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2005 ANNUAL REPORT

Institute of Nuclear Energy Research

ATOMIC ENERGY COUNCIL, EXECUTIVE YUAN

Contents

Enlightens Accumulated Experiences and Creates Knowledge Economic through Constant Enhancements of Technologies in the Pursuit of Perfection

Director-general

The year of 2005 is a year of transmutation for INER. In the year, we introduced substantial innovations in administration and technical enhancements in R&D programs. Overall, each of the performance indices we set for the year, such as No. of patents, journal papers, research reports, and annual revenue for technical services, etc., has reached within the high- or the medium-level of our target. In comparison with other domestic research institutions, we stand a predominant position.

Based on a document issued by the Executive Yuan on January 25th, 2005, INER has been assigned to the third-phase priority list for transforming into a Public Corporation. In order to meet future challenges, we take actions to transform ourselves by “Strengthening Implementation Capability as well as Enhancing Competitiveness” and “Cohering Team Consensus as well as Reducing Gap in Internal Cognition”.

The Institute's contributions in the nuclear aspect are becoming more and more substantial. For instance, revenue from technical services in nuclear safety related areas, the sale as well as technical services of radiopharmaceuticals have significantly increased. More and more new personnel are joining our group to receive training in nuclear fields. On top of this, owing to the skyrocketing oil prices as well as the Kyoto Protocol's effect to limit carbon dioxide emission, the Institute steers its R&D efforts toward energy resources and carbon dioxide reduction problems that have become important and current national issues of the administration.

The nuclear related technologies accumulated over the years by the Institute have put INER in an authoritative position domestically. This has not only been affirmatively recognized by the Atomic Energy Council (AEC) and the Taipower Company (TPC), a profound reputation regarding to INER's technical capability has also been established worldwide. This technical competitiveness can prevent overseas corporations from building unfair monopolization in Taiwan in terms of technology supply and business practice. Typical examples about these technical achievements include: Nuclear Fuel Reload Design; Safety Analysis; Thermal Power Effectiveness Analysis and Surveillance; Nuclear Fuel Inspection and Testing; Nuclear Safety Related Component Dedication and Qualification; Non-Destructive Inspection and Testing; and Simulator Upgrade; etc. In the strategic planning aspect, INER introduces existing technologies from overseas on one hand, and on the other hand develops in-parallel technologies to complement. In the aspect of resources allocation, in addition to inhouse research activities, we aggressively promote technical integration of strategic alliances and technology collaborations with domestic and international academia as well as industries. In the aspect of technology applications, our short-term goal is to actively promote technical services to domestic nuclear organizations including AEC and TPC. In the long term, our goal is to establish a technical service industry on the island through incubating, licensing, and transferring related technologies, depending on market scale and development potential.

The Radiopharmaceutical Center of the Radiation Application Technology Center is actively engaged in the research of biomedicine applications. The mission is to serve to the welfare of our people by applying atomic energy related technologies. There are currently 14 drug permits owned by the Institute. The Institute is the only Radiopharmaceutical manufacturer that has passed the third-level cGMP inspection administered by the Department of Health (DOH) in

Taiwan. In 2005, the Institute acquired 2 additional drug permits from DOH, namely: “INER Tc-99m TRODAT-1 Imaging Agent” and “ INER In-111-Pentetreotide Injection”. These two drugs have obtained respectively a gold medal and a bronze medal award in the medical R&D contest held by both the DOH and the Ministry of Economy (MOE). Moreover, during the year the Institute successfully sold 2 invention patents entitled “Method for Synthesis and ^{99m}Tc Labeling of 2-Alkoxyisobutylisonitrile” and “Preparation of Copper 2-Alkox yisobutylisonitrile Complexes and ^{99m}Tc Labeling of 2-Alkoxyisobut ylisonitrile” to Cardinal Health Company of the United States. This event marks a new milestone of great achievement in promoting the Institute's R&D output to the international market.

The decontamination and decommissioning (D&D) of nuclear facilities upon expiration of their license and the related nuclear wastes disposal are inevitable tasks in pursuit of nuclear applications and technical development. This is becoming more and more urgent as domestic power plants are likely to face such a challenge in the coming two decades. In view of this, the Institute made advance investments in the R&D of both radioactive waste treatment and disposal technologies, as well as decommissioning technologies of nuclear facilities. The objective is firstly to establish advanced and reliable technologies for implementing D&D of nuclear facilities in the Institute that have been suspended from operation. Secondly, in order to establish a radiation-safe homeland, INER will accumulate related experiences and capabilities for applications that serve the welfare of our nation and to ensure the safety of our environment and citizen. To this end, INER not only established several important facilities, but also accomplished portions of many D&D tasks within site boundary of the Institute. More importantly, we have actually introduced or developed relative technologies that will serve as the foundation for future technology development. These practical experiences can serve as useful references for the D&D planning, safety evaluation and operation implementation of nuclear power plants in the future.

Facing the current crises of global warming, air pollution and oil exhaustion, as further compounded by the goal to limit carbon dioxide emission in the Kyoto Protocol, nations worldwide are aggressively searching for alternative formula to substitute fossil energy by searching for green energy production. Following this government policy, the Institute devoted aggressively our R&D efforts into new energy technologies. Through implementing two projects entitled " Renewable Energy Focused Development Program " and "Application of Nuclear Energy Expertise on Nano Technology Development ", the Institute has smoothly accomplished various goals set for new energy related R&D programs in 2005.

In the area of plasma technology development and applications, the Institute has established the following four facilities for industrial promotion and the development of resource technologies: High Power Plasma Torch Testing Center, Plasma Treatment Process Development Center, Plasma Slag Recycling Research Center, and Plasma Melting Technology Industrial Application Platform. These research activities expand further into three focused development programs entitled " Development of the Commercial Applications of the High-Power Plasma Torch ", "Development and Applications of the Plasma Melting and Recycling Technologies ", and "Development of the Plasma Gasification Technology for the Conversion of Organic Waste to Energy ".

It is today a general consensus by our domestic science and technology circles to place more and more emphasis on the development of knowledge economy and to strive hard in turning acquired technologies into industries. INER has been aggressively promoting knowledge economy for years and has demonstrated significant results on the effectiveness in investing our research efforts. For instance, in the nuclear safety technical service area, substantial amount of foreign exchange expenditure has been avoided in virtue of providing technology supports to TPC. In the radiopharmaceuticals area, Tl-201 is another good example. Taiwan had to import Tl-201 from abroad before INER successfully developed and produced the product. Since then, the market price for performing such examination

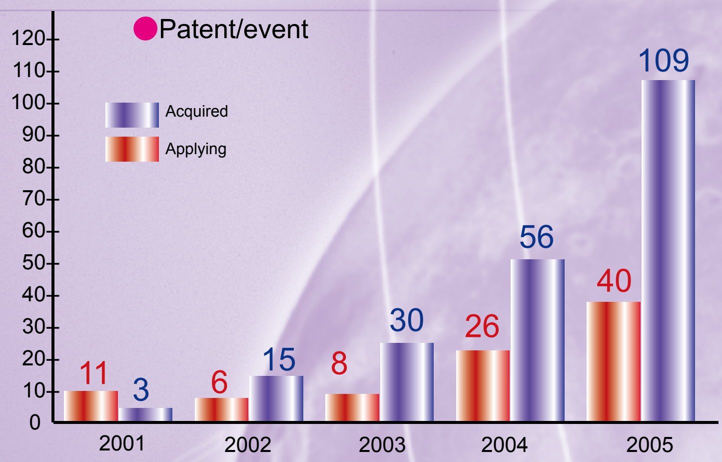
is went down 50% and the National Health Insurance Bureau saved nearly 100 million NT dollars from its pocket annually. The Institute will transfer these technologies to domestic manufacturer so as to help the establishment and growth of the domestic nuclear medicine industry.

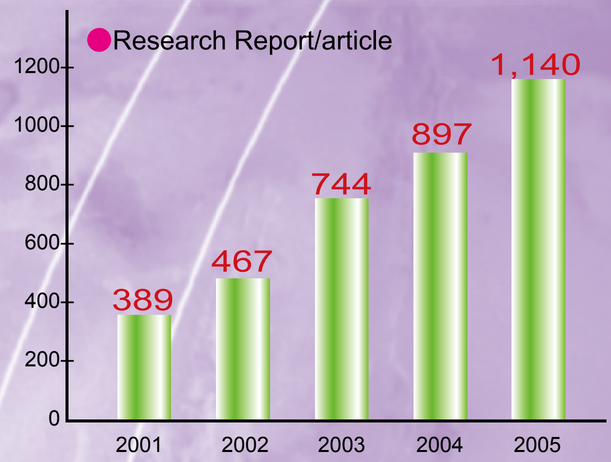
In 2005, the Institute participated a national standardization assessment program held by MOE and obtained the award of a team achievement prize. This marks a worthy approval of the Institute's continuous endeavor to gain public trust over the years. This recognition powers up our motivation to meet the ever increasing future challenges. We firmly believe that the culture for innovation is the foundation for the sustainable development of the Institute. This culture for innovation in practice is “To Constantly Enhance Technology in the Pursuit of Perfection ”. The Institute commits to devote all efforts to this practice and will persist in pursuing for technological excellency required of a world-class research institution.

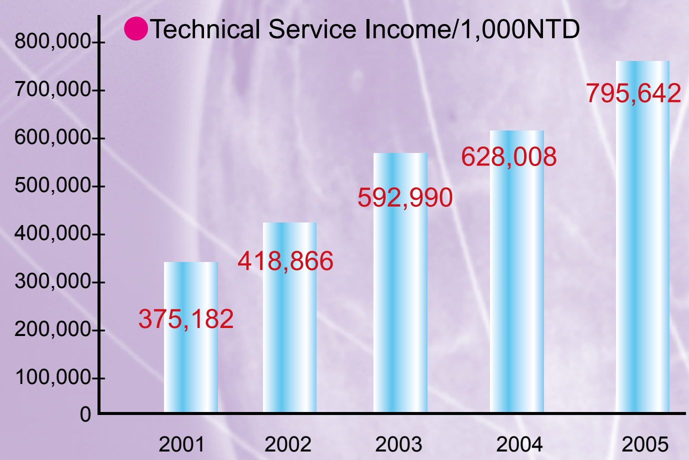
Introduction of the Institute of Nuclear Energy Research

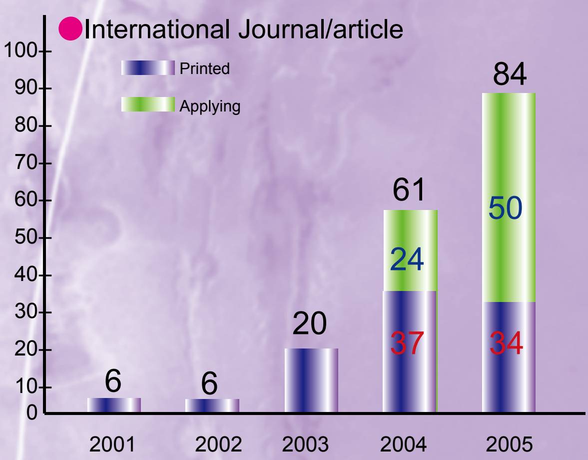
In accordance with the current requirements of governmental reform as well as an endeavor for sustainable development, the Institute of Nuclear Energy Research (INER) established three technology centers in July 2002. The three technology centers, namely, Nuclear Safety Technology Center, Environmental 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.

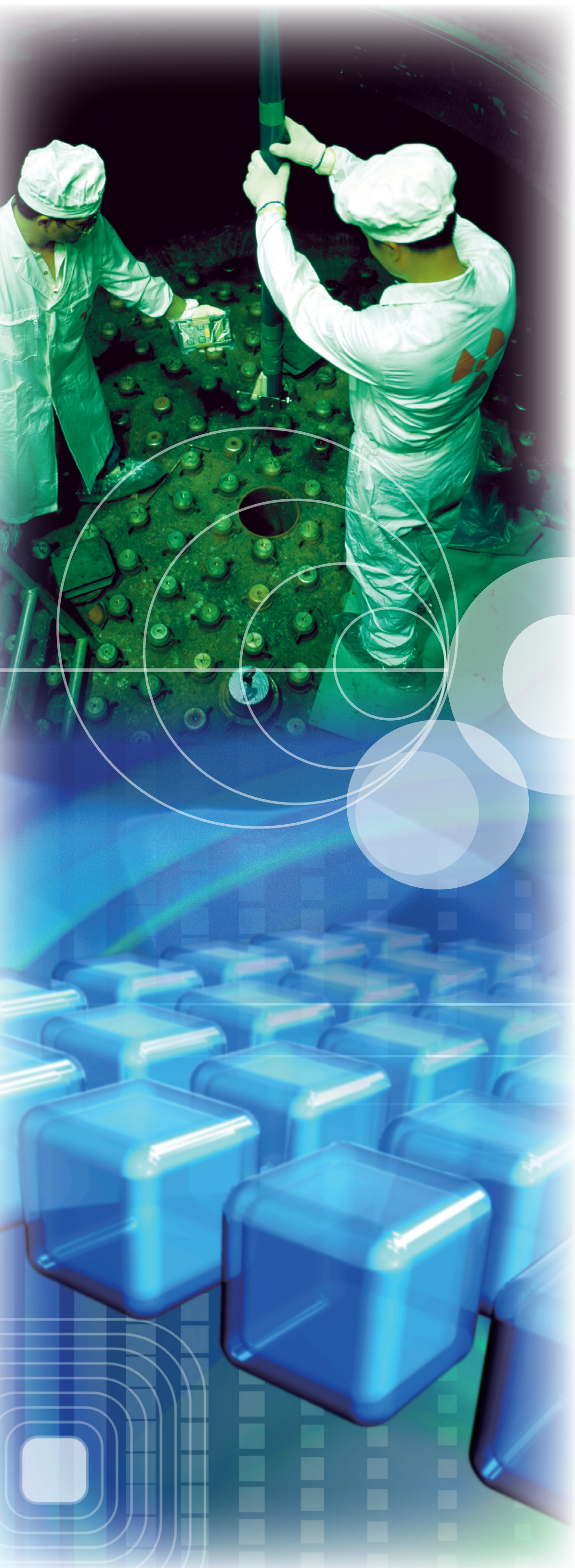
By the relentless efforts by the three Centers, the quality and the quantity of patents, research reports, international journal papers, and revenue from technical services have significantly enhanced and increased during the year. These achievements have certainly founded a solid base for INER in the effort toward becoming a world-class competitive research institution.











