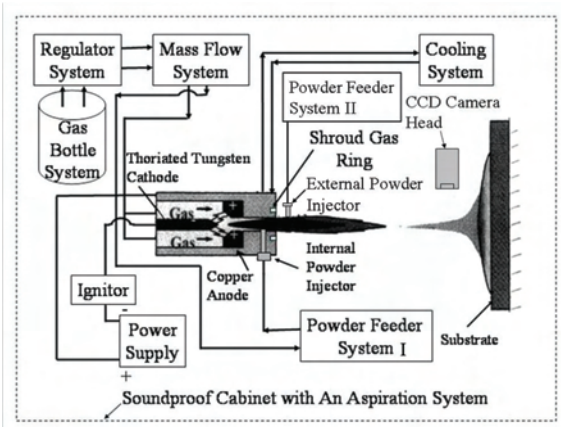
Nano-structured SOFC Anode Fabricated by Plasma Spraying

■Chang-Sing Hwang

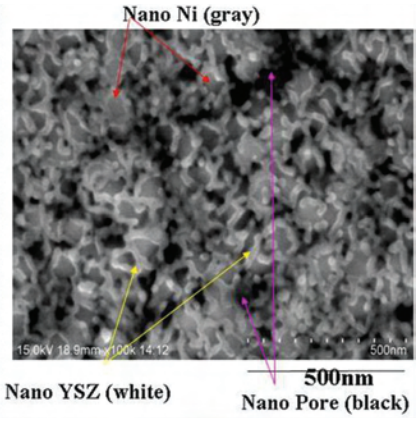
This study is to fabricate a nano-structured SOFC anode cermet film with nano-pore channels on a porous Ni support substrate by atmospheric plasma spraying (APS). The typical thickness of this anode is about 30 μm. Agglomerated powders with a composition of 8 mol% yttria-stabilized zirconia nano-powders, black NiO nano-powders and a PVA (Polyvinyl Alcohol) organic binder are injected into the high temperature plasma flame of DC plasma torch by powder feeders as shown in Fig.1 The organic

binder will be burn out quickly and agglomerates will be rapidly dissolved into original nano-powders. Part of these nano-powders is accelerated and heated up quickly by the high temperature plasma flame into a semi-molten or molten state and quenched shortly on hitting the substrate to form YSZ/NiO film. The speed of the X-Y table can be adjusted to get the required thickness. The YSZ/NiO film is reduced to YSZ/Ni film in an atmosphere of 7% hydrogen and 93% argon at about 800 °C for 4 hours. Fig.2 shows the SEM surface morphology of porous nano-structured YSZ/Ni film in a higher magnification. Fig.3 shows the SEM sectional image of YSZ/Ni film. It is clear that nano-gas channels are produced in the YSZ/Ni film. These nano-gas channels are used to propagate hydrogen gas and water steam. Furthermore, the electronic conductivity comparison between a micro-structured YSZ/Ni film prepared by tape casting technology and a nano-structured YSZ/Ni film prepared by plasma spray technology is given in Fig.4 Nano-structured YSZ/Ni film has a higher electronic conductivity due to the better connection among nano Ni particles and provides significantly larger triple-phase boundaries for hydrogen oxidation reaction. Fig.5 is the I-V curve obtained from a Φ24mm in diameter button cell that adopted this nano-structured YSZ/Ni as anode, YSZ as electrolyte and LSCo/GDC as cathode. It can produce 160mW/cm^2 at 800°C.

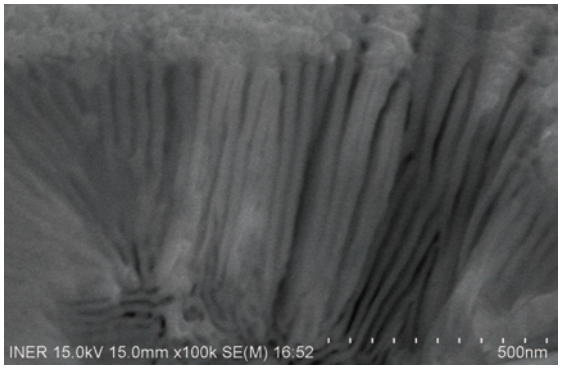
Research Team:
Chang-Sing Hwang, Chih-Hung Lo, Chun-Huang Tsai, Jong-Sheng Chen.



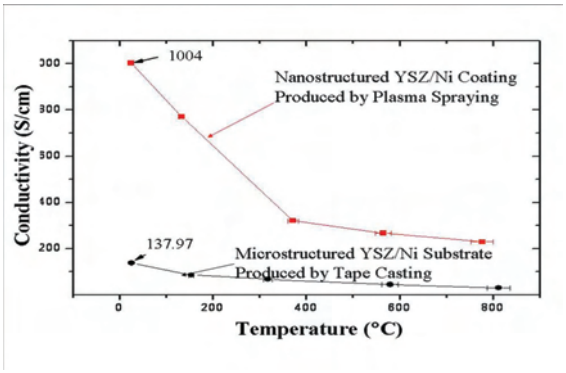
▲Fig.1 Schematic drawing of atmospheric plasmaspray system.



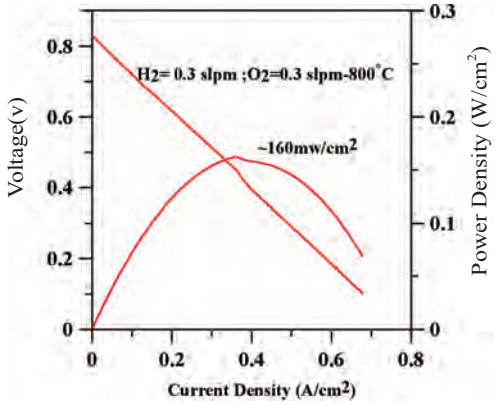
▲Fig.2 SEM observed surface morphology of nanostructured YSZ/Ni anode.



▲Fig.3 Cross section views of nano gas channels in the nanostructured YSZ/Ni coating.



▲Fig.4 Measured conductivity results for nanostructured YSZ/Ni coating and microstructured YSZ/Ni substrates.



▲Fig.5 I-Vcurve of 24mm indiameter button cell(YSZ/Ni-YSZ-LSCo/GDC)

Hydrogen Storage in Metal-Organic Frameworks (MOFs)

■Ming-Sheng Yu

Development of efficient, safe, and cost-effective hydrogen storage technologies with greater than 6.5 wt% are required if hydrogen is to become a viable energy carrier for vehicular hydrogen storage system. Nanostructured materials, such as metal-organic frameworks (MOF), that have uniform nanopores and sufficiently large surface area, are regarded as promising materials for hydrogen storage. However, the storage capabilities of these materials remain unclear and need more effort to understand factors governing their performance.

Structural characteristics of IRMOF-1 (Iso-reticular Metal-Organic

Framework-1) were studied by using samples synthesized at fixed reaction temperature in a refluxing system but with various cooling rates. The structural features such as BET specific surface area, Langmuir specific surface area, micropore volume were investigated by nitrogen adsorption at the temperature of -196°C. The degree of crystallinity and the variations of morphology of synthetic materials were studied by X-ray diffractometer and SEM, respectively. Hydrogen storage capacities were measured by using High Pressure Thermal-gravimetric Analyzer (HPTGA). The correlation between structural characteristics of products and synthetic cooling rates was explored. In general, the higher the cooling rate, the purer the synthetic IRMOF-1 and the higher capacity of hydrogen uptake. However, there are some exceptions in some cases. The primary reason is due to the appearance of another new phase and the possible pore coalescence during synthetic process while cooling rates are lesser than 0.2 ^{0}C/min. Besides, the maximum hydrogen uptake of IRMOF-1 with cooling rate higher than 0.5 ^{0}C/min can reach 0.295 wt% at room temperature with hydrogen pressure of 6.9 MPa. However, subsequent work involving Pt/AC catalysts and carbonized bridges with an IRMOF receptor and glucose increased the spillover of hydrogen to ~3.3 wt% at room temperature and 7.5 MPa.

Research Team:
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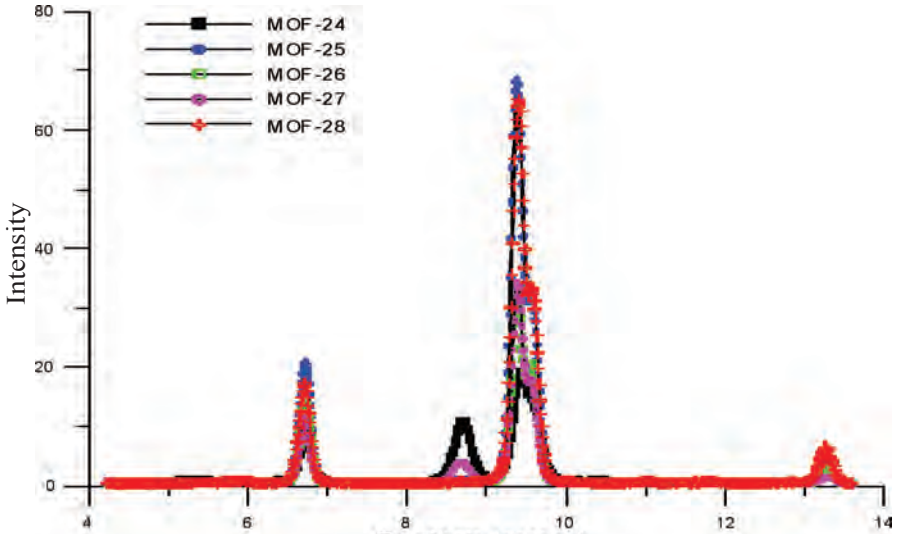

Figure shows the XRD patterns obtained by using K x-ray of Cu target for various IRMOF-1 synthesize at the same reaction temperature but with various cooling rates; MOF-24 cooling rate is 0.2^{0}C/min, MOF-25 is 0.5^{0}C/min, MOF-26 is 0.1^{0}C/min, MOF-27 is 0.05^{0}C/min and MOF-28 is larger than 5^{0}C/min.

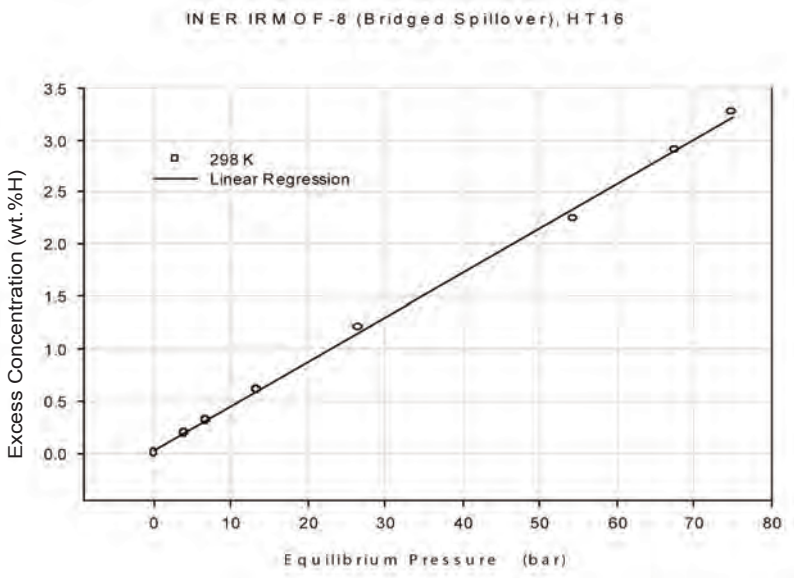

Figure shows the variation of hydrogen adsorption capacity for IRMOF-1/ Pt/AC /Glucose sample, while hydrogen pressure increases from atmosphere to 7.5 Mpa by utilizing HPTGA system. The result indicates that the maximum hydrogen uptake can reach 3.3 wt% at RT with pressure 7.5 Mpa, as current IRMOF sample after the treatment of bridge-building.

DMFC for Applications in the 3C Power System

■Charn-Ying Chen

Fuel Cell systems offer the potential for clean and reliable energy generation used for power stations, road transportations and portable power supply units. Among various kinds of fuel cells, the Direct Methanol Fuel Cell (DMFC) operates at low operation temperature (RT-80^{0}C), and uses methanol as the fuel which is a liquid and is thus easier for fuel storage and transport than hydrogen. Compared to Li-ion battery, DMFC exhibits higher energy density and is considered to be a suitable power source for longer operation of personal electronic devices such as Notebook , PDA or Cellular phone. The aim of INER DMFC program is to develop a DMFC system with improved power density, reduced size and lower cost for portable applications.

The Membrane Electrode Assembly (MEA) is the key component of DMFC. INER has developed innovative Pt-Ru and Pt-Ru-Ir catalysts for MEA applications using carbon nanotubes as the carrier. The home-mode MEAs manifest a power density of 110mW/cm^2 (80^{0}C, 1M MeOH) and have been under durability test for 1,200 hrs with no appreciable voltage drop at a constant current. A 25-cell DMFC stack with a single MEA of 25 cm^2 active area is also successfully fabricated in-house, the power of this stack can reach up to 44W at 70^{0}C in the air mode.

In addition, a prototype DMFC system of 20/25W is developed for use as a power source for Notebook. A methanol sensorless control technique is applied in this system which can run for 8 hrs with 200c.c. 100wt% neat methanol. The energy density of 72 hr mission of this system is estimated to be 335 Wh/L (362Wh/kg), which is greater than that of Li-ion battery of 250Wh/L (150Wh/kg). Furthermore, the volume and weight of the system are only 2.4L and 2.2 kg, respectively. Currently, INER has demonstrated this system in 2006 Fuel Cell Seminar. Also, INER is collaborated with a number of industry partners for technology transfer.

Research Team:
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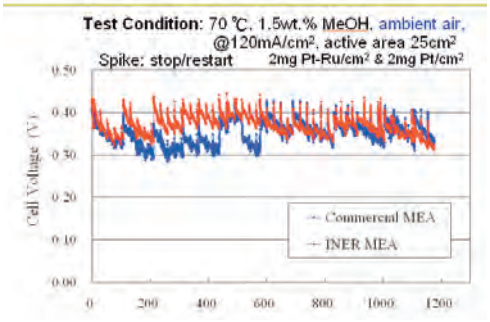
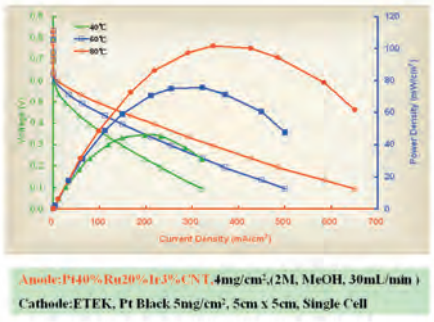


▲MEA durability test for 1,200 hrs.



▲Carbon nanotubes of catalyst with lower Pt content and better electrochemical performance.

▲20/25W DMFC prototype systems for notebook application.

Fabrication of A High Integrity Anode Substrate for Solid Oxide Fuel Cell-Membrane Electrode Assembly (SOFC-MEA)

■Maw-Chmain Lee

INER initiated the project of SOFC development in the year 2003. Both software and hardware capacities, as well as technologies in the regard are established step by step. The SOFC is an energy conversion device that produces electricity by electrochemical combination of a fuel and an oxidant across an oxide electrolyte. The attractiveness of the SOFC is its clean and efficient power generation from a variety of fuels. The planer type SOFC with Anode Supported Cell (ASC) is selected for operation at temperature range of 650-850°C. Key materials for Anode, electrolyte, and cathode are NiO+8YSZ, 8YSZ / GDC, and LSM / LSCF, respectively. Both anode and electrolyte substrates (dimensions: 10x10cm^2; thickness: 150~1200μm) are mainly fabricated either via tape casting or innovative processes. The screen printer, plasma spray, sputtering coating, and spin coating techniques are alternatively employed to fabricate SOFC-MEA in the sequential steps for product orientation. The nano-scale powders of YSZ are processed and applied for fabrication of SOFC-MEA with thin and dense film of electrolyte to achieve the target of high power density. The sophisticated technology for fabrication of high integrity anode substrate for solid oxide fuel cell-membrane electrode assembly (SOFC-MEA) is briefly described as the following process.

Step I: Preparation of well homogeneous powders (either electrolyte or electrode materials) via homogenizer (e.g. ball mills / blenders, etc.) to obtain the powders with specific properties.

Step II: Preparation of the slip slurry for tape casting system. Key materials include powders, pore former, solvents, dispersants, plasticizers, and binders. The recipe for slurry preparation is critical and confidential for each manufacturer.

Step III: Preparation of green tape of the desired substrate using tape casting equipment. The thickness of green tape is generally in

the range of 20 to 300 μm.

Step IV: Manipulation of the green tape to obtain the green substrates with desired dimension (i.e. thickness, size) and shape. The tape casting carrier / substrate (e.g. Mylar) is separated from the green tape at this step. The green substrate consists of many layers of single green tape.

Step V: Lamination of the green substrate via laminator system to obtain a well fused / integrated / gas free green substrate.

Step VI: Sintering of the green substrate to obtain the ceramic membrane of an anode substrate.

Step VII: Addition of the desired materials (e.g. the cathode / electrolyte layers onto the anode substrate) onto the ceramic substrate via screen printer to obtain the complete MEA. Spray coating / sputtering / dip coating technologies are alternative ways for this process.

Step VIII: Sintering of the complete MEA to obtain the final product of SOFC-MEA for performance test.

The INER's anode substrate (See Figs) owns characteristics of high mechanical strength/flatness, suitable porosity, and high thermal stability, those are critical properties required for production of SOFC-MEA. The power density of INER-SOFC-MEA is over 100mW/cm^2 at this stage.

Research Team:
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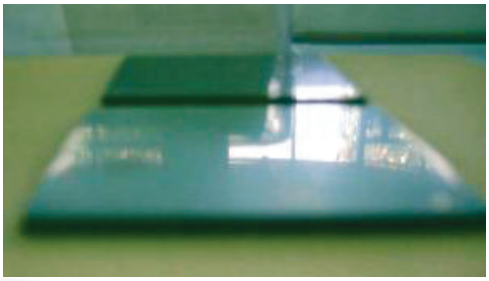
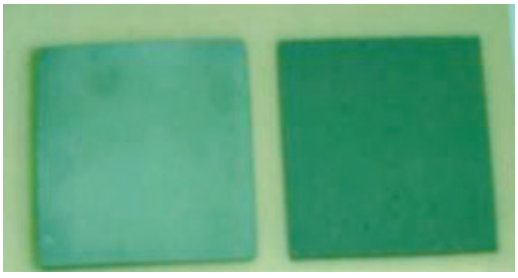


▲a.INER-SOFC-Anode Substrate (5×5 cm^2) (High Flatness).

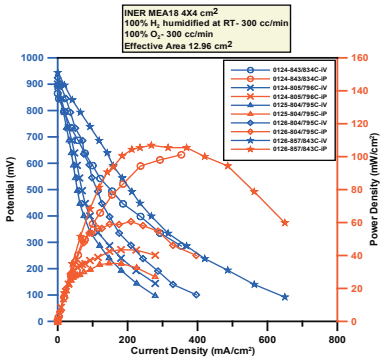


▲b. INER-SOFC-Anode Substrate (5×5 cm^2) (High Mechanical Strength).

▲c. INER-SOFC-Anode Substrate(10×10 cm^2) (High Mechanical Strength).

▲d.INER-SOFC-Anode Substrate (10×10 cm^2) (High Flatness).

▲e. INER-SOFC-MEA (5×5 cm^2).



▲f. Power performance of INER-SOFC-MEA (Prototype).

Figs. Anode substrate and INER-SOFC-MEA.

The Design of a High Efficiency 25 kW Commercial Wind Turbine

■Chin-Jen Chang

The Institute of Nuclear Energy Research has developed and installed a 25 kW experimental wind turbine (WT) in 2005. The blade radius of this WT is about 6.26 meters. Similar to control systems used on most large size WT, it is equipped with blade pitch control, active yaw control, and brake control. The system has undergone one year field test and remarkable improvements on hardware as well as software have been made. Fig.1 shows a typical on-line monitoring performance data and the power curves measured with respect to different pitching angle. Valuable insights gained from daily operation and routine maintenances make the research team capable of designing a high efficiency 25 kW commercial WT.

The 25 kW commercial WT adopts passive control concepts to avoid complex active controls with driving motors and sophisticated control circuits. Furthermore, considering the annual average wind speed in most area in Taiwan is below 10 m/s, the targeting rated power wind speed is designed to be less than 10 m/s. Several important design features (Fig.2) include: (1) 7m long wind blades with fixed pitch configuration, blade solidity 11%, blade root twisted 31°, 4m/s cut-in speed, winglet device at blade tip,

and overall efficiency of 44%; (2) a customized high efficiency (>92%) low speed generator (300rpm) with 1:5 gear connecting with the main shaft；(3) a passive tail vane to control yaw direction and with automatic furling features for over speed protection; (4) an active disk break system for redundant over speed protection and for emergency shutdown as well. This new 25 kW WT is designed with great improvement in efficiency and is design to be fitted for low rated wind speed area to extract its most useful wind power (Figure 3). The only active control system used is the brake control system. In over all, this proposed wind power system is efficient in generating electric power and is believed to be competitive in terms of fabrication and maintenance costs.

Research Team:
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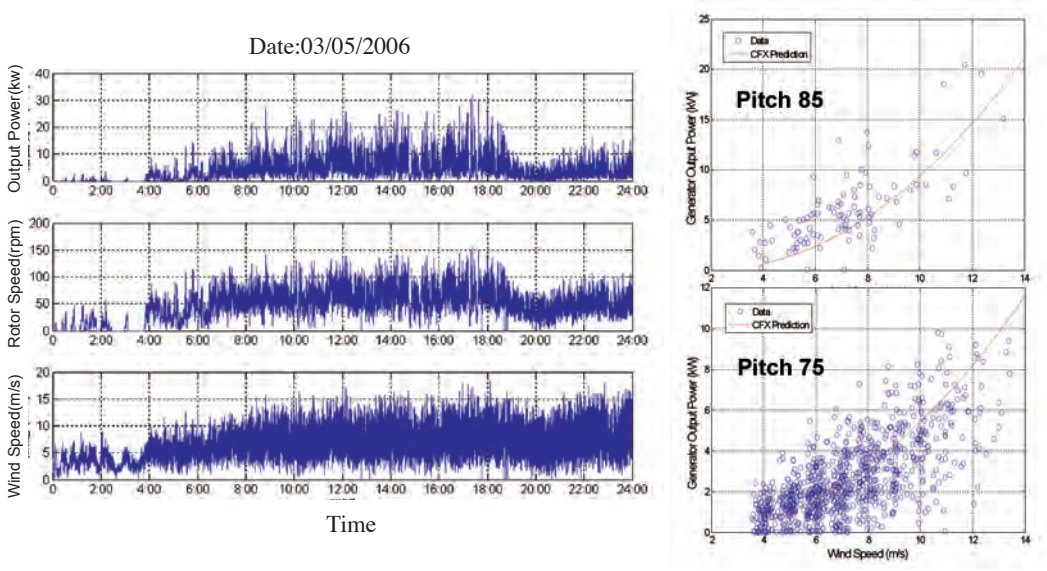
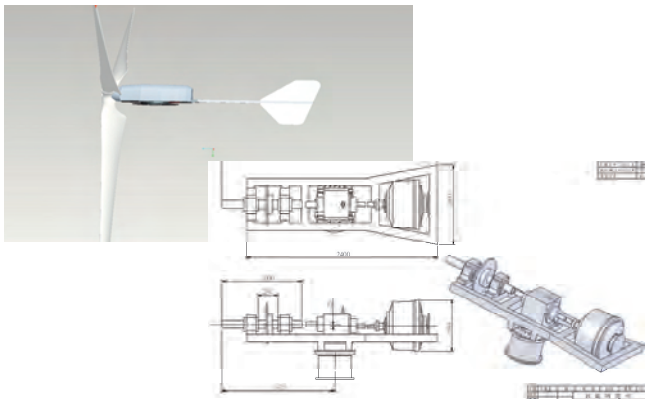
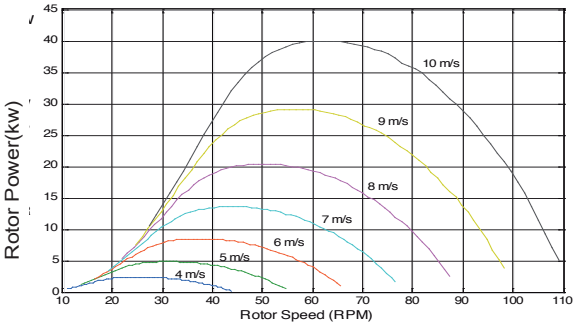


▲Fig.1 The field test data of INER 25kW experimental wind turbine.



▲Fig.2 The exterior and interior view of the INER high efficiency 25 kW commercial wind turbine.



▲Fig.3 The power curve of the INER high efficiency 25 kW commercial wind turbine.

Feasibility Study for the Development of Sustainable IGCC (SIGCC) Industry in Taiwan

■Yan-Pin Chyou

The shortage and substantial increase of petroleum and natural gas prices lately have speeded up the world to look for an alternative source of new energy. Despite to be a conventional fossil fuel, coal with its abundant reserve as well as stable in price and supply becomes an immediate and the most possible choice to reduce and replace the consumption of oil. Integrated gasification combined cycle (IGCC) producing electricity from syngas, which is gasified from coal, not only serves as a power station but also can provide chemical feedstok such as CO and H_2. More importantly, IGCC has fundamental advantages in environment with inherently lower emissions of NO_x, SO_2, and Hg, and highly potential in reduction and capture the greenhouse gas such as carbon dioxide. In addition, the flexibility of utilizing various fuel (such as using coal, biomass, petcoke, and waste etc) is an important feature of IGCC, which will enhance the long-term energy security in Taiwan.

IGCC system has four main units, i.e. air separation, gasification, gas clean-up, and combined cycle. Fig.1 shows the conceptually schematic diagram of sustainable IGCC (SIGCC) that integrates CO_2 capture and

storage (CCS). The SIGCC team in INER has been conducting the present feasibility study since 2006. The project reviewed the present and future development of SIGCC technology, accessed capability of indigenous industry to manufacture the key components of SIGCC and analyzed the domestic electricity market. Since the reduction of CO_2 emissions is an essential issue in power generation industry as concerning the global warming, the team also studied CCS, the emissions trading mechanism and CO_2 tax. Besides, to understand economic benefit obtained from local manufacturers, 3E analysis were also performed.

It is found that in consideration of energy supply security, high efficiency of CO_2 capture, and potential of zero emission, SIGCC is a necessary choice for base-load power station and for the replacement of the current power plants using pulverized coal, natural gas, or oil. Moreover, with water shit process to provide hydrogen, SIGCC can not be ignored in the future generation of hydrogen economy. The CO_2 captured can be re-utilized for ocean farming and stored in saline aquifer layer or deep ocean, according to the geography of Taiwan island. Nevertheless, to establish the ability of local manufacturing of SIGCC plants, government has to formulate long-term strategy and policy to invest in research and development and encourage industries to involve in the project through financial support. It is estimated about 0.8 GW electricity growth of IGCC/SIGCC in Taiwan, accumulating a capacity more than 25 GW by 2050.

A technology road map is proposed as depicted in Fig.2 The sequence to develop and build IGCC is laboratory experiments, pilot plant testing, and demonstration plant operation. Further advanced plants will include CCS and integrate with plasma gasification and fuel cell, which are present research projects in INER, to achieve the a thermal efficiency higher than 50%. The advanced system integration with high efficiency is very competitive to any other advanced coal-fired power plants and keeps the least environmental impact.

Research Team:
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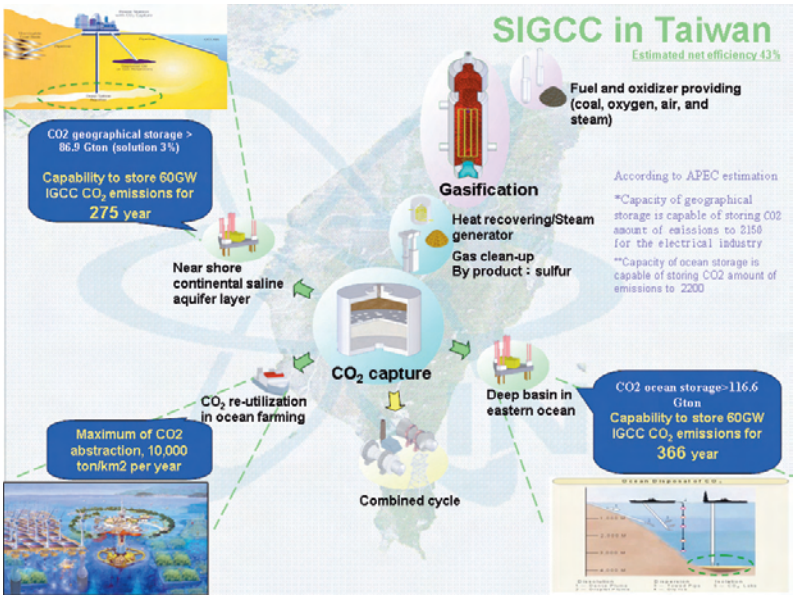
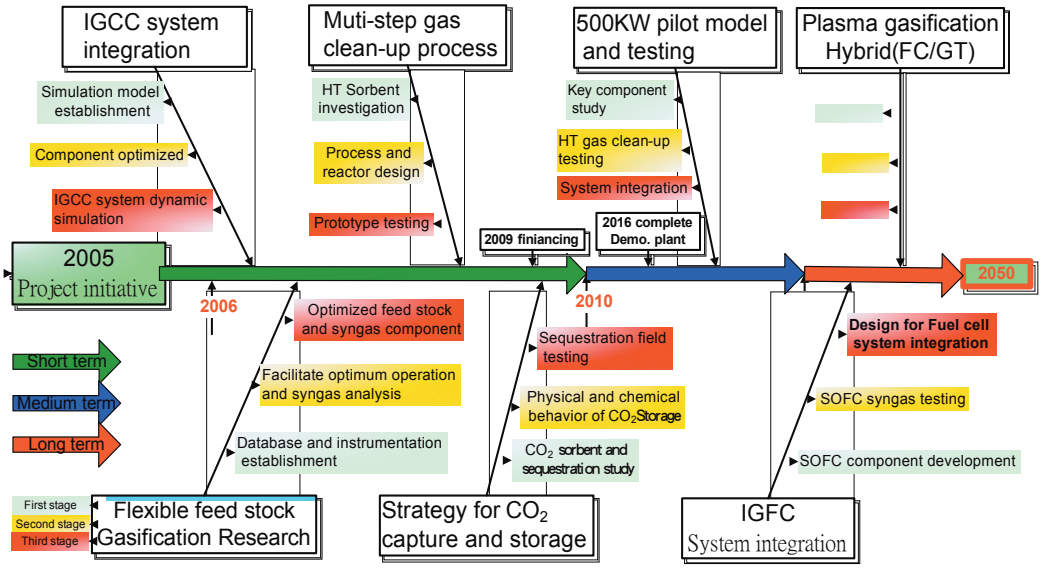


▲Fig.1 Conceptual diagram of SIGCC developed in Taiwan.



▲Fig. 2 Technology road map of SIGCC.

Development and Applications of Environmental Plasma Technologies

■Shiaw-Huei Chen

The awakening of global ecological consciousness recently has shifted the policy of environmental protection gradually from the tube-end treatment, such as pollution control, waste treatment etc. to the sustainable development with the goal of zero-waste for processing, such as clean production, resource recycling and reuse etc. For an island country like Taiwan with problems of over-crowded population and dense industrialization, environmental pollution has been an issue of grave concern. Based on the green concept for sustainable development, the INER has focused on developing advanced environmental technologies to solve the above problems and, as a result, various types of environmental plasma have been studied and applied successfully. For plasma melting technique, the low-level radwaste plasma processing plant had passed the requirements of radioactive test runs and is expecting to be granted the operational permit in early 2007; reutilization of plasma molten slag has been explored to add the overall economic values; clean plasma processes and equipments have been developed to help with renovating the traditional surface coating industries while new plasma surface modification research is started on biomaterials and solar panels. Furthermore in response to the coming oil-shortage era, besides developing plasma fuel reforming technique improving vehicle's engine efficiency as well as exhaust pollutants, INER started a new energy program combining merits of melting, gasification and electricity generation and converting waste into useful materials and energy resource.

The main achievements of 2006 research and development in the three areas of plasma melting and waste reutilization, plasma gasification and fuel reforming, and plasma surface modification will be described by the following seven items:

Preliminary Research on Plasma Gasification of Biomass Wastes

■Heng-Yi Li

Biomass energy as well as waste energy is of great attention worldwide nowadays. Therefore, Institute of Nuclear Energy Research (INER) is actively developing plasma gasification for conversion of biomass as well as organic solid wastes into syngas ($CO+H_2$). The syngas not only can be used as a clean fuel for electricity generation but also a potential candidate for the synthesis of economical chemicals, as illustrated in figure 1. A lab-scale plasma gasifier, see figure 2, had been constructed and tested in July 2006. Currently, a pilot-scale plasma gasification plant is under construction and scheduled to be completed in the end of 2007.

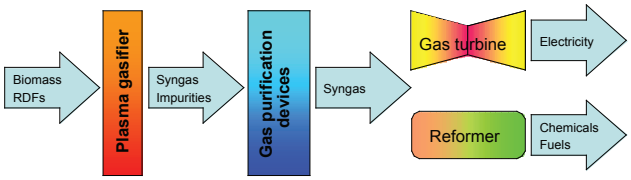
The producer gas from typical gasifier contains not only syngas but also impurities such as tars, CO_2, H_2O, HCl, H_2S, NH_3, COS, and particulate matters (PMs). Tar is generally a kittle problem to traditional gasifiers. To ease this problem, INER develops a novel plasma steam torch as a tar cracker that can generates chemically active species to react with the tar and decompose it quickly. The steam plasma torch not only cleans tar but also produces additional H_2 from steam.

INER, at present time, pays attention to five kinds of biomass including the flood woods, woods from building waste (civil-wood), algae, the refuse-derived fuel (RDF), and the pulverized coals. A one-dimensional steady-state model of a fixed-bed gasifier has been successfully developed for the purposes of the selection of potential biomass, the understanding of speciation of producing gas, and the determination of appropriate oxidant doses needed. In this model, the gasifier is divided into two regions, i.e., gasification/combustion and reduction/pyrolysis regions. Simulation results of this model agree well with other models as well as experimental data by other investigators. The optimum temperature can be determined by the simulation results. The syngas quality, the speciation of undesired products, and the operational parameters can be predicted. Simulation results can also provide, e.g. in figure 3, the proper $[O_2]$/[biomass] molar ratio and $[H_2O]$/[biomass]

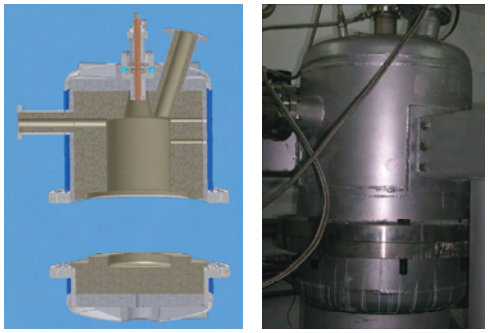
molar ratio. The sunflower oil cake was gasified by nitrogen plasma using the new constructed lab-scaled plasma gasifier, and the experimental result is shown in figure 4 which shows the best gasification effect is obtained at 973°K where CO and H_2 have instantaneous maximum volume concentration of 51.17% and 48.65%.