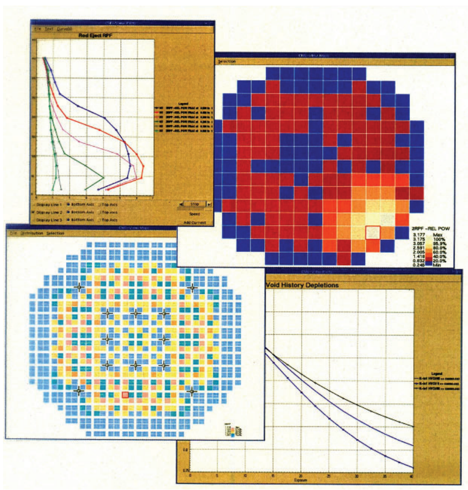
Nuclear Safety Technology

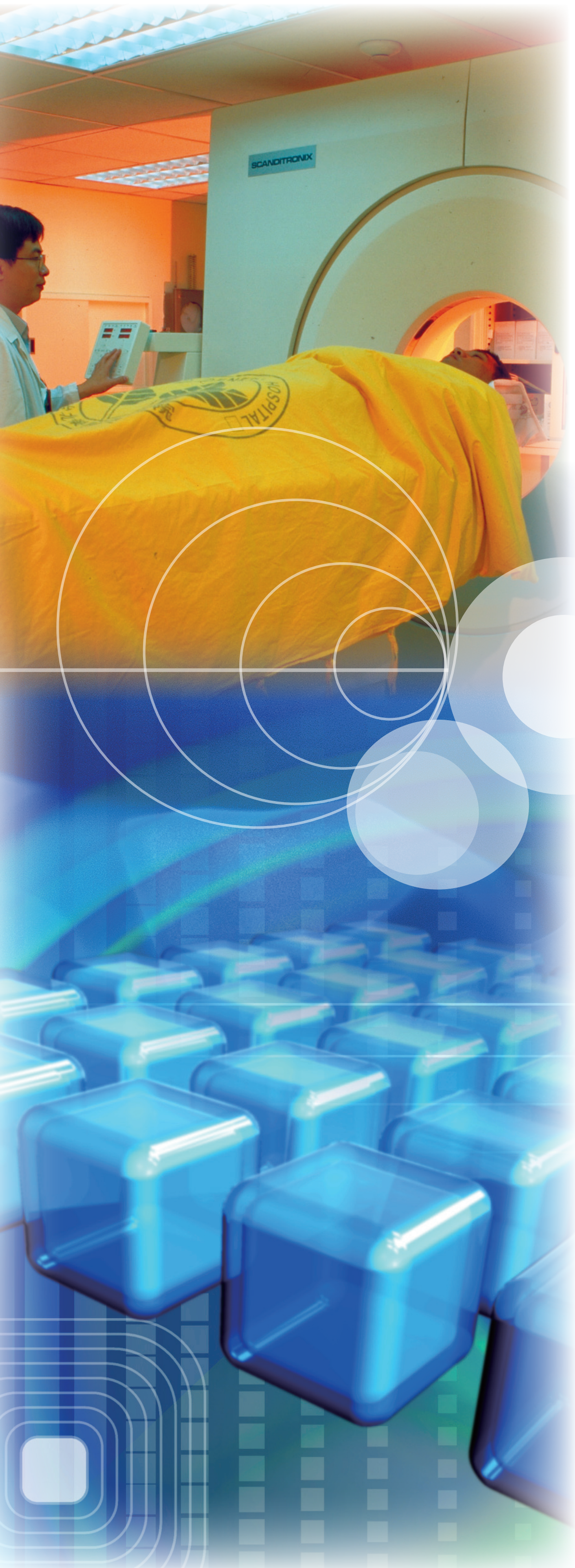
The goal of Nuclear Safety Technology Center is to act as a national laboratory, to cultivate a strong and objective technical arbitration, to enhance the people’s confidence for nuclear safety. The center has developed the world level nuclear safety technologies. The next step is to transfer the technologies to the industrial sector. In 2005, the Center produced are 16 patent applications, 32 international journal papers, with business income of NT$ 342,716,000 and technical licensing fee of NT$ 1,596,000.

The Center has various technical achievements. Typical examples include establishing the relationship between control life-span and the accumulation of neutron fluence for Maanshan Nuclear Power Plant so that control rod could be evaluated and managed more accurately and economically. By improving the fuel sipping and UT system, the failure fuel was successfully detected for Maanshan Power Plant. The excellent fuel loading pattern design impelled the fuel vendor to adopt INER’s core design. The neutron backscatter NDT instrument used for spent fuel pool reracking quality control was appraised by the vendor. The stress corrosion cracking was produced on the surface of Inconel 600TT samples. The LOCA analyses code RELAP 5/D/K which was originally developed by INL was improved by INER for Appendix K application and was feedback to INL. The automation technology of LLW storehouse was conferred to domestic companies. The localized simulator technology has set a new milestone. The integration and evaluation of Risk Significance Determination of Inspection Finding of Nuclear Power Plant was adopted by an international organization. The software to establish risk significant evaluation tool for domestic NPP (PRiSE) has received suitable affirmation when presenting in USA NRC. We also take lead in ^{60}Co water absorption dosage standard reciprocal measurement in Asia pacific area.

The accomplishments in ionizing radiation measurement standards traceability and laboratory accreditation included: established brachytherapy sources and the mammography x-ray dosimetry calibration systems, transferred related standards and quality assurance to health care organizations through radiation protection regulations and calibration/testing traceability systems to safeguard citizens' radiological diagnosis and treatment quality; had NRSL's (National Radiation Standard Laboratory) CMC (calibration and measurement capability) tables reviewed and entered into Appendix C of the BIPM's KCDB (key comparison database); established a national measurement traceability system for radionuclides analysis of environmental samples, received three measurement traceability certificates issued by NIST/USA for having radionuclide analysis technology; the proficiency test central laboratory for environmental radionuclides analysis completed seven standard samples.

In non-nuclear applications, the Center include utilization techniques of digital signal process and automatic control engineering to construct a large-scale deluge prediction model for the Tainan Science Park; application of electric power control theory on developing a integrated generation management system for FPC Hwa-Yang co-generation power plant; application of nuclear PRA technique, and “Quantitative Risk Assessment for the First Phase LNG Storage Tank Systems at Yung-An Plant” executed by CPC, accomplishing the evaluation report as the important supporting reference to apply the substitute inspection for Council of Labor Affairs. Applying non-destructive testing technique to inspect the repaired diaphragm walls of rapid transit station. The developed Fault Tree Analysis Software Package (INERFT0 has been promoted to NTU, NTHU and Aerospace Industrial Development Corporation. Significant contributions to domestic quantification of PRA in national defense, aerospace industrial, petrochemical industry have been established. Besides, energy model for our country is in the planning which introduces the MARKAL program. We hope to establish on integral platform and to integrate research efforts by industry, government, academics and institutes.





Radiation Application Technology

The development goals of the Radiation Application Technology Center (RATC) are: (1) Elevating the reliability of the compact cyclotron, setting up a nuclear pharmacy, lining up back-up supplies and business alliances to assure the production and punctually supply of radiopharmaceuticals. (2) Elevating the market for self-produced radiopharmaceuticals to 50% in 3-5 years, nurturing national industry of radiopharmaceuticals, accomplishing the SPIN-OFF assignment, advancing the industry of biotechnology, to be an important partner in the development projects of “Challenge 2008-National and Development Plan” and “Two Trillions and Two Novas” . (3) Developing new nuclear medicines and technologies, especially radio-labeled MoAb and peptides for cancer therapy that have market potential for cancer diagnosis and treatment. The goal aims at elevating research capability, increasing the value of products, and becoming one of the radiopharmaceutical research and production center in Asia pacific. In 2005, the RATC produced 27 patent applications, 157 scientific reports, 22 international journal publications, 116,511,000 of revenue and 10,298,000 worth of technology authorization fees.

In area of technical contribution, the RATC completed the installation of a 70KW RF amplifier, a RF synthesizer, a driver amplifier and resonator of RF amplifier, achieved the 10mV performance testing of ion source output, elevated the effectiveness of beam transmission up to 30%, the life time of the ion source filament from 3 weeks to 2 months that greatly enhanced the efficiency of the compact cyclotron. The RATC achieved medicinal certificate of In-111-Pentetreotide approved by the Department of Health (DOH), received the honor of a copper award for drug research by the Ministry of Economic Affairs and DOH, to supply for hospital regularly. The Creation of a nuclear pharmacy to support multi-dose to medical centers or unit-dose to local hospitals is under our active pursuit. This will bring substantial convenience for doctors and patients (increasing the number of hospitals on service from 21 to 50). The RATC also achieved medicinal certificate of Tc-99m-TRODAT-1 from DOH and the honor of a golden award for drug research from the Ministry of Economic Affairs (MEA) and DOH, during the year a serial of scientific seminars on "Symposium on the applications of Tc-99m-TRODAT-1 imaging in Parkinson's disease" was held to promote this diagnostic drug. An agreement of international collaborative research program with the Federal University of Sao Paolo-UNIFESP in Brazil was signed for the supply of TRODAT-1 kit for clinical study. In area of Micro-CT/micro-PET development, an internal image registration method, software of dual-image fusion, and the experimental protocol were built completely. Both the cyclotron and Cobalt-60 radiation facility passed the annual quality system authentication of ISO-9001 and ISO-13485b and received ISO qualified certificates from TÜV. The innovative new technique of Carbon-13 breath test of gastric emptying measurement that yields a high reproducibility (CV intra<10%) by using lower dose (50mg) comparing to original dose (100mg), proved to be better than that of abroad. It is expected to displace the less cost-effective scintigraphy technique currently in use for gastric emptying obstacle detection of diabetes mellitus in the future.

Our social contribution that is note worthy includes the supply of radiopharmaceuticals to the E-Da Hospital and the Kaohsiung Veterans General Hospital to benefit patients lived in southern of Taiwan. The Achievement of completing the first medicinal certificate of Tc-99m-TRODAT-1 in the world certainly elevated the international image of Taiwan. The production of radiopharmaceuticals from radioisotope of RATC benefited over 200,000 patients every year suffering myocardial disease and tumor. The RATC is proud to accommodate forty-eight foreign visitors to our facilities witnessing the peaceful application of atomic energy. The RATC initialized a radiation technique to treat -4°C cryogenic product and to radiate 7.5 ton of frozen mango cuttings for Lytone Ltd. Deactivating 4 batches of SARS samples for the Center of Disease Control (CDC) and the National Taiwan University Hospital marks a portion of our responsibility toward the society and in making the diagnosis and treatment of SARS possible.

In international collaboration area, we performed systemic research of PPIS (Planar Positron Imaging System) supported by the Hamamatsu Photonics, KK Company of Japan. Collaborative research on TRODAT-1 with Hospital Sao Paulo of Brazil and the supply of Ac-225 by the US Department of Energy to develop therapeutic nano-radiopharmaceuticals are another examples of efforts.

Environmental and Energy Technology

The major targets of the Environmental and Energy Technology Center are: (1) integrate plasma-related environmental and energy technologies, and develop new energy and clean manufacturing technologies suitable for domestic industry; (2) set up a new energy power generation system in Building 013 to display the R&D capabilities of the institute; (3) actively develop spent fuel dry storage and low waste disposal technologies and integrate the relative technological applications. In 2005, we had 49 patent applications, and published 463 reports and 34 international journal papers. The annual income from outside sources was NT$336,798,000 and income from technical license fee, NT$2,749,000.

Achievements in 2005 are categorized into four parts: environmental plasma, decommissioning and nuclear waste, new energy, and others (such as holding conferences, academic and industrial cooperation, and technology imports). They are illustrated below:

Environmental Plasma

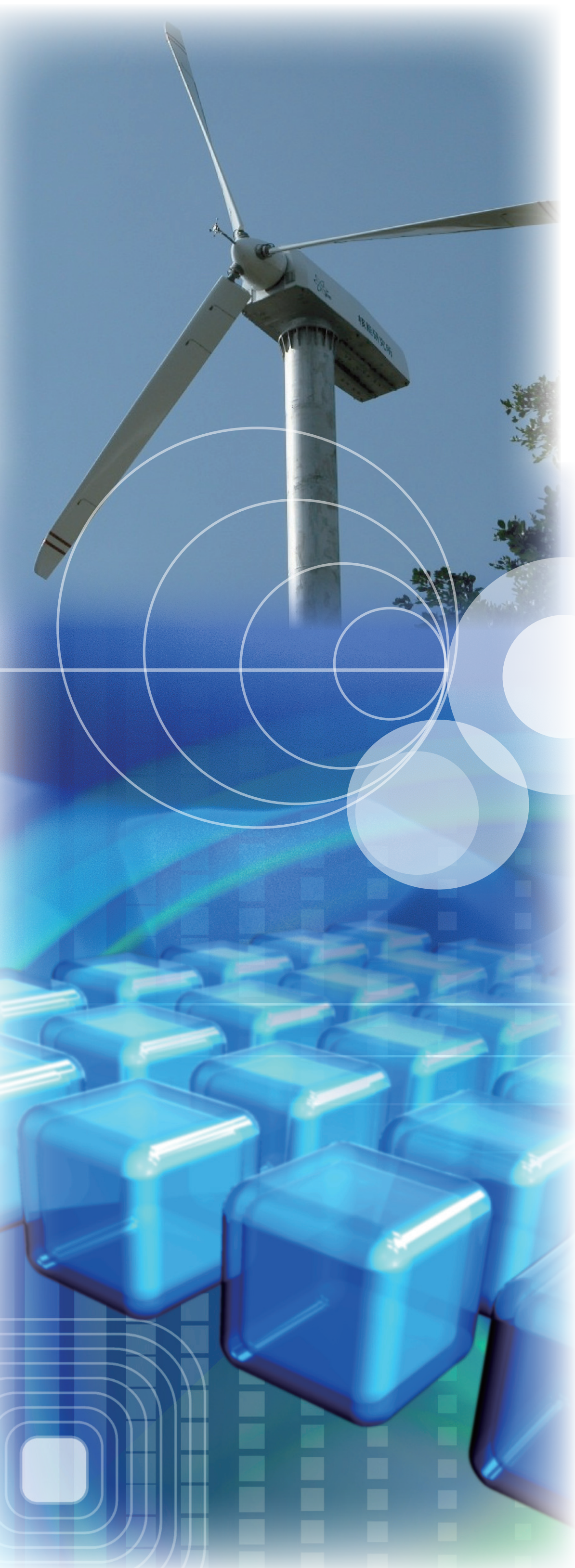
The Center improved the hydrophilicity of polyester cloth using atmospheric glow plasma technology. Plasma immersion ion implantation technology was used to develop materials for artificial joints. The technology can be applied in the domestic development of artificial joints, and precision components (e.g. press mold, plastic mold, micro cutter). The Center also developed the plastic housing EMI manufacturing process using plasma sputtering technology. The finished housing sample has sheet resistance of 0.55 ohm/square cm. The incubator lab. set up a high precision roll-to-roll plasma deposition system for macromolecular substrates (width ≧ 400mm), and 8 sets of chamber-connected plasma in-line deposition installation. For plasma torch, the Center established a high power plasma torch test center and completed the research and development of a 3MW non-transferred and a transferred DC plasma torch. The characteristic measurements of the 100 kW steam plasma torch, construction of a 60 kg/hr plasma melting furnace and a 20 kg/hr plasma pyrolysis furnace and the development of plasma treatment procedures were completed, along with the characteristic measurements on permeable bricks made by water quenching of plasma slag produced.