In the pilot-scale plasma gasification plant, series of gas purification devices such as caustic scrubber, alkaline scrubber, and amine scrubber are installed in downstream of the plasma gasifier to clean syngas. The concentrations of NH_3, NOx, H_2S, SOx, HCl, and PMs are expected to be less than 10 ppm with the assistance of the gas cleaning devices. Four 30 kW micro-turbines are to be installed for the purpose of electric power generation.

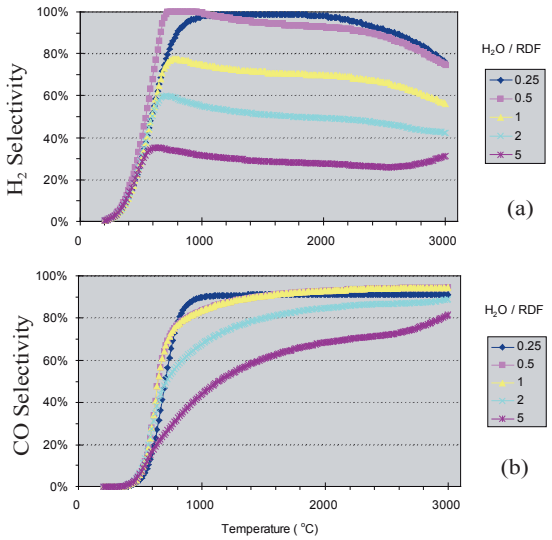
Research Team:
Heng-Yi Li, How-Ming Lee, Chin-Ching Tzeng, Ching-Liang Chen.



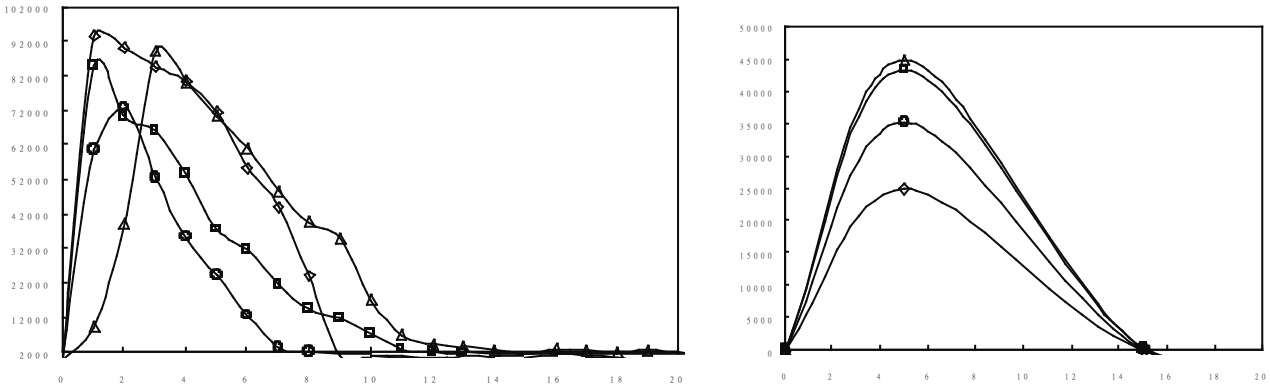
▲ Fig. 1 Schematic of INER's biomass plasma gasification plant.



▲ Fig. 2 Illustration of INER's lab-scale plasma gesfier.



▲ Fig. 3 Simulation of refuse-derived fuel (RDF) gasification. H_2 selectivity (a) and CO selectivity (b) as a function of temperature for selected H_2O/RDF ratios.



▲ Fig. 4 Instantaneous concentrations of CO, H_2 from the pyrolysis of sunflower-oil cake using nitrogen plasma torch at 873, 973, 1073, 1173°K (◇, △, □, ○) vs. t_{rsf}: ∶ (a) CO,(b) H_2.

Development of High-Power DC Steam Plasma Torch

■Deng-Lain Lin

Research and applications of high power plasma torch is a main research project at the INER. For the use of energy transformation from organic gasification a high power DC steam plasma torch have been developed. With steam as the working gas of plasma torch, part of the water molecules are dissociated into chemically active species such as hydrogen atoms, oxygen atoms, and OH radicals. These chemically active species can react with and then decompose quickly the organic compounds. INER have completed the design, manufacturing and assembly for the 600kW non-transferred DC steam plasma torch in 2006, see Fig.1. In order to gain optimal control and operation this torch have been installed inside a high-power testing chamber and tested, see Fig.2, prior to normal operation.

Enhancement of lifetime and thermal efficiency are of vital importance for the application of high-power plasma torch. In order to increase the lifetime of torch, INER has established a plasma diagnostics apparatus employing Alexandrite spectropyrometer. It measures the spectral power distribution of a radiating body through the Alexandrite filter and then calculates the

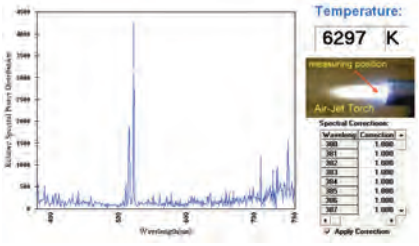
measuring temperature of plasma flame in real-time. (Fig.3)

In 2006, INER have also built a high-speed CMOS video camera diagnostic system to analyze the operational state of plasma torch by making successive shots of transient flame images, see Fig.4. The patterns of jet flow and flame shape are closely related to the structure of plasma torch and operational condition. From the dynamic variation of flames, the characteristics of plasma torch can be obtained while the plasma torch operates. Helpful information can be deduced to increase both the thermal efficiency of plasma torch and plasma torch's lifetime. In addition, future works will be focused on obtaining electric current, voltage signals from plasma torch and detecting physical phenomena such as initiated sound wave, and vibration, in order to study the changes or fluctuations in frequency domain while the plasma torch is in operation.

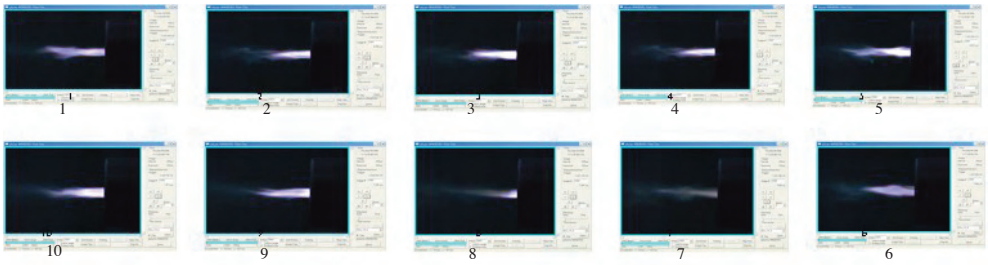
Research Team:
Lin-Lain Deng, Peir-Jyh Wang, Jih-Shan Tang, Shih-Wen Huang, Chen-Yuan Hsu, Jong-Sheng Chen, Chin-Ching Tzeng.

▲Fig. 1 600kW non-transferred DC steam plasma torch.

▲Fig. 2 DC steam plasma torch in test.



▲Fig. 3 Temperature measurement for 20 kW plasma torch with air as plasma gas.



▲Fig. 4 Torch flame in successive transient images using CMOS high-speed video camera system.

Low-level Radioactive Waste Plasma Processing Plant

■Ching-Liang Chen

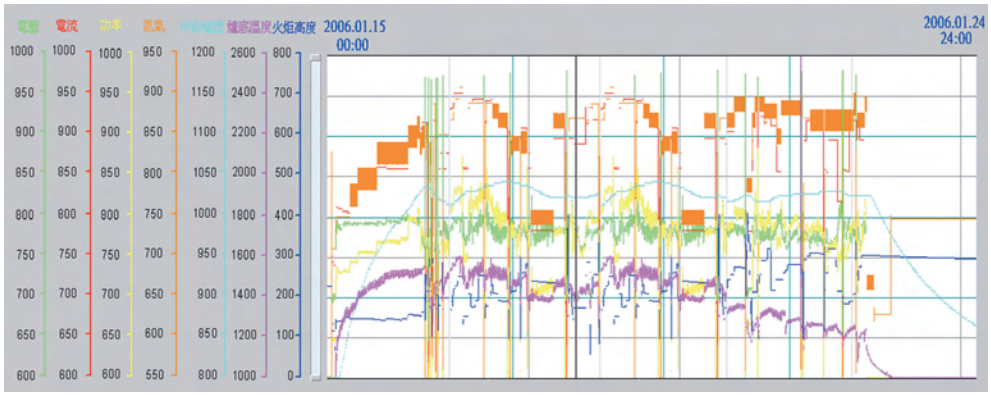
Plasma melting technology gradually becomes important and popular for treatment of the low-level radioactive wastes (LLRW) and hazardous wastes in recent years. A plasma processing plant of 250 kg/h for treating LLRW was established in late 2001 at Institute of Nuclear Energy Research (INER). After four years of system performance test and cold test with surrogates, hot radioactive test with actual radwastes commenced in early December 2005 and ended in late February 2006. Subsequently, the requisite documents including the safety analysis report, operation standard, test run report, and emergency plan were prepared for operation permitting from the regulatory authority. The review process conducted by the authority has been undergoing and the licensing of the plasma processing plant is expected in early 2007.

In the radioactive test, six different kinds of radwastes were melted including the cementitious solidified waste drums from Taipower's nuclear plants as well as radioactive incinerator ash, contaminated soil, contaminated cement block, compacted HEPA filter, and spent insulation material from

INER etc. All of the system functions demanded in the safety analysis report and operation standard were successfully demonstrated. It was also verified that test results were in accordance with the regulatory requirements of the environmental protection and radiation protection. Compressive strength of the lava-like slag from the plasma melter was in the range of 470 ~ 3,500 kg/cm^2, which is far above the regulatory limit of 15 kg/cm^2. Leaching indices of various nuclides range from 8.9 to 17.5, where the index values of Cs and Co were 8.9 and 11.8, which are also superior to the regulatory limit of 6.

Research Team:
Ching-Liang Chen, Jenn-Tsang Uen, Wen-Cheng Lee, Maw-Suey Kuo, Chin-Ching Tzeng.

▲The low-level radioactive waste plasma melter.



▲The 10 days operational record of radioactive test run of the plasma melter.

Installation of the Experimental Apparatus for the Production of Slag Fiber from Plasma Molten Slag

■Ching-Liang Chen

Research on the plasma melting technology at the Institute of Nuclear Energy Research (INER) was focused on treating the low-level radioactive waste in the early stage. In recent years, processing of hazardous wastes and recycling of resources have also been investigated. By plasma melting, incinerator residues, containing considerable amount of hazardous materials, can be properly treated and converted into an inert vitrified air-cooled or water-quenched slag. INER directly utilized the water-quenched slag as road paving material instead of natural gravel and successfully employed the slag as raw material or admixture to develop more valuable products such as permeable brick, artificial stone, glass ceramic, and microstructure materials etc.

In order to enhance the application range of slag reutilization, a three-year research project for producing mineral fibers from slag has been undergoing since 2006. As a substitute for the regulated asbestos-containing materials, the mineral fibers can be widely used in building and many industrial activities for fire resistance, thermal insulation, heat preservation, and sound absorption applications. In 2006, a melt-blowing apparatus, including the subsystems of feeding, melting, blowing, fiber collecting, off-gas treatment, data processing, etc., was set up. Experimental work of fiber production with slag and waste glass additive, on parameters such as furnace operation temperature adjustment, molten slag discharge temperature control, distance change between nozzle and molten slag, and regulation of nozzle air pressure, was performed systematically. Preliminary studies showed that among different batches the fiber products had an average diameter ranging from 0.5 to 2.5 μm, a fibrous packing density of about 0.06 g/cm^3, a shot content of about 30 wt %, and fiber thermal resistance more than 700 °C. Above results illustrate that the mineral fiber products can be promoted to commercial grade if the shot content is improved to less than 16 wt %. In 2007, the study will focus on further investigation of the operational parameters to improve

the fiber quality. To facilitate commercial application, further reprocessing of fiber products into fiber blanket or fiberboard will be investigated as well.

Research Team:
Ching-Liang Chen, Kin-Seng Sun, Yung-Woou Lee, Sheng-Fu Yang, To-Mai Wang, Chin-Ching Tzeng.

▲Mineral fiber producing apparatus and fiber sample produced.
(Left: Fiber producing apparatus; Top right: Fiber sample produced; Bottom right: SEM of the sample)

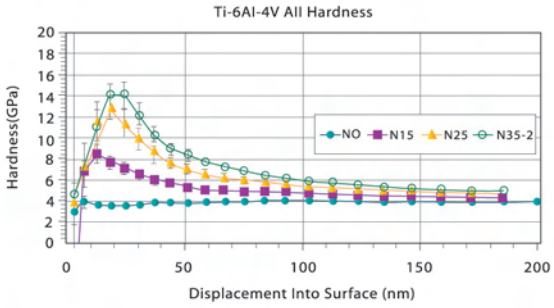
Surface Modification of Artificial Joint Material by Plasma Immersion Ion Implantation

■Wen-Fa Tsai

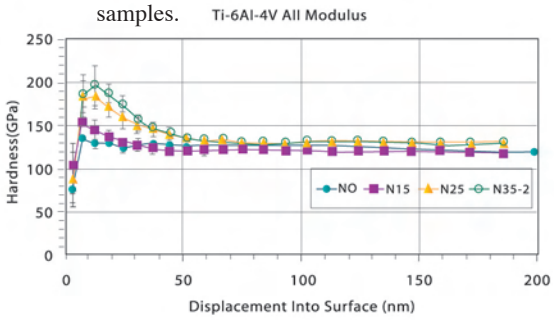
Plasma Immersion Ion Implantation (PIII) technique is an advanced three-dimensional ion implantation method that first creates specific plasma surrounding the target, and then applies negative high-voltage pulses to accelerate ions impacting into the target surface from all directions. The implanted ions can modify the surface properties in various beneficial ways, like hardness improvement, friction reduction, and wear resistance enhancement etc. For the application on the biomedical devices such as artificial joint, many literatures had confirmed that ion implantation showed great improvement on the lifetime due to the delaminating problem, which

often happened in coated surface, didn't occur in the modification layer. In Taiwan, the Ministry of Economic Affairs has also supported the development of artificial joint as one of the strategically promoted items for domestic industry. Wear arising from the counter-friction of Ultra High Molecular Weight Polyethylene (UHMWPE) element against metal often leads to the loosening and its subsequent failure of artificial joints, as clinical reports had pointed out. Therefore, wear reduction by plasma surface modification has become one of the major techniques applied by the international artificial joint manufacturers. By using PIII technology developed at INER we are able to reduce wear debris of UHMWPE by strengthening its counter metal material - Ti6Al4V alloy. Treatment was carried out in nitrogen plasma at pulse voltages of 15, 25, and 35 kV, and at room temperature for two hours. Measurements of wear performance were done at the Joint Prosthesis Technology Research Center of National Yang Ming University. Fig.1 and 2 show that the surface hardness and modulus enhances as the implantation voltage increases, which relates to the precipitation strengthening of the TiN production as the penetration depth of nitrogen ions increases. Fig.3 and fig.4 show the friction coefficient and wear loss of the UHMWPE that decreases with the implantation voltages. At 35 kV the hardness of PIII sample increases three times and the wear loss of UHMWPE after 3 million cycles reduces in half, when compared with untreated samples. In future work, the biocompatibility of PIII treated samples will be tested to satisfy the requirements and standards in the biomedical industry.

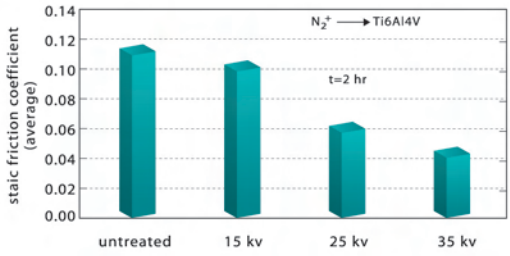
Research Team:
Wen-Fa Tsai, Chia-Cheng Lee, Chi-Fong Ai.



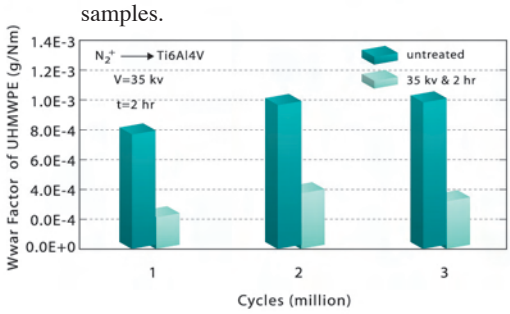
▲Fig.1 Hardness of untreated and PIII treated Ti6Al4V samples.



▲Fig.2 Modulus of untreated and PIII treated Ti6Al4V samples.



▲Fig.3 Friction coefficient of untreated and PIII treated Ti6Al4V samples.



▲Fig.4 Wear loss of the UHMWPE versus wear cycles.

Surface Processing of Solar Reflector and its Test

■Tien-Hsiang Hsueh

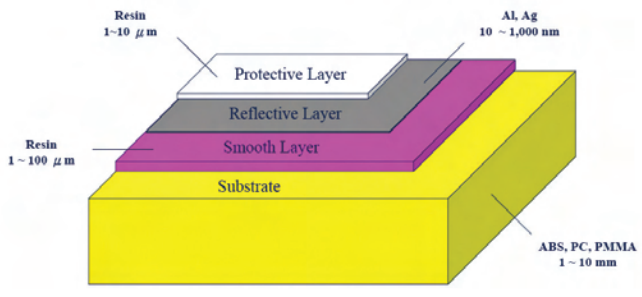
According to the scientists' estimation, solar energy delivered to the earth's surface per day is about equal to 200 times the consumed energy one year in the world. Thus, relevant research on solar energy utilization is a very attractive field and the focus is on either the solar energy to be used directly or to be converted to other useful energy. In recent years, many kinds of solar energy conversion devices have been developed such as photoelectric and photo-thermal devices used for water heating, with its product value of about NT$2 billion per year in Taiwan. Among these devices, one standard and key technique is to reflect the solar energy collected to its conversion devices by a parabolic mirror. Since most of the solar energy is in visible and near-infrared regions, the biggest problem encountered today is the inherent low reflectivity for the solar reflector. At the Institute of Nuclear Energy Research (INER) the main

research goal set for developing is the solar reflectors for higher reflectivity together with cheaper, larger scale and continuous processes.

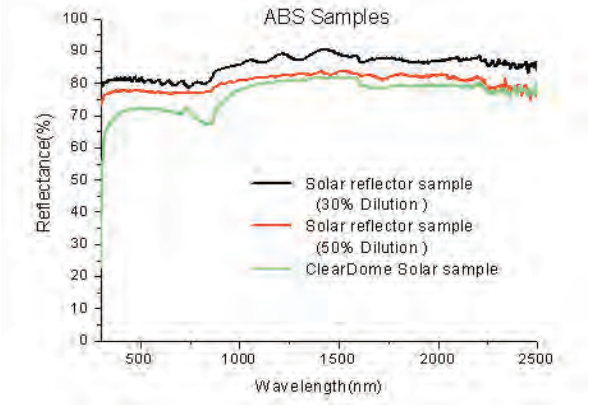
A solar reflector is typically consisted of four layers, including a substrate, a smooth layer, a reflective layer and a protection layer as shown in Figure 1. Solar reflector with high reflectivity in the spectrum range between 300 and 2,500 nm was produced by combining vacuum DC magnetron sputtering and sol-gel coating technologies. Acrylonitrile-Butadiene-Styrene (ABS) plate was used as a substrate and coated with a commercial UV-curing resin as a smooth layer. The reflector layer was an aluminum film deposited by DC magnetron sputtering and the transparent protection layer was a heat-curing resin coated by a spin coater and a rod coater.

In this study, the conditions for vacuum pressure, sputtering power and thickness of aluminum film were adjusted to obtain the best deposition parameters for high reflectivity of the reflector layer, which is better than commercial product as illustrated in Figure 2. The solar reflector had also been tested in various environmental and weather conditions. It also performs well in acid resistance, alkali resistance, salinity resistance, rain resistance, adhesion etc., and passes all qualification tests of solar reflector. Thus, the current process developed has great potential for scale-up and commercialization.

Research Team:
Shih-Chung Lee, Tien-Hsiang Hsueh, Ching-Pei Tseng, Der-Jun Jan, Chi-Fong Ai.



▲Fig.1 The configuration of solar reflector.



▲Fig. 2 The comparison of reflected spectrum of the reflector by INER (using 50 wt% and 30 wt% for protective layer, respectively) and the commercial product.

Development of Motorcycle with Plasma-Reformed-Hydrogen Mixed Gasoline Fuel

■Yu Chao

Hydrogen has the characteristics of fast flame propagation speed and high combustibility. When combined with gasoline to serve as the fuel for spark ignition (SI) engine, merits such as complete combustion, pollution reduction, and efficiency enhancement can be achieved even under lean burn condition. There are more than 10 million motorcycles in Taiwan today, which contribute over 10% of the total CO and HC emissions generated nationwide; consequently, motorcycle is considered as one of the major sources of mobile pollution. The objective of this project is to develop a low-pollution and environment-friendly motorcycle powered by hydrogen-gasoline mixed fuel that can achieve the goal of improving air quality as well as fuel efficiency.

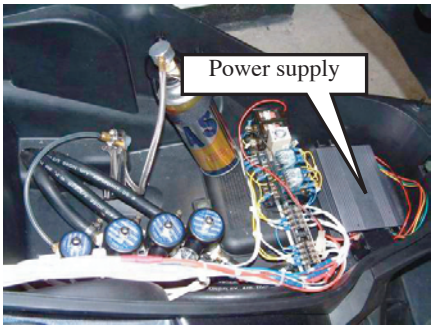
This project integrates three core technologies: plasma reformer for hydrogen generation, compact power supply with high voltage/frequency adjustability, and control system integration. The compact plasma reformer has a short start-up time, which can reach the working temperature in just 15 seconds. It also owns the advantages of flexible operation, small size and low electricity consumption that fulfill the need of onboard hydrogen generation and avoid the drawbacks, such as hydrogen storage and refilling, which hinders hydrogen utilization. The high voltage power supply provides electricity for the reformer to generate plasma. It has the characteristics of high electricity conversion efficiency and compact which is smaller than the size of an A4 paper. By integrating the mechanical, electrical, fuel and air supply systems together; any motorcyclist can ride this motorbike easily without experiencing any extra difficulty.

A prototype of the motorcycle has been refitted (Fig.1 and 2). The effectiveness of the same reformer system has been verified on a dynamometer. In normal operating conditions, the preliminary results shown in Fig.3 had demonstrated a significant reduction in NO_X concentration by 45% ~ 95%. For idle operation, CO emission was reduced by 38% with slight

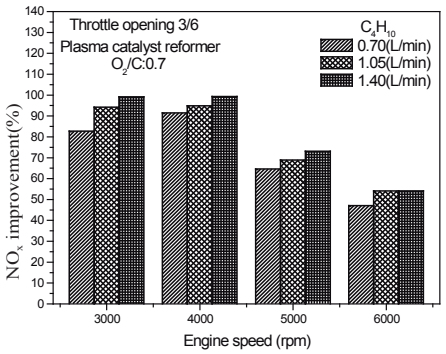
decrease in fuel consumption as well (table 1). During practical motorcycle operation, road conditions as well as variations in engine loading due to acceleration/deceleration will cause the throttle opening and engine rotation speed to alter rapidly. At this moment, the hydrogen-rich gas supply system cannot operate coordinately with these alterations. Further improvement is yet needed.

Research Team:
Ching-Tsuen Huang, Yu Chao, Wei-Ting Huang, Hung-Tsai Hu.

▲Fig. 1 The prototype of H2-gasoline mixed fuel motorcycle (within the circle is the plasma reformer).



▲Fig. 2 Small power supply and other control units (within the circle is the power supply).



▲Fig. 3 The improvement of NO_X emission reduction (%) in the condition of throttle opening 3/6 at various speeds.

Fuel	Engine speed (rpm)	Gasoline consumptio (ml/min)	CO (%)	HC (ppm)	NO_X (ppm)
Gasoline	1500	11	7.64	201	28
	2000	9	8.53	165	34
hydrogen-gasoline mixed fuel	1500	10	4.72	175	24
	2000	6	4.94	131	43
Improvement(%)	1500	9.09	38.22	12.94	14.29
	2000	33.33	42.09	20.61	-26.47

▲Table1. The improvements of gasoline consumption and exhaust for the idle operation.

Research and Application of Nuclear Medicine and Radiation Biology

■Shiou-Shiow Farn, Ying-Ling Wang

The developing purpose and orientation of Radiation Application Technology Center (RATC) are (1)to improve the reliability of the TR30/15 cyclotron operation, (2)to cultivate domestic nuclear medicine industry and (3)to develop new nuclear medicine and radiation therapeutic technology for both diagnosis, and therapeutic demands.

Accordingly, thirteen major tasks had been performed as following:

1. Upgrade of the RF System of the INER TR30/15 Cyclotron
2. Study on Radiopharmaceutical Labeling Synthesizer
3. Development and Registration of the INER Tc-99m-MIBI Imaging Agent (INER MIBI KIT)
4. The Research of Radiopharmaceuticals for Breast Cancer Treatment
5. Development and Application of Proteomic Radiopharmaceuticals
6. Development and Applications of Anticancer Drugs
7. Development and Applications of the INER micro-PET/CT
8. Synthesis of NNDAM as a Precursor of 4-^{18}F-ADAM for Serotonin Transporter Imaging
9. Structure Elucidation of Radiopharmaceuticals by High Performance Liquid Chromatography - Tandem / Linear Ion Trap Mass Spectrometry
10. Accelerating the Growth of Ulva by γ- Irradiation
11. Development of Radiopharmaceuticals for Diagnosis of Alzheimer's Disease
12. Biodistributions of In-111-DTPA-Oct-Liposome
13. Preparation and Analysis of High Functional Antibacterial Fabric Composites Containing Nano-material

Besides elevating research ability and increasing the profit, INER is expecting itself to become one of the research centers of nuclear medicine and radiation biology in Pan-Asia Pacific Basin.

Upgrade of the RF System of the INER TR30/15 Cyclotron

Ting-Shien Duh

The TR-30/15 cyclotron can accelerate both proton and deuteron particles with energy range and beam capacity of 15-30 MeV and 500μA for protons, and 8-15 MeV and 150μA for deuterons. For the past years, many of the newly built compact cyclotrons can have beam capacities of up to a milli-ampere. To join the club of the milli-ampere cyclotrons, an upgrading project for INER TR-30/15 cyclotron was proposed to increase the beam capability of one milli-ampere. The upgrading project consists of three phases: (1) the improvements of the ion source and injection systems to increase the output current of the ion source and the efficiency of the beam transmission, (2) the upgrade of the RF system, providing more power into the Dee to accelerate the protons, and (3) the beamline extension and the establishment of a high power solid target station, so as to be able to work with one milli-ampere proton beam.

Up to now, the 1st and 2nd phases of the upgrading project have been completed. For the improvements of ion source and injection line, the test results showed that the output current (H^-) of the ion source increased from 5 to 8 mA, and at the same time the stability was improved as well. The beam transmission was promoted from 10% to 20-50%, depending on the beam current. For the upgrading of our RF system, a new RF power amplifier was built in 2005, and the factory test showed that the maximum output of the new amplifier was 100 kW. For our cyclotron a power of 60 kW is enough for running 1 mA proton beam up to 30 MeV. This newly built 100 kW power amplifier has been installed and tested at INER this year, and has been proved working with our cyclotron very well. Due to the limitation of the beam capacity of our solid targets, the preliminary acceleration test showed that our cyclotron could run a proton beam up to 800μA smoothly. At present, in fact, our cyclotron has already the capability to run 1 mA proton beam. Therefore, we may say that INER TR30/15 cyclotron is one of the compact cyclotrons of mA order in the world.

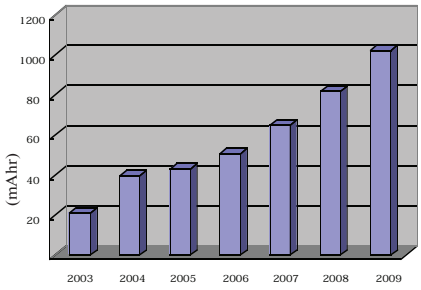
INER Cyclotron after the upgrades of the 1st and 2nd phase can run dual beam very steadily. The dose capacity therefore may be doubled with the dual beam irradiation. In the next few years, we are going to complete the beamline extension and a high current solid target station, so as to complete the whole upgrading of our cyclotron. Until then, the dose capacity will increase up to 300%. The irradiation yields of the INER cyclotron depends on the needs of the hospitals, and is increased year by year. INER cyclotron is ready for the future challenge.

Research Team:
Ting-Shien Duh, Chien-Chian Kuo, Mao-Hsung Chang, Ching-Lin Liaw, Chia-Zong Fann, Ping-Yen Huang, Dow-Che Chen, Kuo-Yuan Chu, Kuei-Yuan Hsu, Hogan Hong.

Machine parameters

Particles	**H^-**	**D^-**
Energy(MeV)	**15-30**	**8-15**
Extracted Beam(A)	**500→1000**	**150**
RF		
Dee voltage(kV)	**50**	**27**
Frequency(MHz)	**73.129**	**36.578**
Output Power(kW)	**40 → 100**	
Source	**H^-/D^- cusp type**	
Output current (mA)	**5 → 8**	**1.8 → 4**
Injection Efficiency	**10% → 50%**	
Vacuum(torr)	**< 5 x 10^{-7}**	
Magnet	**4-sector radial ridge**	
Beamlines	**4**	
Solid Target Station		
Beam Capacity (μ A)	**250 → 500 (to be done)**	

▲(a) Specifications of INER cyclotron.



▲(b) A trend of the irradiation doses of INER cyclotron.

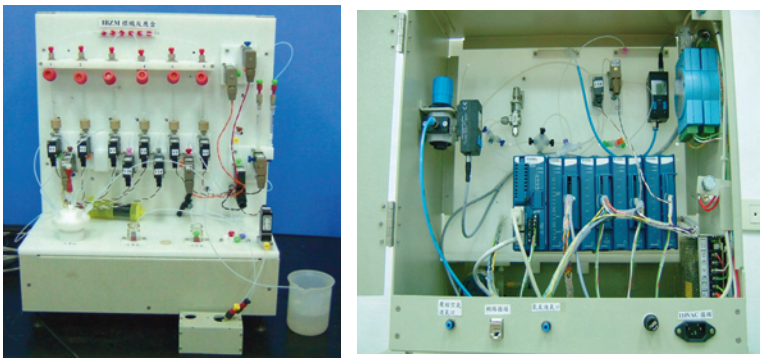
Study on Radiopharmaceutical Labeling Synthesizer

■Ai-Ren Lo

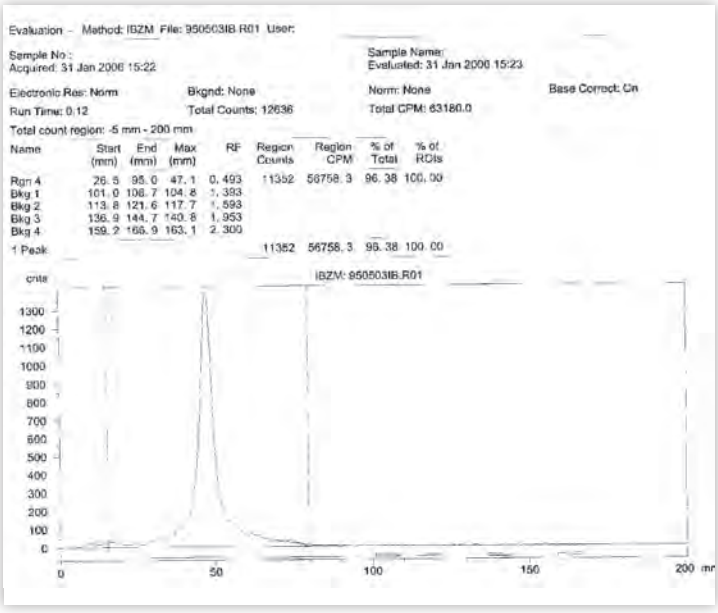
The purpose of this study is to develop a fully automatic controlled compact synthesizer for the synthesis of I-123-IBZM. Main procedures of the processes include: (1)injection of [^{123}I]NH_4I; (2)oxidation reaction; (3)quench and neutralization with $NaHCO_3$; (4)separation and collection. The advantages of this fabricated synthesizer are described as following. Firstly, the whole processes are operated in a closed system with a charcoal trapper to avoid radioactive I-123 gas released into atmosphere to reduce the environmental radiation. Secondly, the size of the synthesizer is made as small as possible. Thirdly, this synthesizer is performed with a fully automatic control program for synthesis of I-123-IBZM. The reaction time is about 20 minutes. The

products obtained with purity greater than 95% are sufficient to meet the specifications of I-123-IBZM as clinical nuclear medicine. Other than the previous statements, the software commands can be executed step by step precisely to undertake the synthesizing procedures. During the performance of the synthesizing, temperature and pressure of each step and variation of radiation dose can be monitored and recorded spontaneously. Also, the procedure of I-123 IBZM synthesis should be compliant with the regulation of GLP/GMP.

Research Team:
Ai-Ren Lo, Ther-Jen Ting, Meng-Chang Chiou, Jin-Jenn Lin, Tseng-Chung Huang, Fang-Hsiu Kuo



▲Inner structure of I-123 IBZM Synthesizer



▲Radiochemical purity of I-123 IBZM .

Development and Registration of the INER Tc-99m-MIBI Imaging Agent (INER MIBI KIT)

■Mei-Hsiu Liao

Nuclear imaging, such as single photon emission computed tomography, is a powerful non-invasive diagnostic modality that relies on the use of radiolabeled pharmaceuticals and imaging instruments. The physiological and pathological information obtained with nuclear imaging is critical for deciding the most appropriate therapeutic intervention by physicians. Registration is required for pharmaceuticals supply commercially. To fulfill the regulation for registration, INER started the development of Tc-99m-MIBI precursor in the core technology and facility of INER that was established more than 10 years ago. The goal of the INER is to develop and manufacture radiopharmaceuticals with high economic value to meet the demand for nuclear imaging in Taiwan.