Decommissioning and Nuclear Waste

During the past year, the Center collected 500 shielding sections, 10 cans of uranium powder, 2 baskets of pressed aluminum claddings, and completed other waste from the TRR spent fuel pool. The Center also performed the development and detail planning of the TRR fuel stabilization procedures; the UCTPP equipment dismantling, the detail planning for the decommissioning of the transuranium facility in Building 016, and the establishment of a radiation injury medical treatment system. The construction of a high volume-reduction wet-waste solidification system at the Taipower's second nuclear power plant, the testing of a 20 L/hr recycled waste water TOC treatment facility (reached the target of TOC lower than 150 ppb) and the nuclide analysis of 210 cement solidification waste samples at Lanyu Storage Plant mark our direct contribution to TPC. In addition, the Center completed the concept design, detailed manufacturing design and licensing process of a volume reduction system for used control rod blades at the Taipower No. 1 nuclear power plant. The project for spent-fuel dry storage facility at the Taipower No. 1 nuclear power plant was awarded to the Center during the year. This marks an important milestone for the goal of establishing the domestic spent-fuel dry storage technology. This technology will possibly bring a total value well above NT$ 20 billions to related domestic industries.

New Energy

In the field of nano technology, after applying special treatment of dispersion agent, the average granularity of the YSZ powder material produced by the Center reached a range of 13.5nm-100nm. The development of kilogram-class YSZ powder manufacturing process has also been completed. For power systems, the Center assembled a 1 kWp SOFC system and completed the design and system assembly of a 1 kWp solar power tracking platform,



with a remarkable tracking precision within ±0.5° . The weight of a second generation focusing type solar cell module has reached the level of 0.42kg/Wp, which is lighter than that developed by a renown US manufacturer at 0.54kg/Wp. The Center also completed a 25kW wind power generation system a second generation ethanol catalyst hydrogen production reformer for use by SOFC, a 20 kW steam plasma torch system of biomass plasma gasification, and the research and development of using APCVD equipment to make QD lighting components. The coating technology of SiNx thin film on silicon and sapphire substrate were successfully developed. Under room temperature and unaided vision, photoluminescence source and its spectrum can be seen.

Conferences Held

In 2005, the Center held: the Reformer Hydrogen Production Technology Seminar, 2005 Taiwan Atomic Energy Forum, 2005 Plasma and Related Processes Simulation Seminar, 2005 Taiwan SOFC Seminar, Taiwan-Japan Engineering Seminar, and 2005 Taiwan Carbon Nanotube Hydrogen Storage Seminar, etc. Well-known specialists and experts were invited to attend the conferences to discuss future technological developments.

Cooperation with Academic Institutes and Local Companies

To integrate research resources, enhance research efficiency and develop innovative products, the Center cooperated with the following academic and research institutes. National Tsinghua University, National Chiao Tung University, National Central University, National Taiwan Ocean University, National Taiwan University, National Chung Kung University, Da Yeh University, Yuan Ze University, Chung-Shan Institute of Science and Technology, Industrial Technology Research Institute, and local companies, such as: Win Semiconductors, VPEC, and Leatec Fine Ceramics Co., Ltd.

Technology Imports

Discussions were held with HTcermix Co., Switzerland on the long-term performance measurement of SOFC reliability, as well as research and development of SOFC stack design and sealing technology. The Center also discussed with FZL, Germany, on thermal current analysis for the start-up, operation and shutdown of SOFC, sealing technology of stacks, and thermal stress analysis of batteries. The same was held with US DOE/PNNL on participating in the SECA research, SOFC stack innovative design and simulation of SOFC system operation controls.

Research Fields

Development of O&M Technologies for Nuclear Power

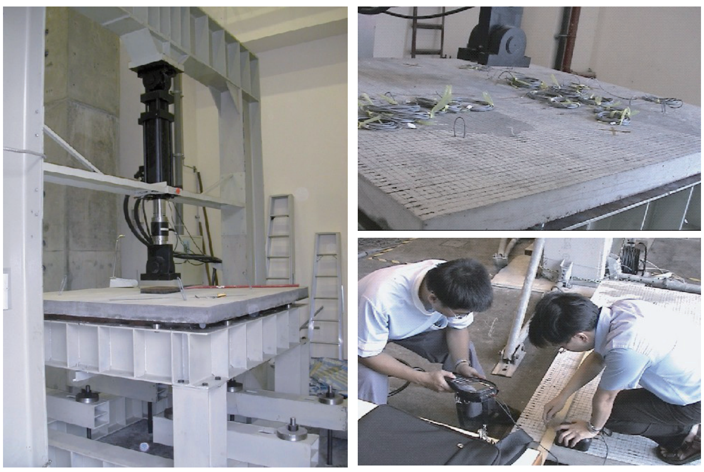
As a domestic leader in nuclear technology research, the Institute of Nuclear Energy Research (INER) has established international credibility in many areas, such as root cause analysis of fuel failure, safety analysis of digital instrumentation, risk monitoring system and severe accident analysis. Furthermore, 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, non-destructive testing and simulator upgrade. The strong ability to complete 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 Nuclear Safety Technology 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 core management and safety analysis, inspection, instrumentation upgrade and safety, as well as PRA applications and national radiation standards.

Ultrasonic Scanning Using Dry-Contact Flaw Detector System A-1220

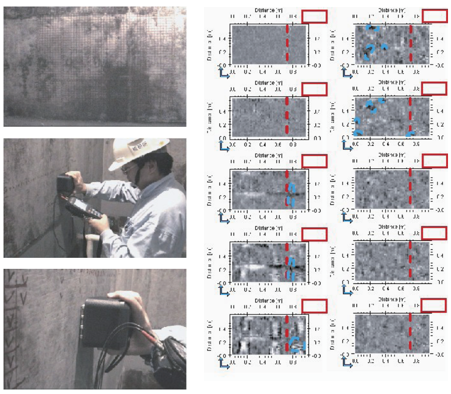
Ultrasonic testing (UT) has been used to evaluate the integrity of concrete structures for more than three decades. However, reliable evaluation on readings is difficult because of varying coupling condition of the detector head on rough concrete surface. This problem also troubles the scanning techniques on concrete. To resolve these problems, INER introduced a new low-frequency DPC transducers designed by Acoustic Control Systems, Ltd. from Russia. This probe can produce ultrasonic pulse in required mode (shear or pressure wave) within an acoustic contact zone (tip) of the size about 1/30~1/120 of its wavelength. The probe tip acts on the object surface as a point oscillation, and therefore assures the coupling stability during scanning.

The cushioned probes enable a good and consistent contact on concrete surface, so that B-scan and C-scan can be available. Small voids, interfaces or steel bars within concrete can reflect the pulse back to the probe receiver to produce black-white dots/blocks signals shown on the system monitor. The digital results can be visualized as a top-view tomograph for engineering usage.

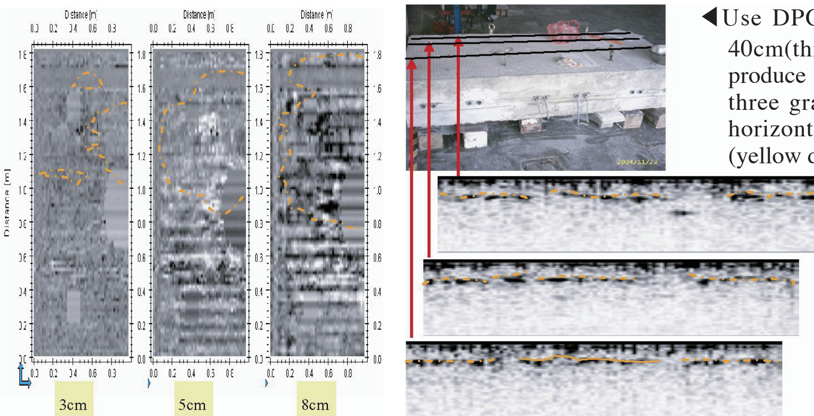
According to the tomograph (see the examples in Figures), the damaged concrete areas (i.e. places marked by red dot-lines) can be located and analyzed. The top-views at different depths reveal more accurate evidences for the better understanding of the integrity of concrete structures.



▲Use DPC sensor to detect the damage of broken reinforced concrete plate.



▲Integrity evaluation for the concrete of the spent fuel pool in Maanshan Nuclear Power Plant, using C-scan tomography to display the sectional graphs of different depths.



◀Use DPC sensor to B-scan a pre-cracked 40cm(thick) reinforced concrete board and produce sectional profiles (e.g. the following three graphs). The position of the internal horizontal cracks can be seen in the graph (yellow dotted line).

Risk Significance Determination of Inspection Finding of Nuclear Power Plants

Risk-Informed Regulation (RIR) had been widely adopted by international nuclear regulatory authorities. It focuses on using risk insights, complemented by traditional defense-in-depth and safety margin philosophy, as the basis for decision making. The objective is to allocate resources to regulatory issues according to their risk significances and without compromising safety. It can also optimize the effectiveness of regulation and reduce the unnecessary burden on the regulatory body and the utilities. The Probabilistic Risk Assessment (PRA) methodology has been commonly used in risk-informed regulation as a major tool to quantify the risk. The PRA is exercised within the context that correlates three important questions: (1) What can go wrong? (2) How likely is it? (3) What are the consequences? It also requires a comprehensive understanding of the system under analysis in order to obtain the most realistic results. While this technique uses probability as the language, it bases on facts and statistics data, combining associated expert judgements, to provide extensive information. This feature makes it a very powerful tool for decision making.

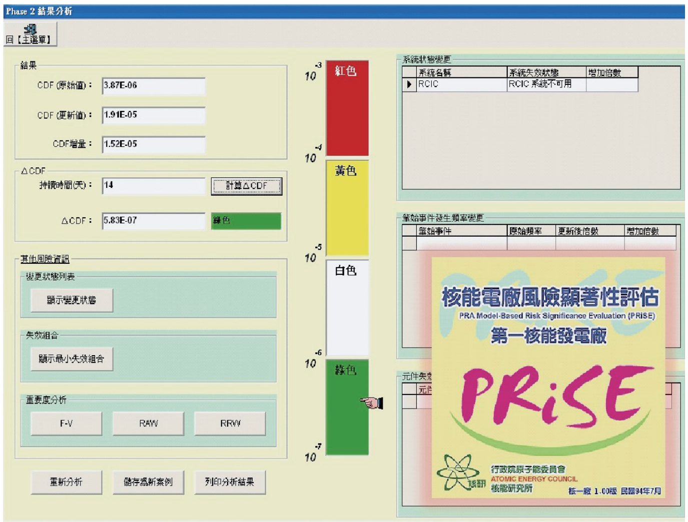
【Honor】

The associated report entitled,"The System Establishment of Probabilistic Risk Assessment and Management" by Dr. Tsu-Mu Kao, Mr. Ching-Hui Wu, and Dr. Chun-Chang Chao of the PRA team, INER won the 2005 Excellent Research Award of the Executive Yuan, Taiwan, R.O.C..

【International Review】

Dr. Tsu-Mu Kao from the PRA team of INER presented a talk on the PRiSE, a risk significance tool for risk quantification of inspection findings, at the 523rd ACRS (Advisory Committee on Reactor

Safeguards) meeting of USNRC on June 2, 2005. It raised high attention and obtained positive comments from the meeting members.



Display of the PRA Model Based Risk Significance Evaluation (PRiSE) Code

Nuclear Digital Instrumentation System Technology and Application Development

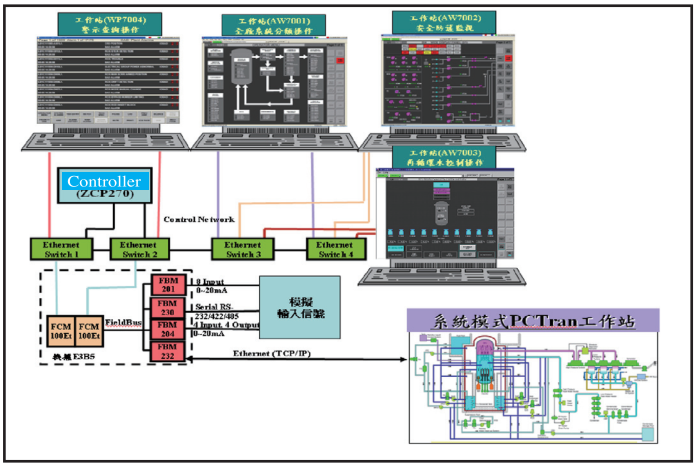
The application of digital I&C system in nuclear power plant is an unavoidable trend due to the progress of digital industry and information technology. The I&C system upgrade in current operating and newly constructing nuclear power plants will apply the advanced digital I&C system. In order to maintain the safety and reliability, the establishment of local support technology is required.

1. Nuclear software safety analysis (SSA) technology: INER's SSA technology has obtained international acknowledgement by participating in the international conference of " Exchange Of Operating Experience Concerning Computer-Based Systems Important to Safety, COMPSIS " which is sponsored by OECD/NEA. In order to improve the quality of digital I&C software further, we will apply risk assessing technology to distinguish and eliminate the hiding faults in software design, and then improve the reliability and safety of the nuclear power plant operation.
2. Network security and system integrated design: INER has already completed the primary goal of digital control system technology localization by participating in distributed control and information system (DCIS) factory acceptance test (FAT) for the Lungmen Nuclear Power Plant project in Taiwan. A digital I&C system test bed has been established in INER's laboratory and

applied for the DCIS design verification during various phases of design and implementation stages.

3. Human Factors Engineering (HFE) Technology: The major HFE achievements include the participation in human interface design and verification, using the DCIS test bed to perform alarming system human interface verification, and performing relative measurement and questionnaire investigation analysis for the Lungmen project. The HFE guideline will be developed and provided to the regulator for reference concerning the review of main control room upgrade in current nuclear power plants.

4. Digital I&C System Test Bed: The digital I&C system has the advantages of easy collecting data, flexible design, and fitting the pluralistic changing of the demand. INER has established a digital I&C test bed platform (as shown in the figure) including control processors (CP), workstations, and network switches etc. The test bed combined with process simulation environment can effectively perform the control strategy optimization, software implementation and V&V, operating procedure analysis and V&V, etc.



Digital Instrumentation and Control System Testing Platform

Nuclear Fuel Management and Safety Analysis

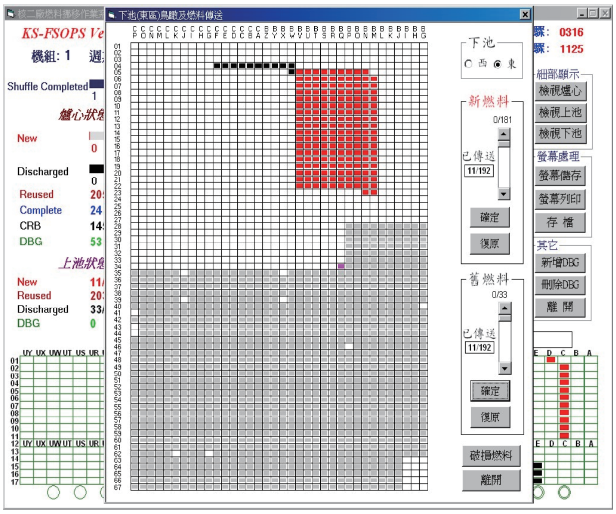
The core management analysis is related to the safety, economics, and operational flexibility of nuclear power, and is involved with the inter-relationship among the regulatory authority, utility, and fuel vendor. INER has established the independent analysis and design tool and methodology, to veritfy and review the fuel vendor design, and to provide the supporting analysis of power plant operation and the clarification of safety issues, so as to assure the safety of nuclear power and to increase the benefit of fuel management.

In order to enable the core management R&D technology to keep up with the world-class standard, INER is continuously maintaining and updating the core management code package based primarily on CASMO-4 and SIMULATE-3, and keeps on updating the self-developed software system to support the core management of nuclear power plant, such as that in order to collaborate the second re-racking engineering of the spent fuel spool storage capacity of the second nuclear power plant, the fuel shuffling operation system for the second nuclear power plant has been updated, to timely achieve the requirement of planning the shuffle steps prior to the outage of second nuclear power plant.

In terms of developing the related technologies in support of the core management of nuclear power plant, the core physics designs of new fuel cycles of the first, second, and third nuclear power plants are verified independently, and the core loading pattern of cycle 18 of the second unit of the second nuclear power plant is parallel designed. Under the requirements of Taipower, the domestic design team performs a parallel design with the fuel vendor, and the qualified core load pattern is obtained. After verifying the core loading pattern suggested by Taipower, the fuel vendor has accepted and used the core loading pattern designed domestically.

To verify the results of analyses of the loss of feedwater heating event and the rod withdraw error in the final safety analysis report (FSAR) of the fourth nuclear power plant, the independent analysis codes SIMULATE-3 and SIMULATE-3K are used to accomplish the independent analysis methods for the verifications of the loss of feedwater heating event and the rod withdraw error of the fourth nuclear power plant, and to independently verify the FSAR analyses carried out by the fuel vendor. By establishing the domestic independent verification and analysis technologies, the shortcoming that it is difficult to go deeper for the paper review of the FSAR can be compensated, so as to assure the correctness of safety analysis performed by the fuel vendor, and to assure the safety of operation of nuclear power plant.

This technique will be devoted to the improvement and development of software tool, the reload fuel design and analysis of nuclear power plant, the analysis and evaluation of advanced fuel design, and the criticality safety evaluation of the spent fuel storage pool and the dry-storage facility.



The nuclear fuel shuffling operation system for the second nuclear power plant after the second re-racking of its spent fuel storage capacity

National Ionizing Radiation Standards

In 1992, INER was entrusted by the Bureau of Standards, Metrology and Inspection, M.O.E.A with the establishment of the National Radiation Standard Laboratory (NRSL) whose major missions are to build and maintain the highest ionizing radiation measurement standards in the nation to provide traceability of radiation diagnosis, radiation therapy, nuclear medicine, radiation safety, laboratory accreditation (proficiency testing) and international comparisons (global mutual recognition arrangement, MRA). 12 national standards have been established including x-ray, ^{137}Cs, ^{60}Co, ^{192}Ir in terms of air kerma, absorbed dose to water for ^{60}Co, absorbed dose to tissue for ^{90}Sr/^{90}Y, ambient / personal dose equivalent for ^{252}Cf and ^{241}Am-Be as well as 3 radioactivity standards covering the activity ($4\pi\beta$-γ coincidence counting system, $4\pi\gamma$ ionization chamber counting system) and the emission rate ($2\pi\alpha/\beta$ proportional counting system) for radionuclides. Among them, 7 primary standards are self-developed by INER and the other 5 are traceable to other national metrology institutes (NMIs). The NRSL passed the assessment of Taiwan Accreditation Foundation (TAF, the former Chinese National Laboratory Accreditation (CNLA)) in 2001 and became the first national radiation standard laboratory which passed the ISO-17025 accreditation in Asia and Pacific region.

In 2005, one major event of the NRSL was that it was invited by the PTB/ Germany to participate in EUROMET 545 international comparison activity on x-ray dosimetry. Also, NRSL completed the ^{134}Cs radioactivity comparison. The capabilities of NRSL have been recognized through such international activities. In standards research and development, NRSL established ^{131}I pharmaceutical radioactivity standard measurement technology to promote the measurement accuracy of the radionuclide of ^{131}I practiced in Taiwan's pharmaceutical manufacturers and nuclear medicine departments and to assist doctors in controlling the pharmaceutical radioactivity to be received by patient. On the other hand, the establishment of the high efficiency gamma spectrum analysis system in NRSL not only extended the gamma radioactivity standard from MBq level to KBq level but also make Taiwan's radioactivity measurement ranges more complete.

After several years of hard work, INER has become a formal member to the Asia Pacific Metrology Programme (APMP) and the International Committee of Radionuclide Metrology (ICRM). INER is also an associate member of General Conference on Weights and Measures (CGPM). Joining the above organizations will help NRSL's participation in international comparison activities and the recognition from other national metrology institutes for its measurement capabilities and calibration reports. In the future, NRSL will make economy- and civil- application-oriented plans to create the basis for standard energy enlargement to improve the quality and safety of people's lives.

Measurement Standards and Applications

Standard \ Application	Radiation Diagnosis	Radiation Therapy	Nuclear Medicine	Radiation Safety	Proficiency Testing	Mutual Recognition Arrangement
10-50 kV X-ray air kerma rate (primary)	V			V	V	V
50-250 kV X-ray air kerma rate (primary)	V			V	V	V
^{137}Cs r-ray air kerma rate (primary)		V		V	V	V
^{60}Co r-ray air kerma rate (primary)		V		V		V
^{60}Co r-ray absorbed dose to water (primary)		V				V
^{90}Sr/^{90}Y absorbed dose to tissue				V	V	
^{252}Cf ambient / personal dose equivalent				V	V	
^{241}Am-Be ambient / personal dose equivalent				V		
^{192}Ir reference air kerma rate		V				
$4\pi\beta-\gamma$ absolute activity measurement system (primary)			V	V		V
$4\pi\gamma$ ionization chamber			V	V		V
$2\pi\alpha/\beta$ proportional counting system (primary)				V	V	

Self-fabricated Free Air Standard Ionization chamber

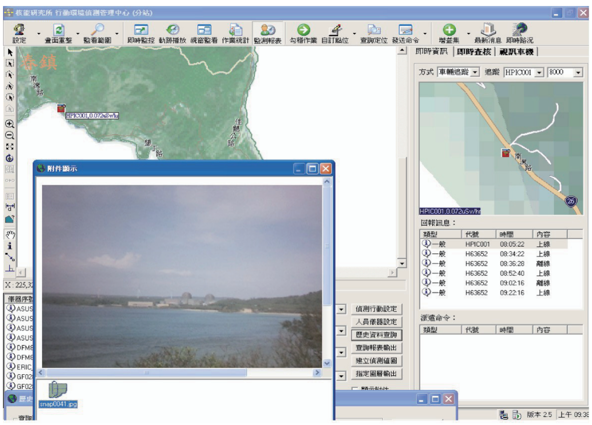
The Real Time Technology for Environmental Radiation Survey

Environmental radiation survey stands as the front line work for environmental protection by collecting on-site data to build the communication basis and help with the related decision making. To make the survey more acceptable and reliable, INER integrated survey results and digital photos by using PDA and GPS and transferred the information to the management center through the GPRS (General Packet Radio Service) technology. The information was combined with GIS system to provide the function of showing survey results and images in real time. Photo records not only can provide better understanding for the on-site situations but also increase the

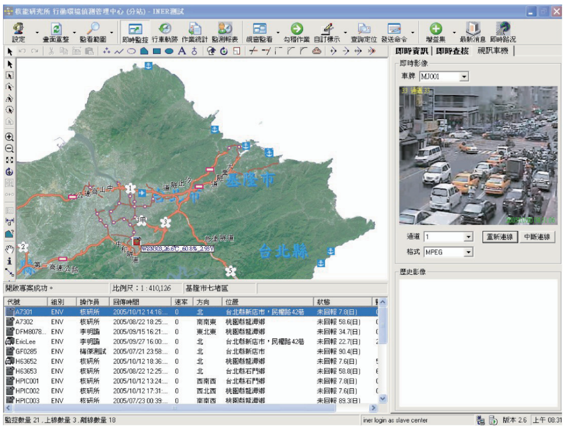
transparency of survey. So we believe that in the future, with the development of information technology, this system will become a standard tool for environmental survey.

R & D Achievements

- Completed the Aided Mobile Radiation Survey System by comprising the GIS software developed by domestic companies with appropriate programming and the PDA, GPS and GPRS technologies. The system has the patents of Taiwan (M255406) and China (ZL 200420005376.3) and is in the progress for the application of Japanese patent.
- Finished the network structure among the main station and substations of the survey management center. The substations can transfer data by wireless networks to achieve the goal of mobile management.
- Completed the connection between the management center and survey motors so the images located by the motors can be displayed on the electric map dynamically.
- The hand-held environment survey PDA can record the survey data and transfer the picture or other information to the management center.
- Sent real trips on the system to areas around the nuclear power plants and Taiwan Island to perform the radiation survey work and system tests to analyze the data and complete the island-wide spatial dose distributions.



The Photo from the Mobile Unit with its Location Shown on the GIS Management Center

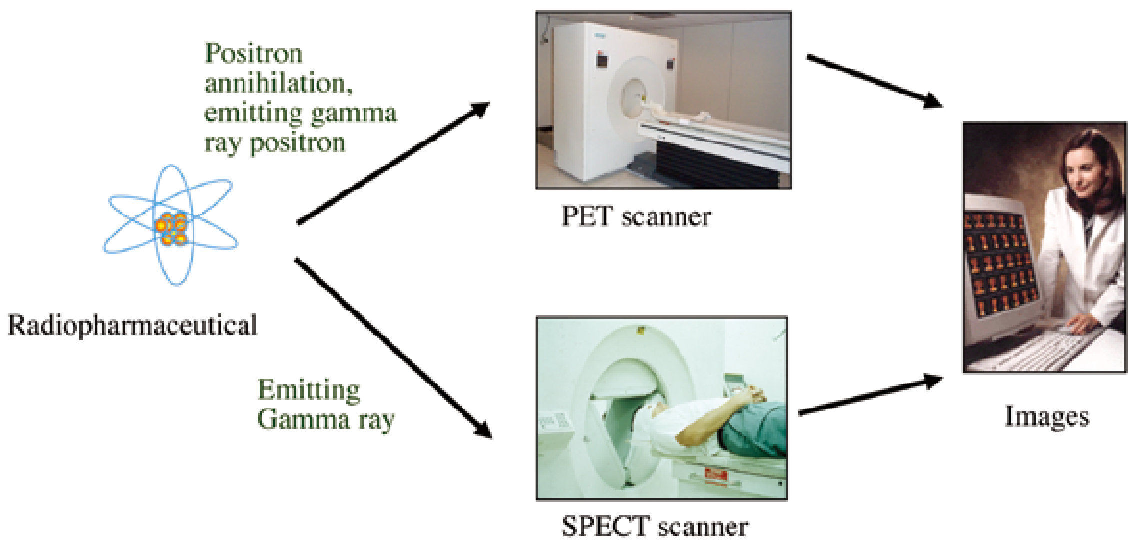


The Real Time Video with its Location Shown on the GIS Management Center

R&D and Applications of Radiopharmaceuticals

Nuclear image uses trace radiopharmaceuticals taken by specific tissues to diagnose or to treat diseases. The radiopharmaceuticals are detected by gamma cameras that work with computers to provide metabolic and functional information about diseases. Nuclear imaging could complement anatomical imaging such as CT or MRI. Today, nuclear medicine techniques are essential in many medical specialties such as oncology, cardiology, neurology, psychiatry and nephrology, etc.

Two main types of imaging are used in diagnostic nuclear medicine - single photon emission computed tomography (SPECT), and positron emission tomography (PET). SPECT which detects the single photons emitted by radionuclides, is the most commonly used form of nuclear imaging procedures. PET tracers are typically positron-emitting isotopes with short-half lives and must be produced in a cyclotron at or near the site of the PET scanner. PET is one of the most sophisticated medical imaging technologies available today.



The Principles of Nuclear Medicine Imaging

In view of the mission to improve modern healthcare, INER which owns core and related research facilities for developing radiopharmaceuticals devotes to the civil applications of radiation technology. In addition to support the research and development of diagnostic and therapeutic radiopharmaceuticals, INER aims to facilitate biotechnological and pharmaceutical companies with the common goal to bring products to market faster, such as offering small animal imaging services.

The Radiopharmaceutical Production Center (RPC), a cGMP-compliant (Current Good Manufacturing Practice) facility of INER, accommodates a variety of development, manufacturing and supply programs to meet domestic requirements. Currently, 14 products are licensed and INER launched two novel radiopharmaceuticals. One is INER TRODAT-1 kit and the other is INER In-111-Pentetreotide Injection, which won a golden award and a copper award of Drug Technology Award held by the MEA and DOH, respectively. INER TRODAT-1 kit, a molecular imaging agent, is the second registered product worldwide that enables physicians to objectively visualize the changes of dopamine transporters in dopaminergic neuron terminals. In-111-Pentetreotide Injection, targeting to the somatostatin receptors, is an imaging agent for diagnosis of neuroendocrine tumors. Besides, two patents have been licensed to Cardinal Health 414, Inc. of USA this year. This marks an expectant start for us to enter into the international market. These two patents are “ Method for synthesis and ^{99m}Tc Labeling of 2-Alkoxyisobutylisonitrile” (US5210270) and “Preparation of copper 2-alkoxyisonitrile complexes and ^{99m}Tc labeling of 2-alkoxyisobutylisonitrile” (US5346995).

INER TRODAT-1 kit: the First Technetium-99m-labeled Imaging Agent for Visualization of Dopamine Transporters

Due to the rise of prevalence of age-related diseases such as cancer, Alzheimer's disease, Parkinson's disease, stroke and heart failure, there are increasing demand of medical diagnostics driven by ageing population to develop tests that can assist in earlier diagnosis and aid selection of the most appropriate treatments in order to reduce social costs.