The development of the INER MIBI KIT started in 2003 and was submitted to the Department of Health (DOH) on May 3rd, 2006 for registration approval. The research and development on the kit formulation, quality control, and various Chemical Manufacture and Control (CMC) have been completed and documented by the time of registration submission. Further works on the validation of all related process required by current Good Manufacturing Practice (cGMP) were completed and documented shortly after the registration submission. The supplemental documents of cGMP compliance were then submitted to DOH in August, 2006. The registration of INER MIBI KIT was approved on October 12th, 2006 by DOH. It is a great success for taking such a short period of time (less than 6 months) for the registration.

The clinical indications for INER MIBI KIT are the imaging of myocardial perfusion and breast cancer. It is expected that more than 8,000 patients will receive the imaging diagnosis with INER MIBI KIT at the early stage of marketing in Taiwan. The development and registration of INER MIBI KIT is a successful project, in which the research conducted in INER can be used clinically to benefit the public. The marketing of INER MIBI KIT will also likely bring down the price of other generic MIBI kits, which will make

the cost for the MIBI imaging more affordable and therefore benefit more patients.

Research Team:
Mei-Hsiu Liao, Fu-Lei Huang, Suh-Mei Lin, Shiou-Shiow Farn, Mei-Chin Wu, Chun-Yan Wu, Kung-Tien Liu, Yi-Chih Hsia, Young-Kai Chen, Tse-Zung Liao, Tung-Chuan Chiang, Wuu-Jyh Lin, Lie-Hang Shen.

The Research of Radiopharmaceuticals for Breast Cancer Treatment

■Tsai-Yueh Luo

According to the report of World Health Organization, there were 1.2 million people diagnosed with breast cancer in 2005. In Taiwan, breast cancer had the highest prevalent rate compared to other cancers. Supplying the best treatments for the clinic is an urgent issue in this moment. Although chemotherapy is an available choice for cancer therapy, the non-specific mechanisms always bring severe side effects and restrict the further use. Radioimmunotherapy combining the benefits of radiotherapy and monoclonal antibody can afford a very promising result for the original and metatstatic cancer.

The development of therapeutic radiopharmaceuticals is mainly depended on the chemical property of the ligands and therapeutic isotopes. Metallic radioisotope with alpha, beta emitting chelated with these ligands enhanced the therapeutic effect. INER has developed the Re-188/W-188 generator technique and supplied Re-188 solution regularly for the domestic radiopharmaceutic research. Recently we are trying to develop the radioimmunotherapeutic agents for cancer treatment. Herceptin is a commercialized antibody that specifically binds to Her-2/neu receptor on the breast cancer cell membrane, and then suppresses growth and division of cancer cells. SOCTA is newly synthesized as bifunctional ligand by INER. The complex of combining both ^{188}Re and SOCTA-monoclonal antibody showed very good stability in human serum and would be used in animal study in the near term.

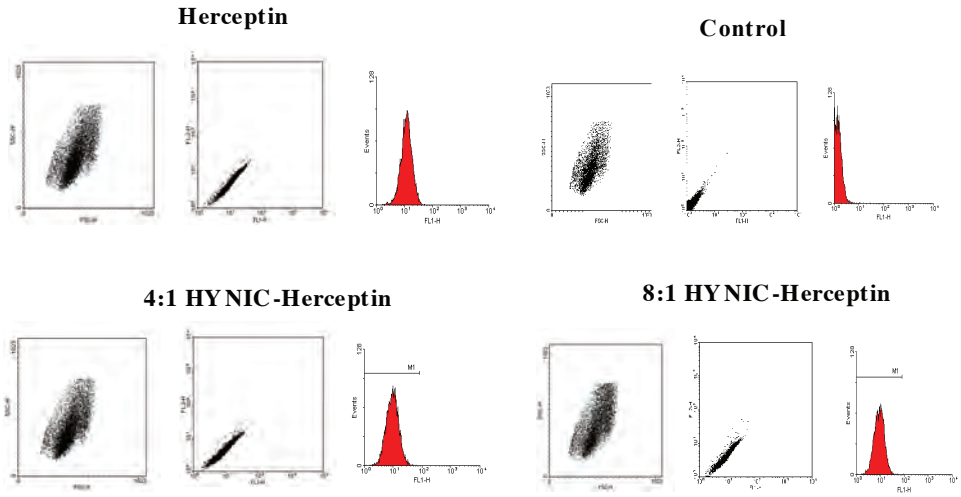
We also developed a new therapeutic radiopharmaceutical ^{188}Re-labelled trastuzumab (Herceptin®) through a bifunctional chelator, hydrazine nicotinamide (HYNIC). The results of flow cytometry revealed that the immunoreactivity of the Herceptin bound with HYNIC only slightly decreased. The radiochemical purity of ^{188}Re-HYNIC-Herceptin can achieve 88% at 90 min after chelating reaction at 25°C, and 97% at 24 hr after chelating reaction when tricine existed.

The preliminary results showed that ^{188}Re-SOCTA/HYNIC- Herceptin could be potential radiopharmaceutical for breast cancer therapy. In the future, we still need to compare the therapeutic effects in the in-vitro cell lines and breast cancer animal models to prove it.

Research Team:
Tsai-Yueh Luo, I-Chung Tang, Yu-Lung Wu, Hang-Hsing Yang, Chang-Mau Shing, Ching-Jun Liou, Te-Sheng Liang, Shan-Yun Cheng.

Analysis HYNIC-Herceptin complex by flow cytometry

Parameter name	Herceptin	Control	4:1 HYNIC-Herceptin	8:1 HYNIC-Herceptin
GMean	12.05	1.29	9.58	9.28



Development and Applications of Proteomic Radiopharmaceuticals

Mei-Hui Wang

Global proteomics advance rapidly in these years due to the completion of human genomics and the introduction of new mass spectrometry. Since gene expression is influenced not only gene itself but also environment and diet, research on proteomics could provide more information for the individual healthy situation and physiological condition.

Proteome is the expressed protein complement of a genome. Proteomics is functional genomics at the protein level, which identifying and characterizing the proteins expressed by an organism, tissue or organelle. By comparing the differential display of normal and diseased group, we can discover new disease related biomarkers and cancer targets. The former could be further developed into in-vitro diagnostic agent used as medical screening or therapeutical evaluation, and the latter could be further developed into antibody-based drugs specific to cancer target, either diagnostic or therapeutical radiopharmaceuticals. The differences of diagnostic and therapeutic radiopharmaceutical are the isotopes employed. If the isotopes employed are γ-emitters such as Tc-99m or In-111, it is called diagnostic radiopharmacuticals which are often used as functional image or validation of targeting effectiveness. If the isotopes employed are γ-emitters such as Y-90 or Re-188, it is called therapeutic radiopharmaceuticals, which are often used as target radiotherapy.

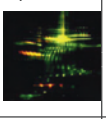
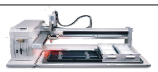
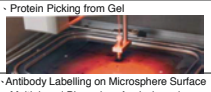
There are more and more necessities of protein drug for cancer therapy. Prior to 2000, Rituxan was the only antibody-based drug with indications for cancer. But after humanized antibody successfully developed, there have been 10 antibody-based drugs approved, with 7 of the 10 aimed at treating solid and soft tumor cancers. If the monoclonal antibody we choose is specific to the incorrect cancer target, the therapeutic radiopharmaceuticals maybe shrink the tumor, but at the same time it will also seriously damage the other non-target area such as liver and kidney. Besides, the structures of the serum tumor marker and the cancer target on the cancer cell membrane are

often different, it is unsuitable to use serum tumor marker based antibody for targeting radiopharmaceuticals. For example, the structures of prostate specific antigen and prostate specific membrane antigen are different, it is reasonable that the specific antibodies are dissimilar. Furthermore, the Western cancer target may be not suitable for Eastern people use due to ethnical differences. It is necessary for us to develop our own cancer target or biomarkers.

Now some isotope labeling techniques are developing for protein radiopharmaceuticals in our Institute. With the appropriate cancer target, it will increase the image accuracy and safety in the following animal and clinical trials.

Till now, we employed three methods selectively profiling proteome or N-glycoproteome of sera. In the approach, SELDI-TOF (Surface Enhanced Laser Desorption Ionization-Time of Flight), aminophenyl boronic acid chemistry, and two dimensional differential electrophoresis gel are used to enrich N-glycoproteome or proteome. With the differential mass spectrum between diseased and healthy group, we could find the appropriate biomarkers. We expect to spend one year to complete liver fibrosis biomarker discovery, and spend two year to validation by immunoassay and setup the model of liver fibrosis diagnosis kit. All of these effort and development will be the critical techniques of proteomic radiopharmaceutials of INER in the future.

Developing Instrument and Techniques of INER Proteomics

Instruments	Core Techniques	Application and Prospect
1、Matrix Assisted Lase Desorption and Ionization-Time of Flight (MALDI-TOF/TOF) Mass Spectrometry 2、Surface Enhanced Laser Desorption and Ionization-Time of Flight (SELDI-TOF) Mass Spectrometry 	1、Protein Identification 2、SELDI-TOF Biomarker Discovery 3、MB (Magnetic Beads)-MALDI-TOF Biomarker Discovery 4、MALDI-Imaging 5、Isotope Code Protein Labelling (ICPL) Biomarker Discovery 6、Isobaric Tag for Relative and Absolute Quantitation (ITRAQ) 7、Oligonucleotide Analysis 8、Single Nucleotide Polymorphism (SNP) Identification 9、Microorganism Identification	Biomarker Discovery Biomarker discovery and validation of early liver cirrhosis, liver cancer, gastric cancer, pancreatic cancer and Alzheimer disease. Get Innovation Patents and Produce high reliable, convenient and low cost of screening kits.
3、Liquid Chromatography (LC) MALDI 	10、Protein Separation and Fraction with LC-MALDI 	
4、Two Dimension-Differential Gel Electrophoresis(2D-DIGE) 	11、2D-DIGE Biomarker Discovery 	
5、Gel Spot Picker 	12、Protein Picking from Gel 	Clinical Use of Multiplexed Biomarkers Develop multiplexed biomarkers kits for large scale screening of early liver cirrhosis, liver cancer, gastric cancer, pancreatic cancer or Alzheimer disease, which benefits clinical diagnosis and follow-up of therapeutic effect.
6、Flexible Multi-Analytel Profiling Technology Platform 	13、Antibody Labelling on Microsphere Surface 14、Multiplexed BiomarkersAnalysis and Quantitation 15、Early Liver Cirrhosis Screening 16、Early Alzheimer Disease Screening 17、Early Gastric Cancer Screening 18、Early Pancreatic Cancer Screening	

Research Team:
Shui-Cheng Lee, Mei-Hui Wang, Chun-Chia Cheng, Wen-Yu Hsu.

Development and Applications of Anticancer Drugs

■Chih-Hsien Chang

Cancer has been a serious disease to threaten human health. To find effective approaches to treat the disease are indeed desired. Targeting anti-cancer drugs are designed to treat tumor with specific targets on cell membrane. Targeting liposomes are regard as effective delivery systems for anti-cancer drugs. Liposomes are formed by one or several concentric lipid bilayers. Due to its amphibious property, liposomes can encapsulate both hydrophilic and hydrophobic materials in aqueous phase and lipid bilayer, respectively. Targeting liposomes could deliver drugs to specific tumor tissues, and reduce cytotoxicity to normal tissues. INER design targeting liposome encapsulating doxorubicin (Lipo-DOX) to enhance the chemotherapeutic efficacy, reduce the cytotoxicity to cardiac tissues. Octreotide (Oct), a peptide, has been used for early detection, localization of neuroendocrine tumors. The Oct-modified Lipo-DOX was developed to specific binding to overexpressed somatostatin receptor (SSTR) on tumors. The formulations included lipid film hydration, extrution for targeting liposome and loading doxorubicin. The size of synthetic targeting liposome was between 75 nm and 85 nm, and size remained stable at least four months at 4^0C ; Doxorubicin is stable entrapped in liposome at least for five and a half month, less than 8 % was leakage during the storage period. *In vitro* cellular uptake and *in vivo* SSTR over-expressed tumor-bearing mice studies showed the targeting effects of Oct-liposome. Our results indicated the targeting liposome would play an important role for cancer therapy by specific target on tumor cells.

Research Team:
Te-Wei Lee, Chih-Hsien Chang, Wei-Chuan Hsu, Shu-Pei Chiu, Chia-Yu Yu, Chung-Li Ho, Tsui-Jung Chang, Ya-Jane Chang, Yu-Hsien Wu, Wan-Chi Lee, Shu-Ling Chen, Chung-Hsin Yeh, Shyh-Yi Chyi, Tien-Fu Huang.

Development and Applications of the INER micro-PET/CT

■Meei-Ling Jan

Four years ago, the Institute of Nuclear Energy Research (INER) and the National Health Research Institute (NHRI) brought in the micro-PET system

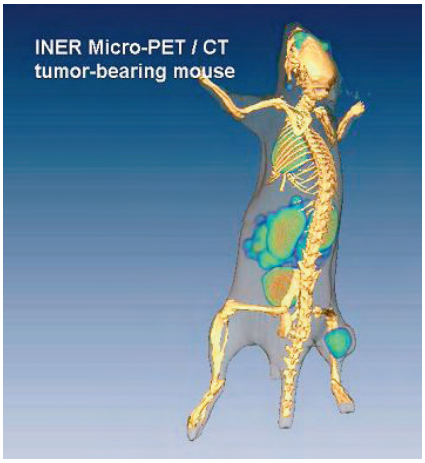
for small animal imaging. However, the system has the limitation that it can only provide functional images, which are difficult to interpret while applying molecular probe with high specificity. To overcome the problem, INER has developed its own high resolution micro-CT system with structural images. Integrated with the original micro-PET system, INER has successfully completed the advanced micro-PET/CT animal molecular imaging system.

INER independently completes the micro-CT system development including the planning, design, components selection, alignment, calibration and test. To reduce the development cost, all components are domestically sourced except for the X-ray tube and the sensor. After completed the development of the Phase I micro-CT system, the research team integrated the micro-PET and micro-CT scanners, developed a convenient three-dimensional image fusion technology, and completed the development of the micro-PET/CT system. This domestically developed micro imaging system can provide fused functional/structural images with high registration precision. It is suitable to be used in mass and routine animal imaging on drug evaluation. Combined with the recently developed fusion imaging quantitative technology, the precision of using animal molecular imaging to evaluate the efficacy of new drugs can be greatly enhanced.

The micro-PET/CT animal molecular imaging system, combined with the molecular imaging probe developed by INER, will provide professional imaging services of living animals with high sensitivity, high quality and good quantification. Such a system can be conveniently used in developing the diagnostic and therapeutic drugs of cancer as well as central nervous system diseases. INER is planning to transfer the technologies to domestic companies that have interest in this system. The product commercialization will enhance the domestic imaging instrument industry and improve the competitiveness of Taiwan.

Research Team:
Meei-Ling Jan, Yu-Ching Ni, Geo-Wei Chen, Cheng-yen Chiang, Hsin-Chin Liang, Yu-Ting Fang, Chuen-Shing Shyu, Shyang-Yeu Wang.

▲Photo of the INER micro-PET/CT



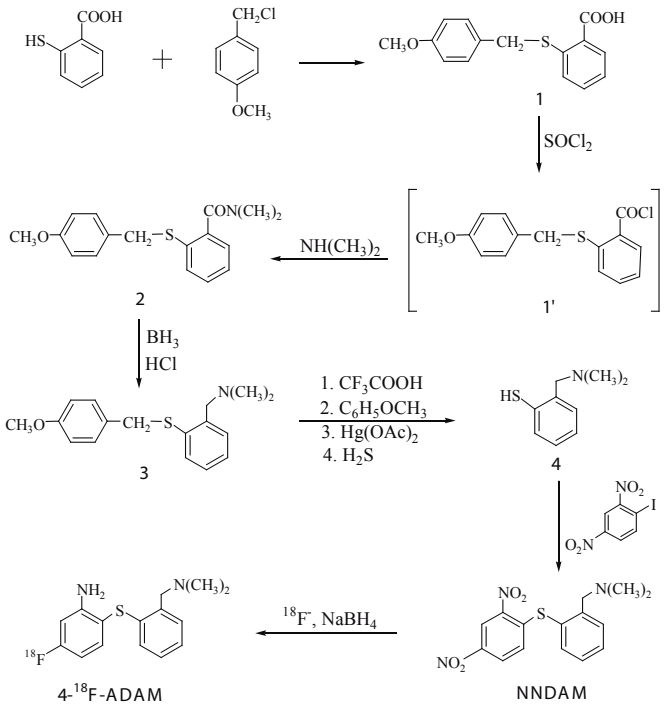
▲Tumor-bearing mouse image obtained from INER micro-PET/CT

Synthesis of NNDAM as a Precursor of 4-^{18}F-ADAM for Serotonin Transporter Imaging

■Cheng-Hsien Lin

The synthesis of **NNDAM** (N,N-dimethyl 2-[(2,4-dinitrophenyl)thio] benzylamine) is described. The thiol group of thiosalicylic acid was protected with 4-methoxybenzyl chloride to give **1** (2-[(4-methoxybenzyl)thio]benzoic acid) which was subsequently activated by thionyl chloride to afford an intermidate **1'**. Amadation of **1'** with dimethylamine yielded 2 (N,N-dimethyl 2-[(4-methoxybenzyl)thio]benzamide). The amido group of 2 was reduced by borane-tetrahydrofuran complex to give **3** (N,N-dimethyl 2-[(4-methoxybenzyl) thio]benzylamine). Compound **4** (N,N-dimethyl 2-thiobenzylamine) was prepared by thio-deprotection of **3** immediately prior to use. The coupling reaction of **4** with 2,4-dinitroiodobenzene in alkaline acetonitrile solution afforded **NNDAM**. All compounds were characterized by IR, NMR and mass spectral data.