▲The Symptoms of PD

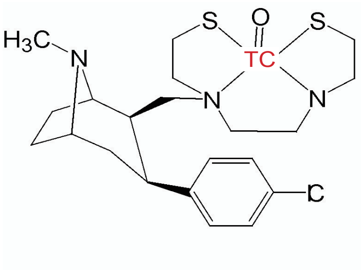
PD is a common progressive neurological disorder that results from degeneration of neurons in a region of brain that controls movement. This degeneration creates a shortage of the neurotransmitter known as dopamine, causing impaired movement. PD was first formally described in "An Essay on the Shaking Palsy, published in 1817 by a London physician named James Parkinson. Usually the first symptom of PD is tremor (trembling or shaking) of a limb, especially when the body is at rest. The tremor often begins on one side of the body, frequently in one hand. Other common symptoms include slow movement (bradykinesia), an inability to move (akinesia), rigid limbs, a shuffling gait, and a stooped posture. People with PD often shows reduced facial expression and speak in a soft voice. Occasionally the disease also causes depression, personality changes, dementia, sleep disturbances, speech impairments, or sexual difficulties.

Approximately 4 million people worldwide are afflicted with PD. The incidence rises after the age of 60, such that one to two percent of the elderly may be affected. The current diagnosis of PD is substantially based on the clinical symptoms. Up to 25 percent of cases currently diagnosed as PD are actually Essential Tremor (ET), a disease which exhibits similar symptoms to PD but requires very different treatment. Recent innovations in radiopharmaceutical imaging enable the physicians to make a correct diagnosis of PD through visualization of cellular changes in brain.

Dopamine transporter (DAT) is a

protein located on the membrane of the dopamine terminal in the striatum. The reduction of DAT correlates with the loss of dopaminergic neurons in the striatum.

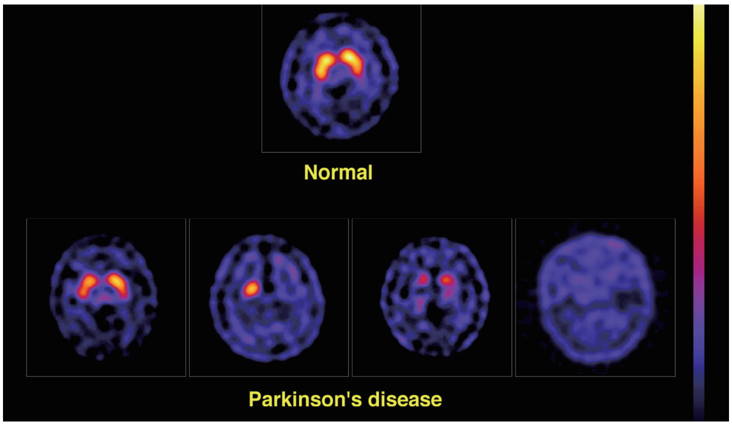
Tc-99m-TRODAT-1, a cocaine derivative, is the first reported technetium-99m-labelled compound developed as imaging the changes of DAT in PD patients. However, the preparation of Tc-99m-TRODAT-1 was complicated by literature reported multi-component kit formulation. In order to meet the routinely demand in clinical application, INER successfully developed a new formulation in an all-in-one kit. To improve the stability and solubility of active



Tc-99m-TRODAT-1

▲The Picture of INER TRODAT-1 Kit

substance, free TRODAT-1 is replaced with TRODAT-1·3HCl. In addition, mannitol is used to stabilize the lyophilized component. After reconstitution with sterile Sodium Pertechnetate Tc-99m injection, SPECT images are obtained at 4 hours post-administration of Tc-99m-TRODAT-1. The differentiation between a normal control and a PD patient is primarily based on striatum shape that reflects differences of uptake intensity. There is significant reduced striatal uptake of Tc-99m-TRODAT-1 in PD patients compared to controls.



▲Tc-99m-TRODAT-1 SPECT Images of PD Patients and Normal Control

INER initiate the TRODAT-1 project in 1997. In the past 9 years, we have finished up the discovery and development processes including synthesis of ligand, formula design, quality control of materials and products, validation of manufacturing processes and QC tests, toxicity studies and clinical trials. The new drug application was submitted to Department of Health, Taiwan in March 2004. After multiple supplements, the diagnostics received the approval in May 2005. Tc-99m-TRODAT-1 was indicated for imaging of dopamine transporters located in the dopaminergic presynaptic neuron terminals in the striatum.

INER TRODAT-1 kit formula invention is patented in Taiwan, ROC. Additionally, the purity analysis method of TRODAT-1 material is applying patent in Taiwan, USA and Brazil. INER has collaborated with domestic and overseas hospitals for investigating the clinical applications of Tc-

99m-TRODAT-1. Up to now, over 60 articles are published in well-known journals as well as in symposiums.

INER TRODAT-1 kit is the world's first Tc-99m labeled diagnostic agent approved for the use in imaging dopamine transporter. With the much less expensive price and extensive availability of Tc-99m, it is generally accepted that Tc-99m-TRODAT-1 will be much more competitive than DaTSCAN, which an I-123 is labeled DAT imaging agent being marketed across Europe. Tc-99m-TRODAT-1 can accurately identify PD and related syndromes thus provide a better chance to prevent the progress of PD at early-stage. The approval of INER TRODAT-1 kit benefits thousands of patients who may be suffering PD and marks a major achievement for INER's Rresearch and development.

行政院衛生署藥品許可證

中華民國專利證書

經濟部智慧財產局 局長 陳明邦

中華民國專利證書

發明第 I 229187 號

發明名稱：多巴胺轉運體造影藥物鎝－99m－TRODAT－1放射化學純度之快速測定法

專利權人：行政院原子能委員會核能研究所

發明人：廖美秀、張國平、魏孝萍、沈立漢

專利權期間：自2005年3月11日至2020年11月30日止

上開發明業經專利權人依專利法之規定取得專利權

經濟部智慧財產局

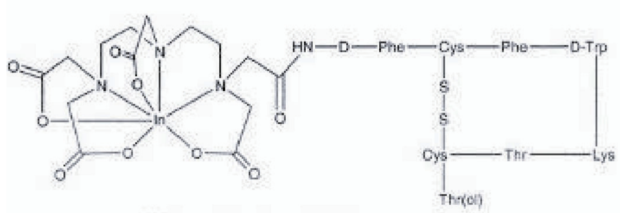
局長 蔡練生

中華民國 94 年 3 月 11 日

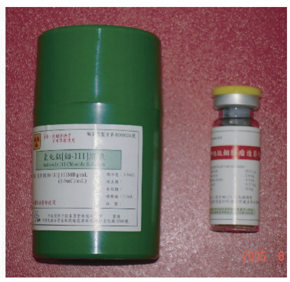
▲License & Patent of INER TRODAT-1 kit

INER In-111-Pentetreotide Injection

Somatostatin, a naturally occurring 14-amino acid peptide, can be thought as a suppress hormone for growth and down-regulator of sensitive tissues. Somatostatin receptor scintigraphy (SRS) with the diethylenetriaminopentaacetic acid conjugated somatostatin analogue [In-111-DTPA-D-Phe1] octreotide, also known as In-111-Pentetreotide (Octreoscan [Mallinckrodt]), which was approved for clinical use by the Food and Drug Administration in June 1994, has been of considerable value in scintigraphically identifying various neuroendocrine tumors. Most neuroendocrine tumors seem to possess somatostatin receptors in sufficient abundance to allow successful scintigraphic imaging with radiolabeled somatostatin congeners. It is a new non-invasive modality for evaluation of tumors that express receptors for somatostatin. These receptors are present on neuroendocrine and other tumors, including lymphomas, pancreatic cancers, and some breast cancers. In oncology, SRS is a promising diagnostic tool for localizing primary tumors, staging, control and follow-up after therapy.



^{111}In-DTPA-Octreotide (OctreoScan®)

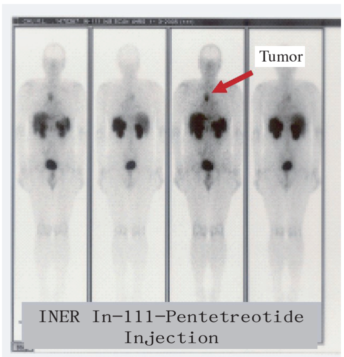


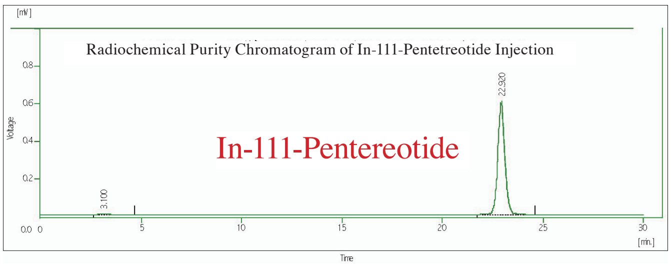
Owing to the urgent needs of patients for neuroendocrine tumors in Taiwan, a research team for the RPC of INER, AEC, has finally developed a high quality medical grade indium chloride (In-111) solution after many years of hard work. Combined with lyophilized Pentetreotide kit developed by INER, INER In-111- Pentetreotide Injection for drug registration was approved by the DOH as the first manufacturing license of peptide radiopharmaceuticals (DOH License No. R000024). The legitimate application of this drug for people in need is truly an event of benchmark significance.

INER In-111-Pentetreotide Injection has been proved to be a high sensitive and specific diagnostic radiopharmaceutical. Whereas, there are large numbers of somatostatin receptors on the surface of neuroendocrine tumors, and In-111-Pentetreotide can be applied to perform specific and sensitive nuclear scintigraphy of in-situ and metastatic neuroendocrine tumors. For clinical application, In-111-Pentetreotide is prepared by labeling a medical grade indium chloride (In-111) to a lyophilized kit, which comprises octreotide conjugated with a chelating agent-DTPA and a special excipient formulation. For stability, octreotide is better than somatostatin in bloodstream.

According to statistics of 2003 cancer death published by Department of Health, nearly 10,000 people die of lung cancer and colorectal cancer each year, and among them, 15-20% belong to the category of neuroendocrine tumors. The prognosis of neuroendocrine tumors is typically poor, because these tumors often metastasize from their original site (including bone marrow) in early stage. Therefore, if In-111-Pentetreotide is applied at early stage to detect the up-regulation of somatostatin receptors on neuroendocrine tumors, followed by octreotide chemotherapy, patient's survival rate can be greatly improved.

INER In-111-Pentetreotide Injection is currently produced by INER, the only radiopharmaceutical plant in Taiwan under the DOH cGMP audit. In addition, diverse tests have been carried out to prove exact chemical equivalence between INER In-111-Pentetreotide Injection and Octreoscan, the original brand one. INER has made great progress to reach the international drug manufacturing standards with extraordinary quality and efficacy. In the near future, such high sensitive and specific diagnostic radiopharmaceutical of neuroendocrine tumors "INER In-111-Pentetreotide Injection" will be provided to patients in Taiwan in terms of a reasonable price and high quality.





Comparison of Sensitivity, Specificity and Accuracy

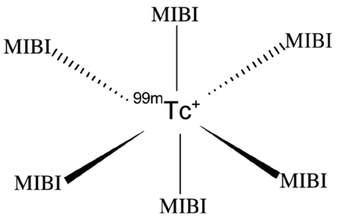
	In-111-Pentetreotide	CT/MRI
Sensitivity	83%	82%
Specificity	93%	86%
Accuracy	87%	84%

INER Saled US patent, entitled Method for synthesis and ^{99m}Tc Labeling of 2-Alkoxyisobutylisonitrile and Preparation of Copper 2-Alkoxyisobutylisonitrile complexes and ^{99m}Tc Labeling of 2-Al koxyisobutylisonitrile

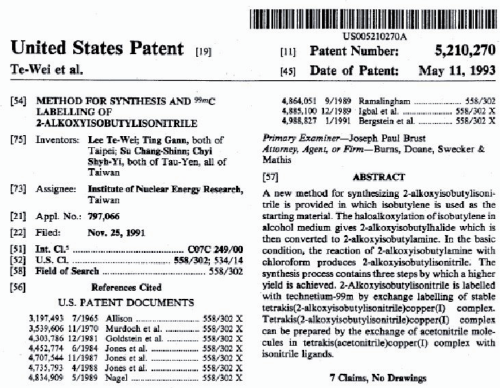
^{99m}Tc-Sestamibi (MIBI) is a myocardial perfusion imaging agent in nuclear medicine. Single-photon emission computed tomography (SPECT) sestamibi is an excellent tool for detection of coronary artery disease (CAD).

While the sensitivity of MIBI SPECT for detecting CAD has been reported to exceed 90%, the specificity ranged between 53% - 100%. Scintimammography with ^{99m}Tc-Sestamibi has been shown to be a good complementary technique to conventional mammography. The sensitivity and specificity of scintimammography for detecting malignant breast tumor were 92% and 87%, respectively. The Institute of Nuclear Energy Research (INER) owns two US patent, entitled Method for synthesis and ^{99m}Tc Labeling of 2-Alkoxyisobutylisonitrile and Preparation of Copper 2-Alkoxyisobuty lisonitrile complexes and ^{99m}Tc Labeling of 2-Alkoxyisobutylisonitrile.

INER and Cardinal Health Inc. have signed a Catent Acquisition Agreement on September 1, 2005. The Catent Acquisition Agreement has a scheduled Assignment , authenticated at the Notary Public Office of Taiwan Taipei District Court, ROC.



The structure of 99mTc-Sestamibi



US005210270A

United States Patent [19]
Te-Wei et al.

[11] **Patent Number: 5,210,270**
[45] **Date of Patent: May 11, 1993**

[54] **METHOD FOR SYNTHESIS AND ^{99m}C LABELLING OF 2-ALKOXYISOBUTYLISONITRILE**

[75] Inventors: **Lee Te-Wei; Ting Gann,** both of Taipei; **Su Chang-Shinn; Chyi Shyh-Yi,** both of Tau-Yen, all of Taiwan

[73] Assignee: **Institute of Nuclear Energy Research,** Taiwan

[21] Appl. No.: **797,066**

[22] Filed: **Nov. 25, 1991**

[51] **Int. Cl.**^{5} **C07C 249/00**
[52] **U.S. Cl.** **558/302;** 534/14
[58] **Field of Search** 558/302

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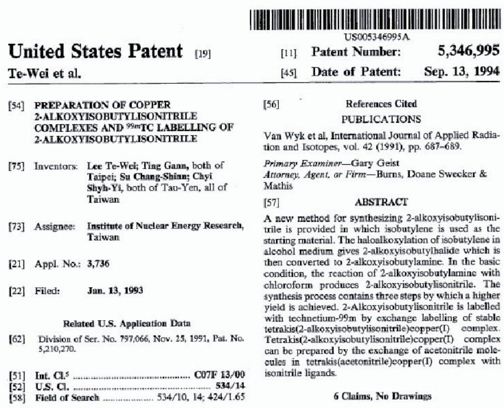
Primary Examiner—Joseph Paul Brust
Attorney, Agent, or Firm—Burns, Doane, Swecker & Mathis

[57] **ABSTRACT**

A new method for synthesizing 2-alkoxyisobutylisonitrile is provided in which isobutylene is used as the starting material. The haloalkoxylation of isobutylene in alcohol medium gives 2-alkoxyisobutylhalide which is then converted to 2-alkoxyisobutylamine. In the basic condition, the reaction of 2-alkoxyisobutylamine with chloroform produces 2-alkoxyisobutylisonitrile. The synthesis process contains three steps by which a higher yield is achieved. 2-Alkoxyisobutylisonitrile is labelled with technetium-99m by exchange labelling of stable tetrakis(2-alkoxyisobutylisonitrile)copper(I) complex. Tetrakis(2-alkoxyisobutylisonitrile)copper(I) complex can be prepared by the exchange of acetonitrile molecules in tetrakis(acetonitrile)copper(I) complex with isonitrile ligands.

7 Claims, No Drawings



US005346995A

United States Patent [19]
Te-Wei et al.

[11] **Patent Number: 5,346,995**
[45] **Date of Patent: Sep. 13, 1994**

[54] **PREPARATION OF COPPER 2-ALKOXYISOBUTYLISONITRILE COMPLEXES AND ^{99m}TC LABELLING OF 2-ALKOXYISOBUTYLISONITRILE**

[75] Inventors: **Lee Te-Wei; Ting Gann,** both of Taipei; **Su Chang-Shinn; Chyi Shyh-Yi,** both of Tau-Yen, all of Taiwan

[73] Assignee: **Institute of Nuclear Energy Research,** Taiwan

[21] Appl. No.: **3,736**

[22] Filed: **Jan. 13, 1993**

Related U.S. Application Data

[62] Division of Ser. No. 797,066, Nov. 25, 1991, Pat. No. 5,210,270.

[51] **Int. Cl.**^{5} **C07F 13/00**
[52] **U.S. Cl.** **534/14**
[58] **Field of Search** 534/10, 14; 424/1.65

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PUBLICATIONS

Van Wyk et al, International Journal of Applied Radiation and Isotopes, vol. 42 (1991), pp. 687-689.

Primary Examiner—Gary Geist
Attorney, Agent, or Firm—Burns, Doane Swecker & Mathis

[57] **ABSTRACT**

A new method for synthesizing 2-alkoxyisobutylisonitrile is provided in which isobutylene is used as the starting material. The haloalkoxylation of isobutylene in alcohol medium gives 2-alkoxyisobutylhalide which is then converted to 2-alkoxyisobutylamine. In the basic condition, the reaction of 2-alkoxyisobutylamine with chloroform produces 2-alkoxyisobutylisonitrile. The synthesis process contains three steps by which a higher yield is achieved. 2-Alkoxyisobutylisonitrile is labelled with technetium-99m by exchange labelling of stable tetrakis(2-alkoxyisobutylisonitrile)copper(I) complex. Tetrakis(2-alkoxyisobutylisonitrile)copper(I) complex can be prepared by the exchange of acetonitrile molecules in tetrakis(acetonitrile)copper(I) complex with isonitrile ligands.

6 Claims, No Drawings

INER owns two US patent

The Patent Acquisition Agreement describes as the following:

PATENT ACQUISITION AGREEMENT

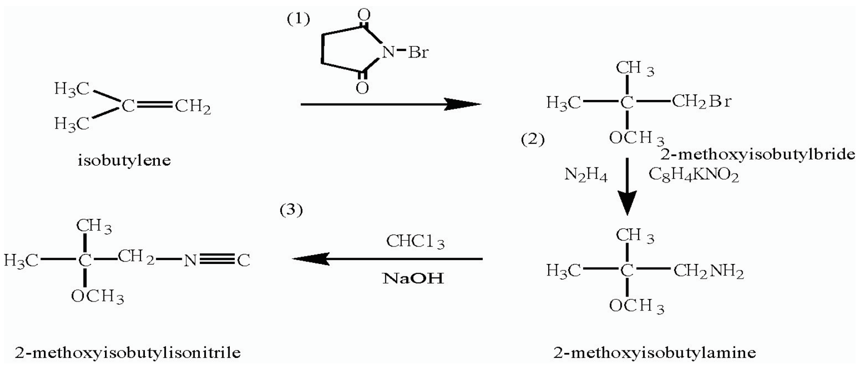
THIS PATENT ACQUISITION AGREEMENT ("greement") is made this September 1, 2005, by and between Institute of Nuclear Energy Research, Atomic Energy Council, Executive Yuan, a government agency of Taiwan, the Republic of China, with address at No. 1000 Wunhua Road, Jiaan Village, Longtan Township, Taoyuan County 32546 ("INER"), and Cardinal Health 414, Inc., a company established under the laws of the State of California, the United States of America, with address at 7000 Cardinal Place, Dublin, Ohio 43017 ("ardinal").

WHEREAS, INER owns all rights, title and interest in and to, and possesses all right, power and necessary legal capacity to assign, the U.S. 5,346,995 and 5,210,270 patents in the United States;

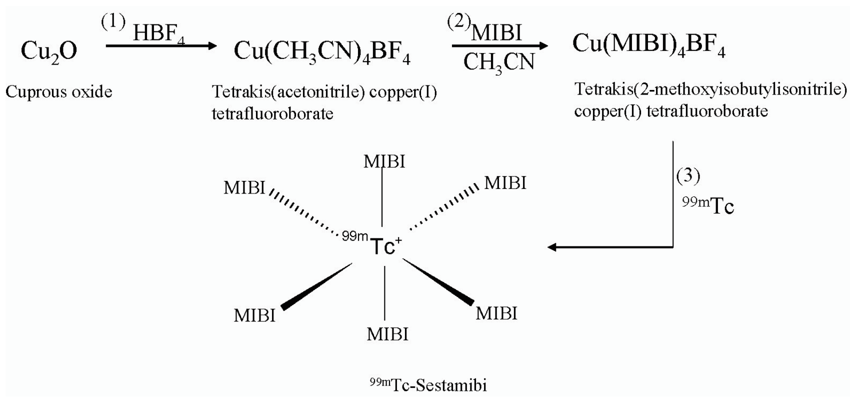
AND WHEREAS Cardinal desires outright ownership of the above patents.

The synthetic route of Method for synthesis and ^{99m}Tc Labeling of 2-Alkoxyisobutylisonitrile is shown in Fig 1. Isobutylene was used as the starting material for the synthesis of 2-alkoxyisobutylisonitrile. The haloalkoxylation of isobutylene in an alcoholic medium gives 2-alkoxyisobutylhalide which is then converted to 2-alkoxyisobutylamine. The reaction of 2-alkoxyisobutylamine with chloroform produces 2-alkoxyisobutylisonitrile under basic conditions. The advantage of the synthetic 2-alkoxyisobutylisonitrile method has been proven to be fewer steps, higher yield (38-43%) and more convenient than knows methods in the literature.

The character of 2-alkoxyisobutylisonitrile has higher volatility and instability. Therefore, we got a US patent about 2-alkoxyisobutylisonitrile complex, entitled Preparation of Copper 2-Alkoxyisobutylisonitrile complexes and ^{99m}Tc Labeling of 2-Alkoxyisobutylisonitrile . The synthetic route of $Cu(MIBI)_4BF_4$ is shown in Fig 2. The reaction between 2-methoxyisobutylisonitrile and tetrakis(acetonitrile)copper(1)tetrafluoroborate yields tetrakis(2-methoxy-isobutylisonitrile)copper(1)tetrafluoroborate in mild conditions. The advantage of the synthetic $Cu(MIBI)_4$ method has proved to be milder, higher yield (90%) and more convenient than know method.



The Synthetic Route of 2-alkoxyisobutylisonitrile



The Synthetic Route of $Cu(MIBI)_4BF_4$ and Labeling with ^{99m}Tc

Development and Applications of Radioactive Waste Treatment and Nuclear Facility Decommissioning Technologies

Decontamination and decommissioning of nuclear facilities as well as treatment and disposal of the related radioactive wastes are very important issues in nuclear applications. Within 20 years, domestic nuclear power plants will probably have to face the twin challenges mentioned above. INER devotes to R&D of radwaste treatment, radwaste final disposal and nuclear facility decommissioning to establish advanced and reliable technical capabilities. Our aims are, to complete the decontamination and decommissioning of nuclear facilities within INER and to accumulate technical capabilities to meet the future national requirements for the benefits of the public and society.

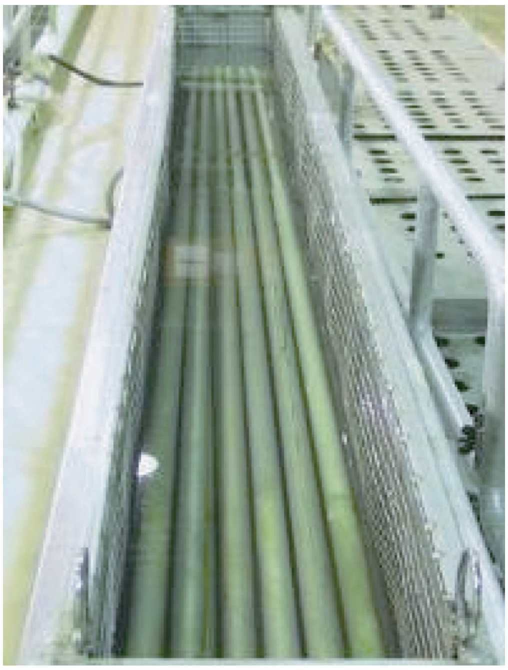
Major tasks conducted by INER this year include: (1) cleaning of spent aluminum claddings; (2) collection of the uranium powder within the fuel pool (3) planning and establishment of the decontamination facilities for radioactive metallic wastes; (4) dismantling of UCTPP; (5) fuel stabilization treatment; (6) research on measurement technology for deregulated wastes; (7) construction of a high volume reduction solidification system for wet wastes at No.2 Nuclear Power Plant; (8) recycled water treatment technology for nuclear power plants; and (9) establishment of a spent fuel dry storage facility.

The nine major projects constitute the tasks necessary for the decontamination and decommissioning of some facilities within INER. Furthermore, INER developed or introduced technologies which are good bases for future development, and acquired experiences for the future planning, safety assement and filed operation on the decommissioning of nuclear power plants.

Cleaning of Spent Aluminum Claddings

Due to high radiation and limited practice space, the cleaning of spent aluminum claddings (with surface dose rate around 20 mSv/h) in the TRR spent fuel pool is very difficult. To clean thousands of claddings, a complete procedure of cutting, decontamination, measurement, transportation and storage needs to be developed first. In addition, issues underwater operational environment and shielding of working staffs also need to be considered. The decontamination method was evaluated and selected from among several technologies, including: super-high pressure blasting cleaning decontamination, electrolytic decontamination, and ultrasonic cleaning decontamination, etc. The parameters for evaluation included are degree of automation, operational space required, decontamination speed, decontamination effectiveness, amount of secondary waste generated, labor required, and budget required, etc. The cleaning technologies of highly contaminated and highly radioactive spent aluminum claddings, as established by INER, include: underwater cutting, underwater ultrasonic decontamination (which has awarded a domestic patent and is applying for a US patent), drying, and transportation and storage with shielded containers. We have cleaned thousands of spent aluminum claddings, decreasing the waste classification from super class C (transuranium) to class A (low radioactivity). The economic benefits of waste degradation and reduction have also been achieved.

Cleaning of Pressed Aluminum Pipes in the Fuel Pool



Cleaning of the Shielded Section of External Pipes in the Fuel Pool

Collection of the Uranium Powder in the Spent Fuel Pool

Cleaning the spent fuel pool is a very difficult task during decontamination and dismantling of nuclear power plants or of nuclear fuel cycle facilities. Uranium powder disseminated in the water not only threatens the environment and health of working personnel, but also increases operational expenses. The collection methods for uranium powder include distillation, precipitation and filtration, etc. Due to the high radioactivity of uranium powder, operation procedures and equipment must be designed in considering radiation protection methods, complexity of equipment and maintenance, difficulty of uranium powder retrieval and inventory, efficiency of collection, and amount of secondary waste produced. The uranium powder collection technology established by INER includes underwater suction, precipitation and storage. Till the end of 2005, INER has retrieved 28 cans of uranium powder and keep the collected powder in the spent fuel pool. The storage method meets the waste regulation requirements of centralized administration and safe storage.

Precipitation Trough of the Collected Uranium Powder

Absorption Operation of Uranium Powder

Collection Barrel of Uranium Powder

Planning and Establishment of the Decontamination Facilities for Scrap Metals

To ensure that the low radioactivity contaminated metal produced during decommissioning activities, meets the regulative clean standard, or to degrade the classification of radioactive waste, our institute plans to establish decontamination facilities for scrap metals at the original reactor plant.

Starting in 2002, the project has completed the design and establishment of the decontamination equipment. The decontamination procedures include pre-classification, chemical and electrochemical decontamination, centrifugal shot blasting and grinding machinery decontamination. Auxiliary equipment usages include: contaminated water waste treatment, decontamination agent regeneration, decontamination agent solidification treatment, monitoring system and decontamination information integration system. During this year, we first completed the on-site installations and functional test of mechanical decontamination equipment and decontamination agent solidification treatment equipment. Then we completed the purchasing procedure, detail planning and design, installation and functional test of pre-classification treatment equipment. In addition, based on the requirements for safe waste management, we set up the monitoring system and decontamination procedure information system, in the original reactor control room. The cleanness, after decommissioning, will be measured by the self-developed total quantity activity measurement system which is installed at the end of the chemical decontamination equipment. After decontamination, washing and drying, the object enters the cleanness measurement system for initial evaluation. Objects that pass the initial evaluation will be sent to the cleanness measurement center for further verification before applying for the removal of “restrictive use” to the governing organizations. Objects that fail the initial evaluation will be re-decontaminated or sent back to the storage facility.

Solidification Treatment Equipment of Waste Decontamination Agent

Pre-Classification Treatment

Shot Blasting and Grinding Mechanical Decontamination Equipment

Chemical and Electrochemical Decontamination Equipment

Equipment Dismantling of UCTPP

Our institute began the research and construction of the Uranium Conversion Test Pilot Plant (UCTPP) in 1982. The facility is used for purification of nuclear materials to produce nuclear-grade UO_2 powder for nuclear research. The facility completed its mission and stopped operations in 1993. In accordance with the Radioactive Material Regulation Act issued by the Atomic Energy Council (AEC) in October 2003, the dismantling of the UCTPP facility began in 2004 and was completed in December 2005.

Major achievements of the dismantling project include (1) Grasping the application and approval procedures of nuclear facility dismantling (decommissioning), and executing the dismantling project according to the law. The main governing organizations include: the Fuel Cycle and Materials Administration (FCMA) of AEC,

Ministry of Audit, and International Atomic Energy Agency (IAEA). (2) Setting up SOP for the UCTPP Facility Dismantling, which includes 16 necessary documents. The dismantling process meets the requirements of the related regulations (operational security/radioactive security/environmental security) and engineering contracts. Besides, the process is regarded as a model of nuclear facility decommissioning. Documents of the process are filed for future references. (3) Completing the facility dismantling of the UCTPP main plant (036A) and the related plants (036W, 036U, 036E, 036G). Key tasks include cutting, decontamination, equipment dismantling, cement foundation dismantling, waste measurement, internal content verification, documentation, package, transportation, storage, space decontamination, cleaning and emptying. An area of about 1,500 m^2 was turned from a " low radiation & low contamination control area" to a "no radiation & no contamination area (monitoring area)" , which can be used for new research projects. (4) Effectively executing the radioactive waste reduction work. Total waste (the majority is steel) dismantled, amounted to 150,324kg, of which only 24,277kg are radioactive waste (142 barrels). Radioactive waste only constitutes 16.15 wt% of the total, while the other 83.85 wt% is assessed as waste meeting BRC(Below Regulatory Concern) standards. (5) The safe relocations of the nuclear material stored in UCTPP meet the requirements of IAEA. Furthermore, the execution of the whole project meets the uppermost standard of high efficiency and zero accidents.