Research Team:
Shih-Tsorng Huang, Cheng-Hsien Lin, Show-Wen Liu, Tsyh-Lang Lin, Cheng-Fang Hsu.



▲Synthesis of NNDAM and 4-^{18}F-ADAM

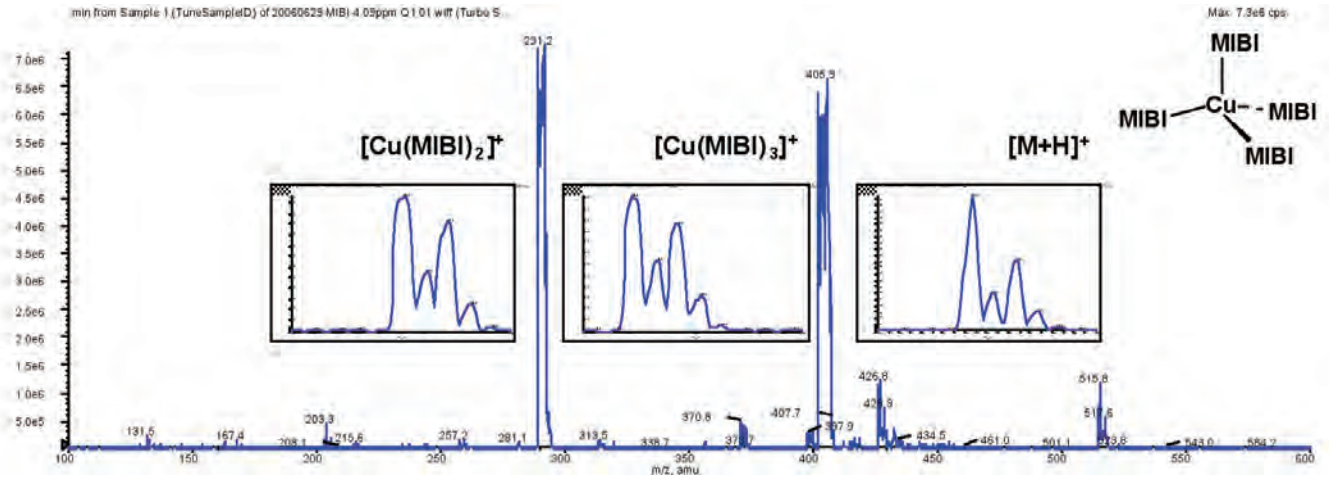
Structure Elucidation of Radiopharmaceuticals by High Performance Liquid Chromatography - Tandem / Linear Ion Trap Mass Spectrometry

■Kung-Tien Liu

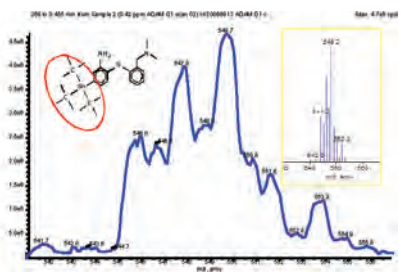
In 2006, high performance liquid chromatography-tandem/linear ion trap mass spectrometer (LC-QqQ/LIT MS) was installed. Structure elucidation of $Cu(MIBI)_4BF_4$, SnADAM, I-127-ADAM (cold ADAM), O-18 water and ECD were well developed by Q1 scan, precursor ion scan, product ion scan and neutral loss scan of LC-ESI-QqQ/LIT MS. First of all, according to the m/z data of MS spectra, the chemical composition and structure of a drug, including its functional group, chemical bonding, coordination number, polymerization state and equilibrium coefficients can be proved directly. For example, coordination number of $Cu(MIBI)_n$ was found of four in Fig. 1. Secondly, the isotopic ratio can be used to distinguish the atoms or bonding

sites. Two isotopes of Cu, Cu-63 and Cu-65, showed that four MIBI were bonding to Cu independently. Ten isotopes of Sn were easily found in both parent and some fragments (Fig. 2). Thirdly, electrospray ionization (ESI) can be used to control the energy of ion for passing MS. Oligomers of water were therefore possible to be found (Fig. 3). Metabolic study achieved by multi-reaction monitoring (MRM), which is a unique method of tandem MS, become the next work in the future.

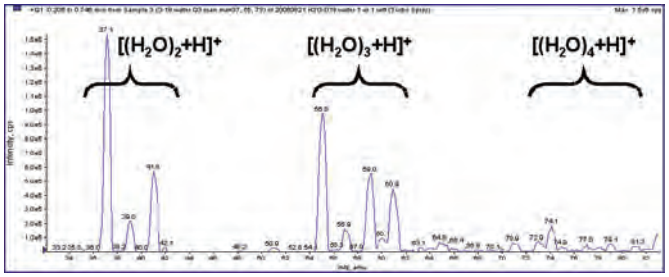
Research Team:
Kung-Tien Liu, Yi-Chih Hsia, Hang-Hsing Yang, Tai-Sheng Lin, Chang-Yung Su.



▲Fig. 1. Q1 scan of Cu(MIBI)4BF4.



▲Fig. 2. Q1 scan of SnADAM.



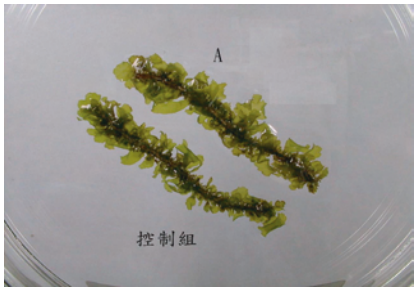
▲Fig. 3. Q1 scan of O-16/O-18 water.

Accelerating the Growth of Ulva by γ- Irradiation

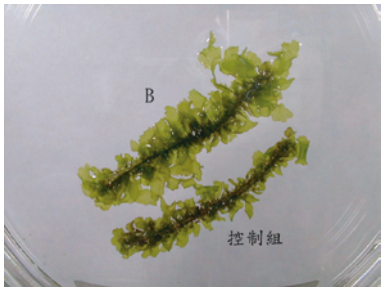
■Kuan-Yin Chen

A novel immobile-alga technique with radiation hormesis was developed to improve the output of alga as the biomass energy source. Giant green algae are able to perform a photosynthesis that resembles of green plants very much. Alga can be grown to produce biomass, which can then be harvested and burned in the same manner as wood, to produce heat and electricity. The present study aims at setting up the immobilization of a alga and studying of the low dose radiation (LDR) caused stimulation of the immobile alga after exposure to different doses (0-100 Gy) of ionizing Co-60 irradiation. As shown in the fig. 1-1 to 1-5, the present invention is a method of hormesis for algae through irradiation, where algae is irradiated with a Co-60 γ ray for a hormesis to grow fast and improve production. After growing through an irradiation of the radioactive ray with a dose between 5Gy to 25Gy, the youngs of sea lettuce obtained have dry weights (Table 1) greater than the young of sea lettuce growing through no irradiation. And, the young of sea lettuce growing through the irradiation with a dose of 15Gy has the heaviest weight. To sum up, the present invention is a method of hormesis for seaweed through irradiation, where irradiated seaweed obtains a hormesis for rapid growth so that production is improved and a material for biomass energy is provided.

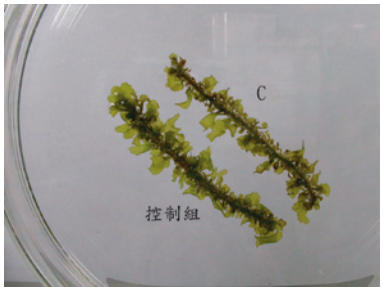
Research Team:
Bin Lin, Kuan-Yin Chen, Hsueh-Hsuan Liu, Chia-Chieh Chen.



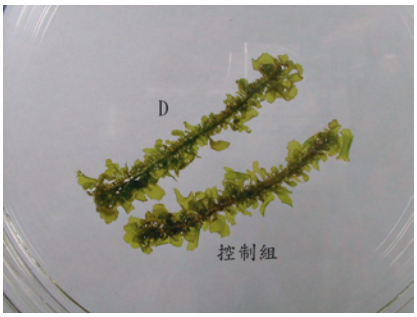
▲Fig. 1-1: 5 Gy irradiation.



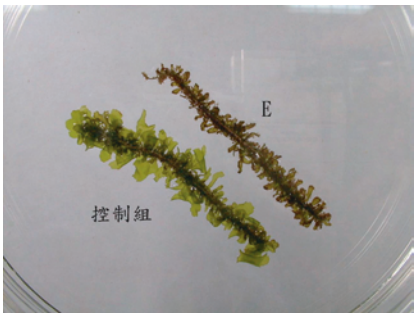
▲Fig. 1-2: 15 Gy irradiation.



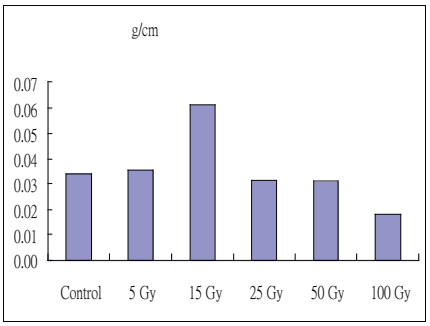
▲Fig. 1-3: 25 Gy irradiation.



▲Fig. 1-4: 50 Gy irradiation.



▲Fig. 1-5: 100 Gy irradiation.



▲Table 1: Algae dried wet (g/cm)

Development of Radiopharmaceuticals for Diagnosis of Alzheimer's Disease

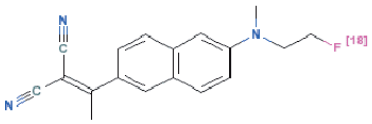
■Shin-Ying Lee

Alzheimer's disease (AD) is a neurodegenerative disorder. The AD patient is characterized by a progressive loss of cognitive function with senile plaques (SPs) and neurofibrillary tangles (NFTs) as the pathologic hallmarks of the disease. AD results in impairment of a broad spectrum of cognitive processes, including verbal and nonverbal memory; language and semantic knowledge, attention and executive functions, and visuoperceptual and spatial abilities. Alzheimer's disease affects 11% of the seniors order than 65 years, and 50% above 80 years old. It is estimated that there are about 1.5 billion people in the world, 4 million people in US, and 40 to 90 thousand people in Taiwan with AD.

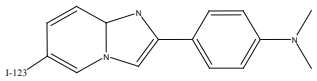
However, an integrated understanding of the disease with clear recommendations for interventions is lacking. In clinical diagnosis, positron emission tomography (PET) and single-positron emission computed tomography (SPECT) are employed to measure the glucose metabolism and blood flow in different regions of patient brain, but both of them lack specificity. Postmortem neuropathologic examinations of the β-amyloid (Aβ) plaques in the brain provide definitive diagnosis of the disease. Development of the probes specific binding to β-amyloid is desired for early diagnosis and treatment.

Radiotracers F-18-FDDNP and I-123-IMPY have been proved to be specific binding with Aβ protein, and have been approved by FDA in phase I and phase II clinical trial respectively. In INER, we have successfully synthesized the precursors of TsDNNP and SnMPY. The radioisotope labeling methods were developed and improved in 2006. The yield of F-18-FDDNP labeling is about 40% and the radiochemical purify is greater than 90%. Binding of FDDNP and I-123-IMPY to Aβ protein were validated by In vitro assay in transgenic mice Tg2576 and data were shown in Figure 1 and 2. Our aim is to cooperate with medical centers to do human studies and eventually to apply clinical trials in the future.

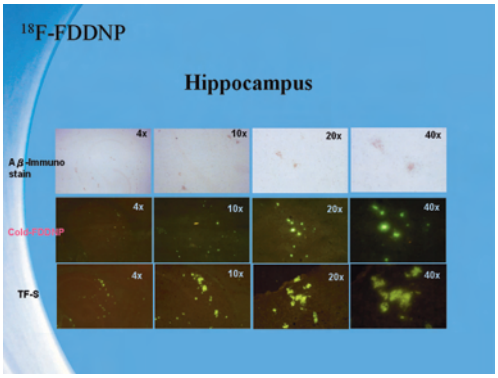
Research Team:
Chia-Chieh Chen, Kang-Wei Chang, Shin-Ying Lee.



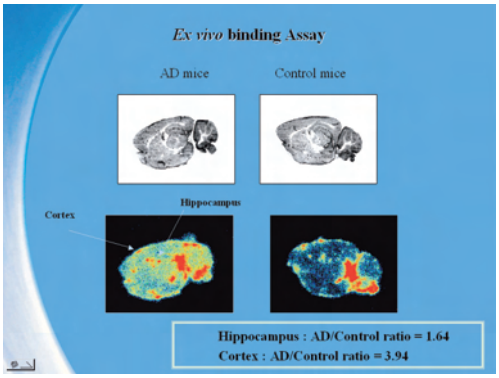
▲Structure of F-18-FDDNP.



▲Structure of I-123-IMPY.



▲Fig.1 Cold FDDNP binding with Aβprotein in hippocampus region.



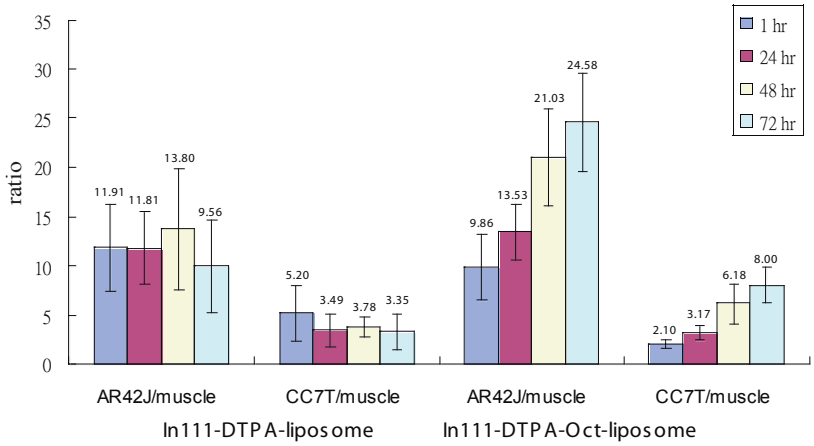
▲Fig.2 I-123 IMPY autoradiography in transgenic mice Tg2576.

Biodistribution Study of In-111-DTPA-Oct-Liposome

■Tsui-Jung Chang

Liposomes are vesicles formed by one or several concentric lipid bilayers. Liposomes can encapsulate both hydrophilic and hydrophobic materials in aqueous phase and lipid bilayer, respectively. Pegylated liposomal doxorubicin (Lipo-DOX), which has been widely used in cancer therapy, reduced concentration of free doxorubicin in blood and avoiding directly toxicity to normal tissues. However, the concentration of doxorubicin in tumor tissues is low due to the non-specific targeting of Lipo-DOX. The therapeutic efficacy of Lipo-DOX is therefore limited. INER developed a targeting Lipo-DOX to enhance the specificity to tumor cells and reduce the toxicity to normal tissues. Octreotide (Oct) is a good targeting peptide used for early detection, localization, and follow-up of both recurrent and metastatic neuroendocrine tumors. The Oct-modified Lipo-DOX was developed to specific binding to overexpressed somatostatin receptor (SSTR) on tumors. To evaluate the targeting distribution of the Oct-liposome, indium-111 (In-111) labeled DTPA-liposome or DTPA-Oct-liposome was intravenous injected to simultaneously high-expressed SSTR AR42J tumor- and low-expressed SSTR CC7T tumor-bearing mice. At various time points (1, 24, 48 and 72 h), mice (n = 3 at each time point) were sacrificed. Blood and organs of interest were removed; the results were expressed as the percentage injected dose per gram of tissue (%ID/g). The results (Figure) showed the tumor-to-muscle ratio increased rapidly and higher following analyzing time points in In-111-DTPA-Oct-liposome injected groups than those in In-111-DTPA-liposome injected groups in high-expressed SSTR AR42J tumors. Our results indicated the targeting effects of In-111-DTPA-Oct-liposome and the potentials of Oct-liposome as a targeting drug-delivery system.

Research Team:
Te-Wei Lee, Chih-Hsien Chang, Chia-Yu Yu, Chung-Li Ho, Tsui-Jung Chang, Ya-Jane Chang, Yu-Hsien Wu, Wan-Chi Lee, Shu-Ling Chen.



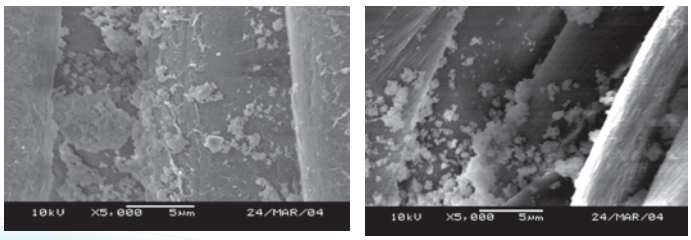
▲Tumor-to-muscle ratio of In-111-DTPA-Oct-liposome and In-111-DTPA-liposome after i.v injection in simultaneously AR42J tumor- and CC7T tumor-bearing mice at various time points (1, 24, 48 and 72 h). (mean (SEM, n = 3 at each time point).