A.Opening Ceremony of the UCTPP Facility Dismantling Project (2005-04-18)

▲Personnel Safety / Operation Seminar

B. Situation Before Dismantling

Situation Before Dismantling of 036A -100&200Area

036W

036G

036E

Before Dismantling -- 036U (UF_6 Dispensing Station)

C.Dismantling Operation

Highly Difficult Tasks of Dismantling at 036U

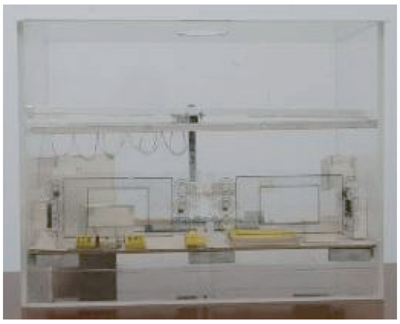
Heavy Machinery Dismantling Work

D.Project Completion

Complete the Dismantling of 036A-100&200 Area

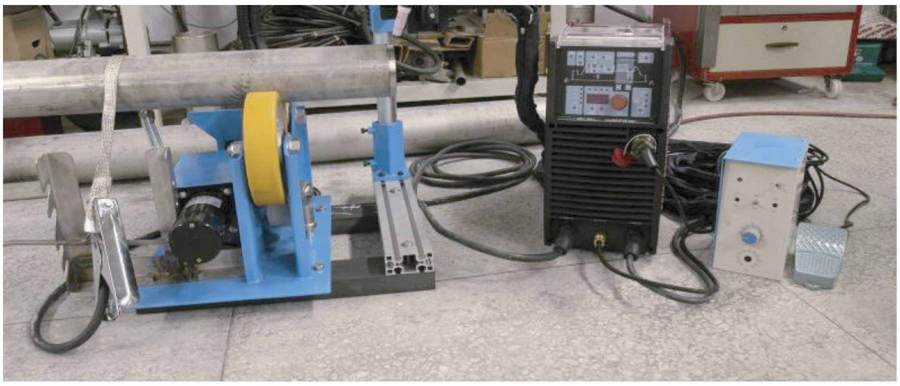
TRR Spent Fuel Stabilization Treatment

TRR spent fuel stabilization means to take out the spent metallic uranium fuel rods from the TRR fuel pool, stabilize them to oxide form, and store in horizontal shielded cask. The stabilization treatment process established by the institute includes cutting to short segment, removing of the fuel cladding, high temperature oxidation to powder/flake form, filling and sealing to powder canisters, and loading to the shielded cask. Since metallic uranium is active in reacting with the oxygen and water of the storage place, there exists a risk of explosion during storage. Considering the safety of long-term storage, metallic uranium needs to be oxidized, in order to become stabilized U_3O_8. The development of stabilization treatment process of metallic uranium fuel is the first experiment internationally.



Model of Stabilization Treatment Equipment (Scale: 1/30)

Operational Simulation of Fuel Rod Cutter



Simulation of Lid Welding and Measurement Operations of the Storage Containers

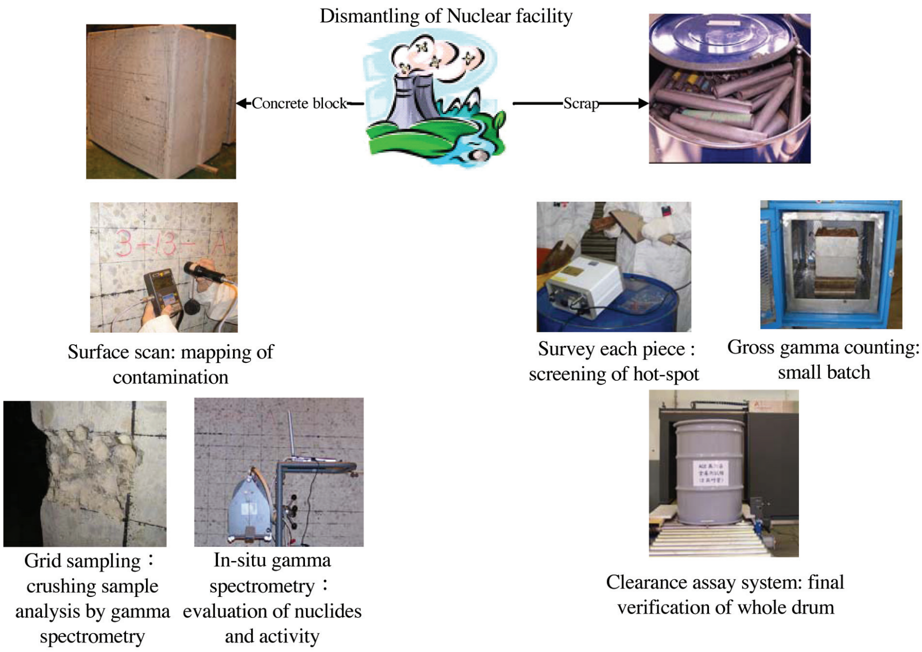
Research on Free Release Characterization Methodology of Decommissioning Waste

Studying from international practices, the INER has set up a Release Characterization Lab for decommissioning waste to solve the problem of very low level waste management. The Lab has installed important assay system and established a inspection and verification procedure. The Lab adopts multi-inspection procedures, different of detection modes concepts and screen out higher contamination to confirm whether the activity concentration of standby clearance waste meet regulation. In this way, the environment and people safety shall be assured, resource can also be effectively re-used and the environmental burden will finally be relieved.

Major achievements in 2005 include:

(1) Proposed draft of detection procedure planning and release: The complete monitoring and inspection procedures and proposed release plan for dismantling large concrete blocks and drum packed scrap waste have been finished.

(2) Total waste inspection system: The clearance assay system, in-situ gamma spectrometry and conveyor-tape contamination screening system for total waste inspection system. The accuracy and sensitivity has met regulatory requirements for inspection and verification of specific waste.

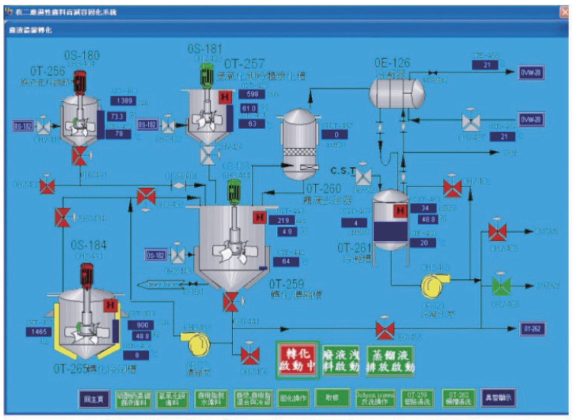


Characterization Procedure of Different Waste

Construction of High Volume Reduction Solidification System for Wet Wastes in Kuosheng Nuclear Power Plant

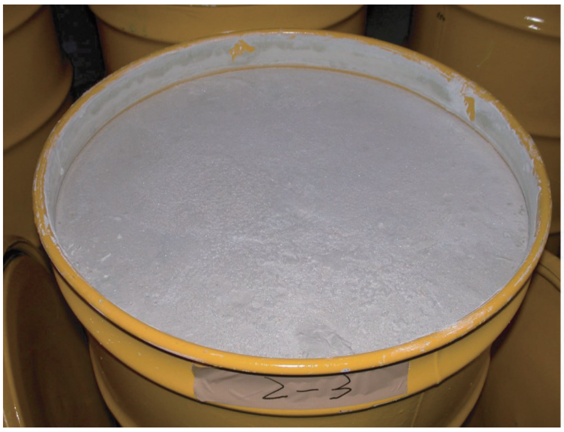
To reduce the solidified wastes produced by boiling water reactor (BWR) nuclear power plants, and improve the quality of solidified wastes, the Chemical Engineering Division of our institute has successfully developed the High Efficiency Solidification Technology for BWR (BWRHEST) wet wastes. The technology employs the strategy of “Using wastes to solidify wastes” , which utilizes the very characteristics of the wastes to realize the goal of reducing solidified wastes of BWR nuclear power plants. The technology has received patents from Taiwan, the US and five countries of the European Union. The application for the Japanese patent will soon be approved. Furthermore, it even won the Silver Medal of 2004 National Invention and Creation award in Taiwan. After being verified by the pilot system, the technology was adopted by Kuosheng Nuclear Power Plant of Taipower in December 2002. The construction of the system and pilot run, were completed at the end of 2005. The system, which began formal operation in 2006, includes use friendly interface, automatically interlocked remote devices, and humanly designed operation units. In addition to waste volume reduction, application of this system will further enhance the safety and reliability of the waste solidification process. It is estimated that with this technology, the original volume of solidified waste in Kuosheng Nuclear Power Plant will be lowered by at least 60%. This result is another world-class volume reduction record of nuclear waste, achieved by our institute, following the unprecedented volume reduction performance at Maanshan Nuclear Power Plant.

High Volume Reduction Solidification System for Wet Wastes in Kuosheng Nuclear Power Plant



User friendiy Control System of the High Volume Solidification System

Control Panel of the High Volume Reduction Solidification System



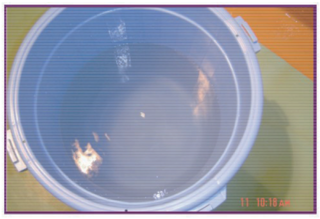
Solidified Object Produced by Pilot Run of the High Volume Reduction Solidification System

Recycled Water Treatment Technology of Nuclear Power Plant Has Reached World Class Level

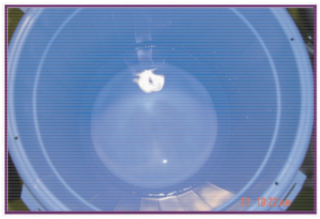
To enhance the long-term operational safety and reliability of nuclear power plants, and reach the goals of saving water and zero discharge of waste water, it is important to remove the total amount of organic carbon (TOC) of the nuclear plants recycled water. Our institute has successfully developed new TOC degradation technology, which has a special effect in removing the organic contamination in waste water. After power plant actual waste water testing, the technology has been verified as capable of reducing the TOC concentration in water to less than 150 ppb. The water quality, after using this technology, is better than the TOC 200 ppb standard required by the EPRI 2000 version of the US.

Besides dealing with the recycled water of nuclear power plants, this technology also has very good effect in removing the TOC of waste water produced by high-tech industries and other industries. The water, after treatment, satisfies the regulatory waste water discharge standards (BOD<30 ppm, COD<100 ppm). Besides, the cost of the technology is lower than the traditional ones. Taking the treatment of organic waste water with TOC of 1,000 ppm as an example, either the number of equipments required or the operational costs are only half of that required by the current methods. This technology offers a low cost and high efficiency solution to the large amount of organic waste water produced by the manufacturing processes of domestic industries..

Recycled Waste Water Treatment Demonstration System



Waster Water Before Treatment



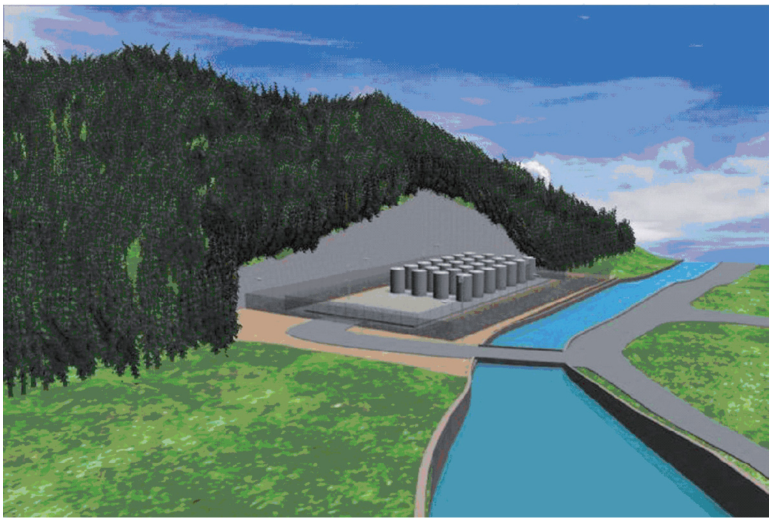
Waster Water After Treatment

Establishment of Spent Fuel Dry Storage Facility

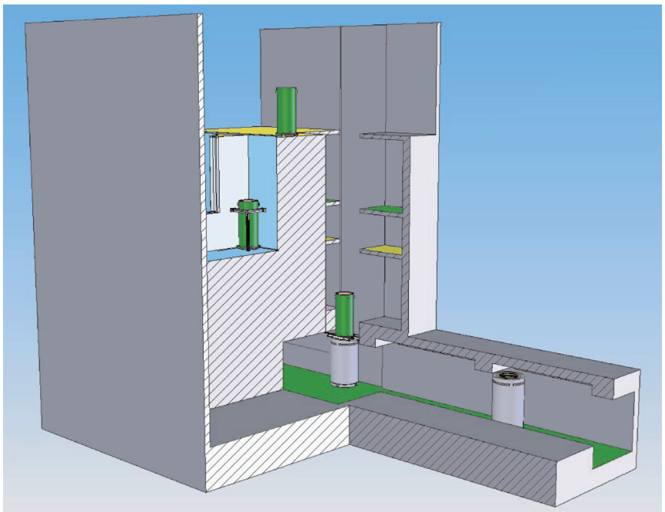
Our institute was entrusted by Taiwan Power Company, in July 2005, to purchase and install the dry storage facility for the spent fuel from No. 1 Nuclear Power Plant. Considering that this is the first time for a Taiwanese organization to install a dry storage facility, as well as the time constraints, the institute decided to transfer the technology from overseas, but build the facility itself. The project is currently running smoothly. The technology transfer, document submission and design of important components have been completed. Major work of 2005, is to complete the Safety Analysis Report (SAR), which should be submitted to Taiwan Power Company and the governing organization for approvals.

The whole project is scheduled to last 6.5 years, and ends in February 2012. Major work projects include (1) Transfer the technology from an overseas dry storage facility manufacturing company, and transfer part of the technology to Taiwan Power Company. (2) Conduct dry storage facility design and safety analysis, and assist Taiwan Power Company to apply for construction and operational licenses. (3) Provide the concrete foundation, relative civil construction and surrounding facilities necessary for installing the dry storage facility. (4) Provide the relative equipment (including transportable storage canister, fuel basket, transfer cask, and vertical concrete cask) necessary for installing the dry storage facility. (5) Fill, transport and store the spent fuel, and provide the relative hoisting, transportation and storage equipments. (6) Provide software and hardware equipments necessary for the dry storage facility.