Preparation and Analysis of High Functional Antibacterial Fabric Composites Containing Nano-material

■Te-Hsing Wu

The bacteriostat is divided into organic and inorganic bacteriostat. This work used inorganic nanosized antibacterial solution or powder grafted on, Nylon and PET fibers to prepare antibacterial fiber products. The nanosized silver particles in solution were reduced and deposited on the surface of fabric used by radiation reduction technique. The microscope TEM, SEM and ICP etc. were to analyze the characteristics of antiibacterial fiber products. The results showed that silver-Nylon and silver-PET antibacte-rial fiber have good antibacterial effects; especially the silver-PET fiber having 99.92% of reduction of bacterial number against *staphylococcus aureus*.

Research Team:
Te-Hsing Wu, Chia-Chieh Chen, Nini-ChenTsai, Bin Lin, Jiin-Hwang Chou.



(1) (2)

▲SEM of antibacterial (1) Ag/SiO_2 nylon (2) Ag/SiO_2 PET fabric after radiation.

Appendix

■Publications and Reports

International Journal Papers

Serial Number	Title	Journal	Authors	SCI	Impact Factor
INER-3801	Feasibility Study of Using Peimager Scanner for Positron Emission Mammography	IEEE Transaction on Nuclear Science	Meei-Ling Jan Ke-Shih Chuang Yu-Ching Ni Cheng-Chih Pei Ching-Kai Yeh Ying-Kai Fu	SCI	1.259
INER-3838	Effect of Thermally-Activated Diffusion on 72 Kev Ni Ion Implantation Into Cu Targets at Elevated Temperatures	Nuclear Instruments and Methods in Physics Research B	Wen-Fa Tsai Cheng-Heng Liang Chih-Chung Kai	SCI	1.181
INER-3847	IIST Small Break LOCA Experiments with the Passive Core Cooling Injection	Nuclear Engineering and Design	Chin-Chang Chang Chien-Hsing Lee Wen-Tang Hung Lang-Chen Wang	SCI	0.47
INER-3856	Characterization of Electrode Structures and the Related Performance of Direct Methanol Fuel Cells	International Journal of Hydrogen Energy	Chang-Ying Chen Cheng-Hsi Tsao	SCI	1.904
INER-3890	OBDD-Based Evaluation of Reliability and Importance Measures for Multi-State Systems Subject to Imperfect Fault Coverage	IEEE Transactions on Dependable and Secure Computers	Yung-Jui Chang S.V. Amari Shih-Yen Kuo	SCI	2.133
INER-3895	Correction Factors for the INER Improved Free-Air Ionization Chambers Calculated with the Monte Carlo Method	Applied Radiation and Isotopes	Wei-Ting Lin Chien-Hao Chu	SCI	0.757
INER-3905	Elemental Analysis of Airborne Particulate Matter Collected on PTFE-Membrane Filters by SRXRF：A Feasibility Study	Journal of Radioanalytical and Nuclear Chemistry	Ming-Cheng Yuan Chu-Fang Wang Cheng-Yuan Chang Su-Chen Huang	SCI	0.46
INER-3935	Kuosheng Bwr/6 Stability Analysis with Lapur5 Code	Annals of Nuclear Energy	Hao-Tzu Lin Chung-Jung Wang Chang-Lung Hsieh Chun-Kuan Shih Show-Chuyan Chiang Tong-Li Weng	SCI	0.62

Serial Number	Title	Journal	Authors	SCI	Impact Factor
INER-3937	Novel Maximum-Power-Extraction Algorithm for PMSG Wind Generation System	Iee Proc. Electric Power Applications	Jung-Tsung Wei Tsung-Yu Lin Wen-Hsien Chuang	SCI	0.587
INER-3939	The Influence of Vicinal Sapphire Substrate on Ga N Epilayers and LED Structures Grown by Metalorganic Chemical Vapor Deposition	Materials Science and Engineering	Wen-Jen Lin Yen-Chang Tseng Hua-Yi HSin Yi-Tseng Tseng	SCI	1.281
INER-3945	High-Cycle Fatigue Behavior of Type 316L Stainless Steel	Materials Transactions	Chin-Yuan Huang Chi-Jung Yeh Sheng-Jung Cheng Chang-Ying Chen Jung-Ching Kuo	SCI	1.103
INER-3951	Comparative Benefits and Limitations of 18F-FDG PET And CT-MRI 4 in Documented or Suspected Recurrent Cervical Cancer	Eur J Nucl Med Mol Imaging	Wu-Chih Lin Tzu-Chen Yen	SCI	3.883
INER-3984	DC Magnetron Sputtering of Si to form Sio_2 in Low Energy Ion Bean	Vacuum	Te-Chun Chan Cheng-Chung Lee	SCI	0.909
INER-3986	The Effect of A-Gaas/A-Si Double Buffer Layers on Gaas-On-Si as Determined by Transmission Electron Microscopy	Applied Physical Letters (Apl)	Wu-Yi Wen Chen-Yu Lee Shan-Ming Lan Tsun-Nung Yang Hua-Yi Hsin	SCI	1.222
INER-3992	Uncertainty and Importance Assessment Using Differential Analysis: An Illustration of Corrosion Depth of Spent Nuclear Fuel Canister	Stochastic Environment Research and Risk Assessment	Ching-Fang Shih Kuo-Feng Lin	SCI	0.704
INER-4025	Longitudinal Evaluation of Tumor Metastasis by an FDG-Micropet/Microct Dual-Imaging Modality in a Lung Carcinoma-Bearing Mouse Model	Anticancer Research	Chih-Hsien Chang Meei-Ling Jan Kuo-Hsien Fan Hsin-Erh Wang Tung-Hu Tsai Ying-Kai Fu Chieh-Fu Chen Te-Wei Lee	SCI	1.604
INER-4026	Comparative Evaluation of FET and FDG for Differentiating Lung Carcinoma from Inflammation in Mice	Anticancer Research	Chih-Hsien Chang Hsin-Erh Wang Te-Wei Lee Hsiang-Jung Chang Ching-Chiung Chen Ying-Kai Fu	SCI	1.604

Serial Number	Title	Journal	Authors	SCI	Impact Factor
INER-4029	Developing Integrated Decommissioning Information Management System (IDIMS) of Nuclear Facilities	Journal of Nuclear Science and Technology	Yi-Hsin Chou Chin-Feng Fan	SCI	0.653
INER-4032	The Preparation and Biodistribution of Novel HL91-Derivative Analogs for the Applications in Hypoxic Hypoxic Diagnosis	Journal of Nuclear Medicine	Chien-Chung Hsia Yu Su Cheng-Hsien Lin Jung-Tsan Wu Li-Han Shen Hai-Jan Chen	SCI	4.684
INER-4033	Development of Accumulator Computational Aid for Determining RCS Injection Volume	Nuclear Engineering and Design	Shih-Chen Wang Chun-Sheng Chien	SCI	0.47
INER-4071	Statistical Analysis Results of Performance Demonstration for Piping Welds	Insight	Hung-Fa Hsu Wei-Chia Hsing	SCI	0.418
INER-4095	Enhancement of Energy Yield for Ozone Production Via Packed-Bed Reactors	Ozone：Science & Engineering	Hsin-Liang Chen Hao-Ming Lee Mu-Pin Chang	SCI	0.495
INER-4098	Reevaluation of the Emergency Planning Zone for Nuclear Power Plants in Taiwan by Using MACCS2 Code	Applied Radiation and Isotopes	Chieh Wu Yung-Mu Yang Ying-Chien Chen Ke-Shih Chuang Huan-Tung Chen	SCI	0.757
INER-4105	Synthesis and Characterization of Tio_2/Baf_2/Ceramic Radio-Sensitive Photocatalyst	Journal of Photochemistry and Photobiology A: Chemistry	Ching-Tsung Yu Chen-Hung Lee	SCI	2.286
INER-4118	Evaluation of the Impact of SAMG on The Level-2 PSA Results of a Pressurized Water Reactor	Nuclear Technology	Yu-Chih Ke Ching-Hui Wu Min Lee	SCI	0.326
INER-4128	A Comparison of Biodistribution between ^{111}In-DTPA Octreotide and ^{111}In-DOTATOC in Rats Bearing Pancreatic Tumors	J. Vet. Med. Sci	Tsai-Yueh Lo Yung-Chang Lin Wan-Yu Lin Chih-Hsiung	SCI	0.663
INER-4132	Effective Preparation of Carbon Nanotube Supported Pt-Ru Electrocatalysts	Materials Chemistry and Physics	Chun-Ching Chien Chun-Tsai Cheng	SCI	1.136

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INER-4165	Children of Helicobacter Pylori-Infected Dyspeptic Mothers are Predisposed to H. Pylori Acquisition with Subsequent Iron Deficiency and Growth Retardation	Helicobacter	Yu-Chung Yang Po-Hsiang Hsu Jui-Cheng Lee Hsiao-Pai Yang Chun-Chung Wu	SCI	2.584
INER-4174	Absolute Counting of ^{188}Re Radiopharmaceuticals	Applied Radiation and Isotopes	Ming-Tseng Yuan Hsiao-Fang Pang Chu-Fan Wang	SCI	0.757
INER-4179	Effect of Dynamic Strain Aging on Fatigue Crack Growth Behavior of Reactor Pressure Vessel Steels	Material Science and Technology	Chun-Yuan Huang Chi-Jung Yeh Jung-Ching Kuo	SCI	0.639
INER-4189	Monitoring The Moisture-Related Degradation of Ethylene Propylene Rubber Cable by Electrical and SEM Methods	Polymer Degradation And Stability	Yao-Tung Hsu Kuei-Shu Chang Liao Tien-Ke Wang Cheng-Tsung Kuo	SCI	1.749
INER-4190	Development of a Small DMFC Bipolar Plate Stack for Portable Applications	J. Power Sources	Chang-Ying Chen Chih-Yen Hsu Yin-Sheng Lee	SCI	2.77
INER-4191	Performance of Direct Methanol Fuel Cell Using Carbon Nanotubesupported Pt-Ru Anode Catalyst with Controlled Composition	Journal of Power Sources	Chun-Ching Chien Chun-Tsai Cheng Hsien-Tu Chiu Su-Hsien Lin Wan-Min Huang Ning-Yi Hsu His-Cheng Yen	SCI	2.77
INER-4199	Comparison on Characteristics of Raduophotoluminescent Glass Dosimeters and Thermoluminescent Dosimeters	Radiation Protection Dosimetry	Shih-Ming Hsu Mei-Hsiu Lin Wei-Li Chen	SCI	0.49
INER-4200	Redundancy of Non-AUG Initiators：A Clever Mechanism to Enhance the Efficiency of Translation In Yeast	The Journal of Biological Chemistry	Chien-Chia Wang Li-Chung Men Kuang-Jung Chang Grance Lin	SCI	5.854
INER-4201	Precipitation Kinetics and Transformation of Metastable Phases in Al-Mg-Si Alloys	Acta Materialia	Cheng-Hsi Tsao Chang-Ying Chen Yu-Shun Cheng Tsung-Yuan Cheng	SCI	3.43

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INER-4228	Magnitude And Effects of X-Ray Scatter of a Cone-Beam Micro-CT for Small Animal Imaging	Nuclear Instruments And Methods in Physics Research A	Yu-Ching Ni Ke-Shih Chuang Meei-Ling Jan Kuo-Wei Chen	SCI	1.224
INER-4259	Heteroepitaxial Growth of Gaas on Si by MOVPE Using A-Gaas/A-Si Double Buffer Layers	Journal of Crystal Growth	Wu-Yi Wen Chen-Yu Lee Yen-Chin Huang Meng-Chu Chen Tsun-Nung Yang Shan-Ming Lan Chuh-Hung Wu Hui-Fen Hung Kuo-Chung Chi	SCI	1.681
INER-4273	Regulatory Software Configuration Management System Design	Reliability Engineering & System Safety	Yi-Hsin Chou Chin-Geng Fan	SCI	0.747
INER-4276	The Sliding and Overturning Analysis of a Free-Standing Cask Under Earthquake	Safety and Structural Integrity Journal	Jih-Feng Hsu Kun Ting Chun-Hsia Yu Chien-Chung Chen Chih-Tien Liu	SCI	
INER-4277	The Study of Fatigue Crack Growth of 304SS with the Influence of Loading Frequency and Temperature	Nuclear Engineering and Design Journal	Chien-Chung Chen Yen-Hsin Shih	SCI	0.47
INER-4278	Instrumental Design and Verification of a Non-destructive Testing with Neutron Backscattering for Boron-Based Material Characteristics	Journal of Nuclear Science and Technology	Cheng-Hsi Tsao Hung-Fa Hsu Hsin-Fa Fang Ming-Chung Hsieh Shih-Chung Cheng	SCI	0.653
INER-4279	Three-Dimensional Dose Evaluation System Using Real-Time Wind Filed Information for Nuclear Accidents in Taiwan	Nuclear Instruments and Methods, A	Chieh Wu Chung-Hsin Lu Shu-Chun Chang Yung-Mu Yang Po-Ching Chang	SCI	1.224
INER-4325	Supported Nafion Membrane for Direct Methanol Fuel Cell	Journal of Fuel Cell Science and Technology	Guo-Bin Jung Ay Su Cheng-Hsin Tu Fang-Bor Weng Shih-Hung Chan Ruey-Yi Lee Szu-Han Wu	SCI	

Serial Number	Title	Journal	Authors	SCI	Impact Factor
INER-4327	Kinetic Modeling on Removing NF3 from N_2/NF_3 Mixture Via Dielectric Barrier Discharges	Plasma Processes & Polymers	Hao-Ming Lee Hsin-Liang Chen Moo-Been Chang	SCI	2.846
INER-4348	Characterization of the NIST Seaweed Standard Reference Material	Applied Radiation and Isotopes	I. Outola Hua-Chou Wei	SCI	0.757
INER-4360	A Study of Porous Slag with Plasma Arc Melting	Advances in Science and Technology	Shuang-Hsi Lien Chih-Kuan Chang Chin-Ching Tseng	SCI	
INER-4382	Development of Drywell Water Level Computational Aid and Application on Containment Flooding Strategy of Mark-III Nuclear Power Plant	Nuclear Technology	Wei-Nien Su Shih-Chen Wang Yi-Ming Huan	SCI	0.326
INER-4397	The Growth of Single-Phase In_2Se_3 by Using Metal Organic Chemical Vapor Deposition with Dual-Source Precursors	Applied Physics Letters	Kuo-Jen Chang Shan-Ming Lan Cheng-Yang Chang	SCI	4.127
INER-4422	Complementary SAXS and SANS for Structural Characteristics of a Polyurethethance Elastomer of Low Hard Segment Content	Physical B	Ya-Hsien Sun Yu-Shun Cheng Yi-Shan Huang Keng-San Liang Chang-Lang Lin Cheng-Hsi Tsao	SCI	0.796

International Conference Papers

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1	INER-3793	Development of a Total System Performance Assessment for Spent Nuclear Fuel Repository	2005 International Symposium on Radiation Safety Management	Wen-Shou Chuang Ching-Fang Shih Fu-Lin Chang Li-Hao Wu Chih-Lung Chen Chun-Ting Lu Neng-Chuan Tien Chung-Chang Tung Chen-Chang Lee Tzu-Feng Tseng
2	INER-3794	Implementation of the Second Phase Site Selection for LLW Disposal in Taiwan	2005 International Symposium on Radiation Safety Management	Wen-Shou Chuang Li-Min Chi Neng-Chuan Tien Fu-Lin Chang Sol-Il Su Ling-Cheng Liu
3	INER-3806	Chitosan Sponges Containing Acidic Fibroblast Growth Factor for Wound Healing	12th International Conference on Biomedical Engineering	Shan-Hui Hsu Yung-Hsiu Chen Chih-Wei Chou Han Chang Te-Hsing Wu Chia-Chieh Chen
4	INER-3813	Progress in DMFC at INER	2005 Fuel cell Seminar	Chang-Ying Chen Chun-Lung Chang Ying-Sheng Lee
5	INER-3814	Streamlining the Evaluation Process of Inspection Findings	The 20th Sino-Japanese Seminar on Nuclear Safety	Chun-Chang Chao Jyh-Der Lin
6	INER-3831	Current Status of Dry Storage Project at INER	The 20th Sino-Japanese Seminar on Nuclear Safety	Yu-Hao Huang Ting-Yi Lee
7	INER-3840	Apparatus and Method for Automatic Preparation of High Concentration ^{188} Re-Perrhenate Solutions for Intravascular Brachytherapy	EANM'05	Po-Tsang Hsieh Tsai-Yueh Lo Ai-Jen Lo Min-Nan Chen Wu-Chih Lin
8	INER-3841	Radiocatalytic Degradation of Spent Organic Ion Exchange Resins Using Baf_2/Tio_2/ Ceramic Nanocomposite	APSORC-05	Ching-Tsung Yu Chu-Fang Wang Wei-Jen Wang Tse-Min Chang

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9	INER-3849	Initiating Event Analysis for ABWR on the Purpose of Risk-Informed Applications	2005 Asia-Pacific Conference on Risk Management and Safety	Chun-Chang Chao Ching-Tien Huang Meng-Chi Chen Jyh-Der Lin Ching-Hui Wu
10	INER-3850	The Risk Impact from Hazard Factor of Fire Probabilistic Safety Assessment for the BWR Nuclear Power Plant in Taiwan	2005 Asia-Pacific Conference on Risk Management and Safety	Ching-Hui Wu Tzu-Jen Lin Tsu-Mu Kao
11	INER-3851	Accident Sequence Precursor Analyses of Taiwan Nuclear Power Plants	2005 Asia-Pacific Conference on Risk Management and Safety	Yuan-Ching Chou Ching-Hui Wu
12	INER-3852	An Approach for Implementing Risk-Informed Evaluating on Check Value in Taiwan BWR Type Nuclear Power Plant	2005 Asia-Pacific Conference on Risk Management and Safety	Kun Ting Yuan-Chih Lee Hsien-Hung Hung Chien-Kuo Wang Fu-Tien Chien Che-Cheng Kang Tsu-Mu Kao Jyh-Der Lin
13	INER-3853	Risk-Informed Regulation and Application in Taiwan	2005 Asia-Pacific Conference on Risk Management and Safety	Tsu-Mu Kao
14	INER-3917	Reliability and Sensitivity Analysis of Embedded Systems with Modular Dynamic Fault Trees	IEEE International Region 10 Conference (Tencon'05)	Hsiang-Kai Lo Ching-Yu Huang Yung-Jui Chang
15	INER-4012	Use of a Pixilated LYSO Detector for Both Positron and Single Photon Imaging Applications	Academy of Molecular Imaging Annual Conference 2006	Hsin-Ching Liang Kuo-Wei Chen Mei-Ling Jan
16	INER-4017	Monitoring of 2-Deoxy-2-[^{18}F]Fluoro-D-Glucose Uptake in Tumor-Bearing Mice by using High-Sensitivity Projection Imaging: Compared with PET Imaging	Academy of Molecular Imaging Annual Conference 2006	Mei-Ling Jan Kuo-Wei Chen Yu-Ching Ni Mei-Hsiu Liao T. Okamoto T. Yamashita
17	INER-4022	Fast Risk Significance Determination Tool for Inspectors of Nuclear Power Plants	International Conference on PSA and Maintenance (PSAM8)	Chun-Chang Chao Meng-Chi Chen Shu-Chen Hsu Jyh-Der Lin Tsu-Mu Kao

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18	INER-4023	Digital I&C Failure Derivation and Analysis for Lungmen NPP	Dependability of Computer Systems DepCos'06	Hui-Wen Huang Su Yi Yen-Chang Tseng Cheng-Tsung Kuo Ming-Hui Chen Yuan-Chang Yu Li-Hsin Wang Hsin-Ho Wang
19	INER-4037	Using Agile Development Process for Web-Based Low-Level Radioactive Waste Management and Analysis System	The 10th International Conference on Environmental Remediation and Radioactive Waste Management	Yi-Hsin Chou Hsieh-Wei Hsiao Hsiu-Ju Yang
20	INER-4039	Preparing the Nanostructured Mesoporous Titanium Dioxide Thin Film for Sensitized Solar Cell	2006 IEEE 4th World Conference on Photovoltaic Energy	Tsung-Yang Wei Yung-Fang Lu Chui-Huan Chiu Jen-Chieh Chung Hua-Yi Hsin Yen-Chang Tseng
21	INER-4044	Steam Plasma Gasifier for Biomass Gasification-Thermodynamic and Kinetic Analyses	ISNTPT-5	Hao-Ming Lee Chin-Ching Tseng
22	INER-4047	Syntheses of ^{123}I-IBOX for Binding-Amyloid Plaques in the Tg2576 Transgenic Mice	The Society of Nuclear Medicine 53nd Annual Meeting	Shih-Ying Lee Kang-Wei Chang Kuo-Hung Wu Chai-Jung Chang Hsueh-Hsun Liu Chia-Chieh Chen Wu-Chih Lin Li-Han Shen
23	INER-4048	Biodistribution of ^{123}I-MIPP in Rat and Radiation Dose Estimation	The Society of Nuclear Medicine 53nd Annual Meeting	Hung-Chun Kao Shih-Ying Lee Chia-Jung Chang Kuo-Hung Wu Kang-Wei Chang Hsueh-Hsun Liu Chia-Chieh Chen Wu-Chih Lin Li-Han Shen
24	INER-4049	^{123}I-MIPP as a Scintigraphic Probe for Norepinephrine Transporter in a Tat Model	Society for Molecular Imaging	Hung-Chun Kao Kuo-Hung Wu Chai-Jung Chang Shih-Ying Lee Hsueh-Hsun Liu Chia-Chieh Chen

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25	INER-4054	Quantitative Risk Assessment of the LNG Storage Tank Systems in Taiwan	International Conference on PSA and Maintenance (PSAM8)	Tsu-Mu Kao Chun-Sheng Weng Jhy-Der Lin
26	INER-4062	Assess Serotonin Transporter Availabilities in Rat Brain by Animal SPECT Scanner	Society of Nuclear Medicine 2006	Chai-Jung Chang Kuo-Hung Wu Shih-Ying Lee Hsueh-Hsun Liu Chia-Chieh Chen Wu-Chih Lin Li-Han Shen
27	INER-4063	Imaging Selective Binding of ^{123}I-MIPP in Rat Brain by Microspect	Society of Nuclear Medicine 2006	Kuo-Hung Wu Chai-Jung Chang Li-Tsung Huang Hung-Chun Kao Shih-Ying Lee Hsueh-Hsun Liu Chia-Chieh Chen Wu-Chih Lin Li-Han Shen
28	INER-4066	Optimization of DBD Reactors for Ozone Generation	ISNTPT-5	Hsin-Liang Chen Hao-Ming Lee Mu-Pin Chang
29	INER-4067	A Promising Hydrogen Generation Technology-Partial Oxidation of Methane with Plasma-Assisted Catalysis	ISNTPT-5	Mu-Pin Chang Yu Chao Hao-Ming Lee Hsin-Liang Chen
30	INER-4068	Radiation Effects: Environmental Radiophotoluminescent Glass Dosimeters Versus Thermoluminescent Dosimeters	6th European Conference on Luminescent Detectors and Transformers of Ionizing Radiation	Chen-Hung Lee Mei-Hsiu Lin Ying-Chien Chen Chu-Fang Wang
31	INER-4077	A Single Stage Single Switch Parallel AC/DC Converter Based on Two-Ouput Boost-Flyback Converter	The 37th IEEE Power Electronics Specialists Conference	Heng-Yi Lee Lung-Kuo Chang
32	INER-4079	Preparation of Antibacterial Fabric Composites Containing Nano-Material	IUMRS International Conf. In Asia 2006	Te-Hsing Wu Yi-Te Tai Chia-Chieh Chen Li-Han Shen
33	INER-4086	Reclamation of Water-Quenched Slag as Permeable Brick and Glass-Ceramic	The Second International Conference on Environmental Science	Sheng-Fu Yang Wen-Tung Chiu Ching-Liang Chen Chin-Ching Tseng

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34	INER-4103	Digital Instrumentation and Control Failure Events Derivation and Analysis by Frame-Based Technique	ICONE 14:14th International Conference on Nuclear Engineering	Hui-Wen Huang Su Yi Yen-Chang Tseng Ming-Hui Chen
35	INER-4108	Study of Extension Imaging Area of a Gamma Detector by Combining Pmts	Society of Nuclear Medicine 2006	Hsin-Ching Liang Mei-Ling Jan
36	INER-4116	QUANTITATIVE Imaging by using a Combined Micro-PET/CT	Society of Nuclear Medicine 2006	Mei-Ling Jan Yu-Ching Ni Kuo-Wei Chen Wei-Lun Hsu Cheng-Yen Chiang Mei-Hsiu Liao
37	INER-4120	Molecular Dynamic Computer Simulation of Thin-Film's Heat Dissipation Rate	2006 MRS Spring Meting	Ya-Yun Cheng Hung-Ming Hsieh Cheng-Chun Lee
38	INER-4135	On Evaluating The RC Plate Containing Epoxy-Repaired Delamination Using C-Scans of DPC UT and High-Frequency GPR	EASEC 10	Kuang-Chih Pei Chia-Chi Cheng Tung-Wei Lin
39	INER-4154	Dose Perturbation of Stents in IVBT for In-Stent Restenosis using Gafchromicmd-55 Film	LUMDETR 2006	Chien-Hao Chu Po-Chang Hsieh Wei-Ting Lin Wei-Li Chen
40	INER-4169	Monitoring Retention of ^{131}I Labeled Vaccine by Quantitative Micro-SPECT Imaging	Fifth Annual Meeting of the Society for Molecular Imaging	Wei-Lun Hsu Chung-Hsing Yeh Mei-Ling Jan Wei-Chuan Hsu Chih-Hsien Chang Te-Wei Lee
41	INER-4170	Propylene Acid Derivatives Polymer Gel	World Congress on Medical Physics and Biomedical Engineering	Po-Chang Hsieh Chien-Hao Chu Po-Hsiu Lee Ya-Wen Lee
42	INER-4178	ABWR RPV and BOP Blowdown Analysis with RELAP5-3D/K for the Event of Feed Water Line Break	Relap5-3D User's Meeting	Kuo-Hsing Liang Chung-Yu Yang Liang-Che Tai
43	INER-4180	Synthesis and Characterization of Self-Activated Tio_2 /Monazite Photocatalyst	AP-AWTGORT	Ching-Tsung Yu Chu-Fang Wang Ya-Ting Chang Tzu-Yu Chen
44	INER-4181	Photosynthesis and Characterization of Pt, Fe and Ag Modified Tio_2	AP-AWTGORT	Ching-Tsung Yu Chu-Fang Wang Ya-Ting Chang Tzu-Yu Chen

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45	INER-4182	A Regulatory Software Maintenance Environment using Agent-Based Software Configuation Management	International Conference on Dependability of Computer System	Yi-Hsin Chou Chin-Feng Fan
46	INER-4198	Electrical Characteristic Improvement of High-K Gated MOS Device by Nitridation Treatment using Plasma Immersion Ion Implantation(PIII)	2006 International Conference on Solid Devices and Materials	Kuei-Shu Chang-Liao Shang-Feng Huang Hsien-Yen Kao Ping-Hung Tsai Tzu-Tseng Wang Wen-Fa Tsai Chi-Feng Ai
47	INER-4206	Removal of Pfcs from Gas Streams Via Dielectric Barrier Discharge and Combined Plasma Catalysis	Asia-Pacific International Symposium on Air and Water Treatments by Green Oxidataion/Reduction Technologies-Catalyst Plasma and Hybrid Systems	Li-Chun Cheng Hsin-Liang Chen Hao-Ming Lee Moo-Been Chang
48	INER-4225	A Quantitative Method for Pulmonary Fibrosis Monitoring by Micro-CT 3D Images	The Society for Molecular Imaging 2006	Yu-Ting Fang Mei-Ling Jan Chung-Hsing Yeh Cheng-Yen Chiang Kuo-Wei Chen Te-Wei Lee
49	INER-4232	Site Selection for the Disposal of LLW in Taiwan	2006 Waste Management Conference	Wei-Shou Chuang Li-Min Chi Neng-Chuan Tien Fu-Lin Chang
50	INER-4233	De-Blurring of Nuclear Image by using Directed Restoration Methods	The Society for Molecular Imaging 2006	Cheng-Yen Chiang Chia-Chieh Chen Chung-Hsing Yeh Kuo-Wei Chen Yu-Ting Fang
51	INER-4286	F-18-FDG Micro PET Scans on Transient Focal Ischemic Rat Stroke Model	2006 Annual Congress of the European Association of Nuclear Medicine	Kuan-Yin Chen Chia-Jung Chang Li-Tsung Huang Kuo-Hung Wu Hsueh-Hsun Liu Chia-Chieh Chen Ying-Kai Fu

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52	INER-4291	Microspect/CT Imaging, Biodistribution and Pharmacokinetics of ^{188} Re-BMEDA-Labeled Pegylated Liposome after Intraperitioneal Injection	The Society for Molecular Imaging	Te-Wei Lee Liang-Cheng Chen Chih-Hsien Chang Shu-Pei Chiu Chia-Yu Yu Tsui-Jung Chang Ya-Chen Chang Mei-Ling Jan Chung-Hsing Yeh Kan Ting
53	INER-4319	Evaluation of Planar Tomography using Large Area Planar Positron Imaging System	IEEE Nuclear Science Symposium and Medical Imaging Conf. (NSS-MIC 2006)	Yu-Ching Ni Mei-Ling Jan
54	INER-4323	Lapur5.2 BWR Stability Analysis in Chinshan Nuclear Power Plant	Proceedings of ICONE14: 14th International Conference on Nuclear Engineering	Chang-Lung Hsieh Hao-Tzu Lin Chung-Jun Wang Chun-Kuan Shih Show-Chuyan Chiang Tong-Li Weng
55	INER-4326	Determine the Optimal Imaging Time for Tc-99m[DTPA1, Lys3 (DADT), Tyr4] Bombesin by Serial Micro-SPECT Imaging in SCID Mice with Human PC-3 Model	The Society for Molecular Imaging	Pan-Fu Kao Tsung-Li Ho Liang-Cheng Chen Chung-Hsing Yeh Ya-Chen Chang Mei-Ling Jan Chih-Hao Kao Te-Wei Lee Mei-Hsiu Liao Ying-Kai Fu
56	INER-4328	Inactivation of Aquatic Microorganisms by Low Frequency AC Discharges	The 4th Asia-Pacific International Symposium on the Basics and Application of Plasma Science and Technology (APSTPT-2005)	Hao-Ming Lee Chih-Wei Chen Moo-Been Chang
57	INER-4329	Influence of N2(A3) on Removing NF3 in Dielectric Barrier Discharge	The 4th Asia-Pacific International Symposium on the Basics and Application of Plasma Science and Technology (APSTPT-2005)	Hao-Ming Lee Chen Hsin Liang Moo-Been Chang
58	INER-4330	PFCS Abatement Via Combined Plasma Catalysis	The 4th Asia-Pacific International Symposium on the Basics and Application of Plasma Science and Technology (APSTPT-2005)	Hao-Ming Lee Moo-Been Chang Chen Hsin Liang

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59	INER-4342	Evaluation of an LYSO Based Multi-PMT Detector for Both Positron and Single Photon Imaging Usage	IEEE Medical Imaging Conference 2006	Hsin-Ching Lang Mei-Ling Jan Cheng-Lung Su
60	INER-4362	Binding of *B*-Amyloid Plaques by ^{123}I-IBOX in a Transgenic Mouse Tg2576	Society for Molecular Imaging	Kang-Wei Chang Shih-Ying Lee Kuo-Hung Wu Chia-Jung Chang Chia-Chieh Chen
61	INER-4371	Evaluation of In-111 TTDA-Herceptin for Radioimmunoimaging	2006 Annual Congress of the European Association of Nuclear Medicine	Tsai-Yueh Lo Han-Hsing Yang Yi-Chung Tang Chen-Tsun Chen Wu-Chih Lin
62	INER-4372	Current Status and Future Prospect of Medical Radioisotope Application in Taiwan	2006 PBNC	Chen-Tsun Chen Ying-Ling Wang Wu-Chih Lin
63	INER-4374	Cyclotron Radiopharmaceutical Industry in Taiwan	9th Congress of the World Federation of Nuclear Medicine & Biology	Chen-Tsun Chen Ying-Ling Wang Wu-Chih Lin
64	INER-4378	The Characterization and Biodistribution of Novel HL91-Derivative Analog for Imaging Hypoxia	2006 Annual Congress of the European Association of Nuclear Medicine	Chien-Chung Hsia Cheng-Hsien Lin Li-Han Shen Yu Su Hao-Jan Chen
65	INER-4396	Development of Evaluation Method for Software Safety Analysis Technique	15th Pacific Basin Nuclear Conference	Hui-Wen Huang Su Yi Cherng-Tsong Kuo Ming-Hui Chen Tsun-Kuan Shih
66	INER-4401	The Development of an 1kw HCPV at INER	2006 IEEE 4th World Conference on Photovoltaic Energy	Yen-Chang Tseng Hui-Fem Hung Chih-Hung Wu Chieh Cheng Hua-Yi Hsin
67	INER-4406	Thermal Stress Analyses of a Planar SOFC Stack During Start-Up and Steady Operation	2006 Fuel Cell Seminar	Chih-Kuang Lin Tsung-Ting Chen Yau-Pin Chyou Lieh-Kuang Chiang
68	INER-4408	A Valuable Computerized Inventory Control System for Automated Radioactive Waste Storage Warehouse at Taiwan Nuclear Power Plant	WM'06 the 32nd Waste Management Conference	Chih-Chieh Ma I-Tao Lung Cheng-Dar Lee Yen-Chieh Wang

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69	INER-4411	Experimental and Numerical Studies on Velocity Distributions in Interconnects for Planar Solid Oxide Fuel Cell	2006 Fuel Cell Seminar (30th Anniversary)	Chia-Ming Huang Sheng-Yang Shih Cheng-Ho Yen Chien-Hsiung Lee
70	INER-4416	A Study of Reset Mode in Advanced Alarm System Simulator	NPIC&HMIT 2006	Tzu-Chung Yenn Hsueh-Ling Huang Pei-Hui Huang Chung-Cheng Hsu Hao-Wu Huang Yuan-Chang Yu
71	INER-4417	Evaluation of Mental Workload on Digital Maintenance System in Nuclear Power Plants	NPIC&HMIT 2006	Hsueh-Ling Huang Pei-Hui Huang Chih-Tsung Lin Kuo-Feng Liang Tzu-Chung Yenn Chung-Cheng Hsu
72	INER-4420	Preparation and Development of the Interconnect Materials of SOFC Stacks by a Glycine-Nitrate Combustion Process	First Asian Conference on Electrochemical Power Sources	Chen-Yun Chen Wei-Chia Hsiung Jui-Yi Lee Ting-Kuo Huang

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