Our institute has set up an outstanding group to handle all the works. Based on past experiences and capabilities, the project team is fully confident in facing all the challenges.



Bird's Eye View of the Future ISFSI Site



Future Operation Procedures Diagram

Development and Applications of New Energy Technologies

Facing the problems of global warming, air pollution, and oil depletion, and under the pressure of the Kyoto Protocols restriction on CO_2 emission, all national governments are looking for renewable energies and related technologies that are environmentally friendly. Following government policy, this Institute is actively promoting the development and application of new energy technologies. In 2005, through two projects: “ Key Renewable Energy Technology Project ” and “ Application of Nuclear Technology in the Development of Nanotechnology ” , the Institute has successfully completed the research and development of the following new energy- related technologies:

1. Wind power system
2. High concentration III-V PV system
3. High temperature SOFC power generation system
4. Biomass energy conversion system
5. DMFC nano-catalyst and its effectiveness
6. Nano material for hydrogen storage

The project achievements are illustrated below:

25 kW Smart Wind Power System

The smart 25kW wind turbine was accomplished in 2005, and was a joint effort by INER, Da-Yeh University, Industrial Technology Research Institute (ITRI), and local fabrication companies. This horizontal axis wind turbine has a blade diameter of 12.5 meters and a stainless tubular tower of 25 meters. The domestic self-manufacture ratio is over 90%. This system, which features low initial wind speed, intelligent pitch angle regulation control similar to that in a large-sized system, and yawing and braking systems, was designed to be a smart wind machine with high efficiency and performance, and to serve as a test platform for advanced wind turbine designs. As it is a smart wind turbine design, we have applied for a number of patents, including: yaw control system, pitch angle control system, braking system and special permanent magnet generator system.

Wind power is now a rapidly developing new energy system in the world. We'd like to transfer the technologies developed through this smart wind power project to domestic companies, and hope to contribute to both Taiwan's wind power application target and the local wind power industry.

The 25kW Smart Wind Power System Located Beside the Building 072 of INER

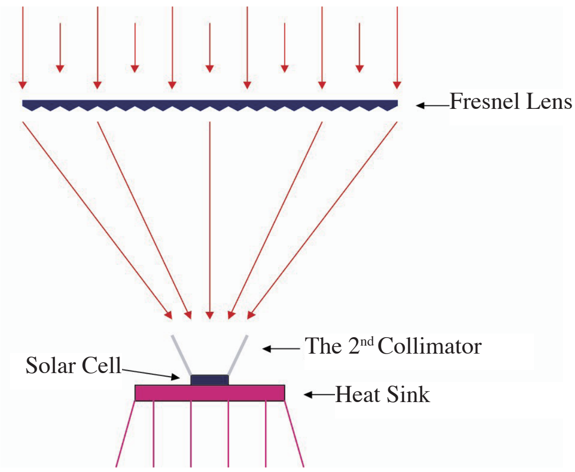
High Concentration III-V PV System

III-V HCPV module is characterized by its use of an optical lens design. Focused by a Fresnel lens, the enormous energy of sunshine is concentrated on the small III-V solar cell. In this way, more power is generated while using less solar cell materials. Thus, the power generation cost can be lowered. Currently, the efficiency of the HCPV module developed by our institute is 22.5%, reaching the world's top-grade level.

The solar power demonstration system developed by our institute integrates 1kW HCPV module, solar tracker, and various power apparatuses. Through the use of a sensor and tracking control loop, the solar tracker automatically and precisely tracks the sunshine so that HCPV module will be able to receive more solar power and produce greater amounts of electric power.

Located in Building 013, our institute completed the installation of the 1kW solar power demonstration system and the monitoring system. We are now actively planning the installation of a 10kW large solar power generation station.

Our solar power research team has received patents for several core technologies, including III-V solar cell component, HCPV module design, solar tracker and holder design, etc. We will speed up the technology transfer to domestic companies to enhance the international competitiveness of Taiwan's PV industry, as well as to increase the proportion of self-supplied energy in Taiwan's energy grid.



Structure Diagram of Concentration Type Solar Cell Unit

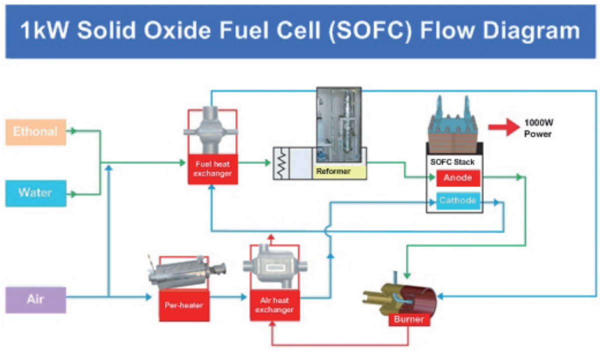
1kW High Concentration Solar Power Generation Verification

High Temperature SOFC Power System

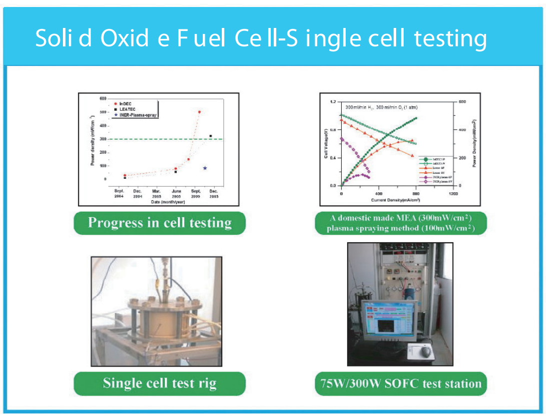
SOFC is composed of total solid structure and directly converts the chemical energy of fuel into electrical energy through electro-chemical reactions. The principle of investigate-planar SOFC is that cathode oxidant (e.g. air or oxygen), undergoing catalysis of cathode catalyst under high temperature, is transmitted to the anode to react with fuel gas (e.g. natural gas, coal gas, methane, hydrogen), and produce electric current through a bi-polar connection panel. The manufacturing process of SOFC begins with the production of anode electrolyte and anode material powder using chemical co-precipitation and hydrothermal treatment. Then the support panel of the cell is made using tape caster, laminator pouch, hot press and high temperature heat treatment furnace. Lastly, we print electrode paste onto the electrode support panel by using screen printing technology.

One of the core technologies of SOFC power generation system is the “Stack” . The SOFC stack is composed of many unit batteries. The assembly and high temperature sealing technologies of the stack is the key to the successful development of SOFC. All the components of the stack must meet the various requirements for high temperature oxidation, maintaining normal size, chemical stability, anti-oxidation, anti-corrosion and thermal expansion coefficient, etc. Currently, the institute has achieved considerable progress on the design, sealing and efficiency testing of the stack.

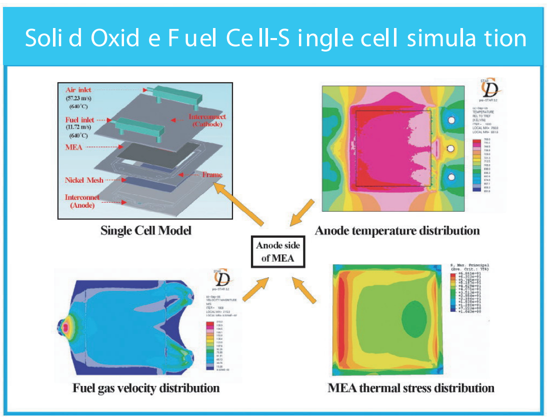
Through the development of the first domestic SOFC power generation test system, and verification of its long-term stability and reliability, we will be able to grasp the key technologies of SOFC and help domestic companies commercialize SOFC products.



The Process Flow Diagram of 1kW SOFC System



(a)



(b)

(a) SOFC Efficiency Test Diagram; (b) Single Battery Simulation and Analysis Diagram

Biomass Energy Conversion Technology

Biomass energy is the energy derived from the conversion of biomass. Materials such as rice husk, rice straw, corncob, bagasse and seaweed, can all be converted into ethanol or hydrogen energies. Our current studies on biomass energy include:

seaweed aquiculture, converting cellulose to bioethanol, hydrogen production from bioethanol, and biomass plasma gasification technology.

Taiwan's sea coast has an abundance of seaweed plants. For example, ulva lactuca is a kind of green algae that can be seen everywhere along the coast. We are now studying its indoor development and adhesion methods, in order to increase the production of shallow sea aquiculture and discover the possibility of using it as a new kind of biomass material.

Bio-alcohol is a kind of globally recognized alternative fuel. Our research is focused on the development of ethanol production technology, using artificial rumen-protected techniques to saccharify and ferment seaweed which contains cellulose in order to produce ethanol. Yeast is always used to ferment glucose in producing ethanol. However, yeast is incapable of converting cellulose to glucose. We are studying using gene engineering to enable yeast to possess both saccharification and fermentation capabilities so that it can be used directly to convert cellulose to ethanol.

The catalyst system for producing hydrogen from ethanol is characterized by small size, portability and simple operation. The system uses three materials: ethanol, water and oxygen, to react on the surface of the catalyst. The hydrogen and CO produced are as fuel for SOFC, which can be used for fuel cell power generation. Currently, the system is designed to produce as much as 1 kW of electricity. We hope to be able to apply this system for future use in distributed power stations and hydrogen gas stations.

Plasma gasification power generation technology employs a plasma torch to produce temperatures above 10,000°C that can decompose the organic components of biomass into useful gas molecules, such as hydrogen, CO and methane, etc. These gases can be converted to high-pressure steam through boilers, and push gas turbines that will generate electric power.

Catalyst System for Producing Hydrogen from Alcohol

20kW Vapor Plasma Torch System

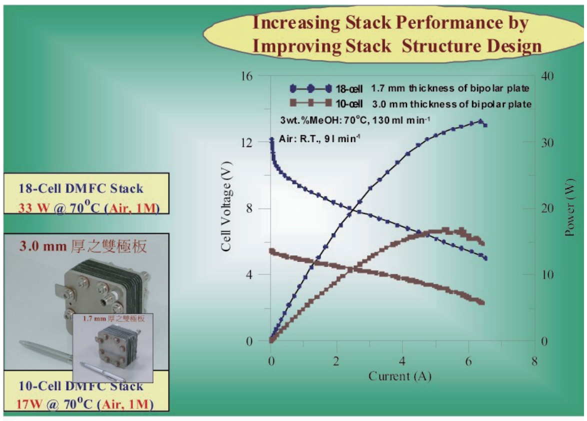
DMFC Nano Catalyst and the Research on Its Effectiveness

The fuel cell is a kind of new energy device of the 21st century. It is widely used in the fields of large power generation equipment; transportation vehicles and portable power supply systems. DMFC is a kind of fuel cell that has stable output power, low operational temperature and which also uses safe liquid hydrogen-abundant fuel. Therefore, it is under active development for applications in 3C products, such as the mobile phone and notebook PC. Our research goals for DMFC is to improve its output power, decrease the size of the system and reduce its production cost.

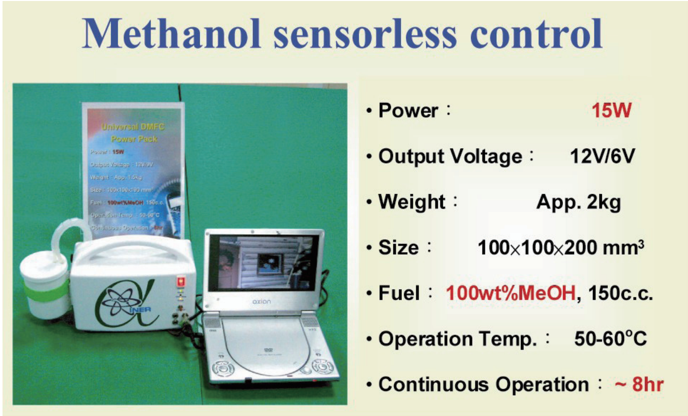
As for the research on the catalyst, we have already developed the manufacturing process for platinum, with nano network structure and alloy catalyst. It first attaches nano size polystyrene or CO_2 balls, to the surface of the carrier, to form a single layer or multi-layer stack. Then it uses reduction or sputtering methods to fill the intervals between those nano balls with platinum or its alloy. Lastly, using high temperature oxidation method, the organic macromolecular polymer in the above structure will be removed by burning, to obtain a platinum catalyst with nano network structure. If SiO_2 balls are employed in the above process, hydrofluoric acid liquid should be used to dissolve and remove them. The catalyst developed through this technology is a high-effectiveness with uniform holes and a large catalysis surface area.

Proton exchange membrane (PEM), an important component of DMFC, is used to separate the two electrodes, connect the circuit (proton path) within the battery, and separate the fuel (prevent bypassing of methanol). Through compactness technologies such as barrier film, barrier coating, irridation crosslinking, and plasma treatment of membrane interface, the fluorocarbon macromolecular material we use is able to improve the methanol crossover of PEM, and ensure the proton flux of the PEM. We have completed establishing the test apparatus and technology of methanol diffusion coefficient, using concentration difference method. The apparatus and technology for testing the proton flux of homogeneous PEM and heterogeneous PEM using alternate impedance method has also been set up.

The DMFC stack developed by our institute has a single layer response area of 25 cm^2, and reaches 33W output power at 70°C. Its size has been decreased to 80 mmx80 mmx51 mm. Currently, this DMFC stack has been used to produce 10-20W DMFC portable power supply system for DVD players.



Design, Assembly and Test of DMFC Stack



INER 15W DMFC Portable System

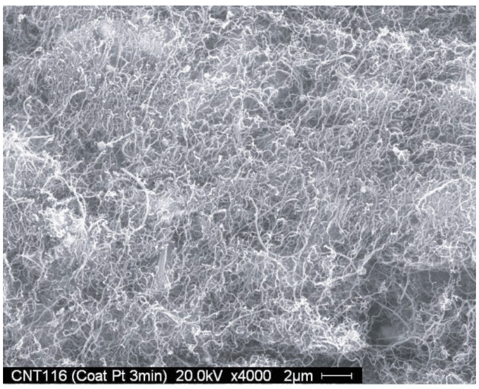
Nano Material Used for Hydrogen Storage

Since the burning of hydrogen energy will not produce CO_2, from the environmental point of view, it is regarded as the best substitute energy for replacing oil. However, at the current stage, hydrogen storage systems still have major drawbacks, such as large size, heavy weight and safety problems, etc. The bottleneck affecting production is caused by the fact that at the current energy density of hydrogen energy, it could not reach the target value of vehicle fuel cells set by US Department of energy, if used as the energy supplier in transportation industry. Therefore, nano material for hydrogen storage is an issue that has aroused wide research interests in the recent years.

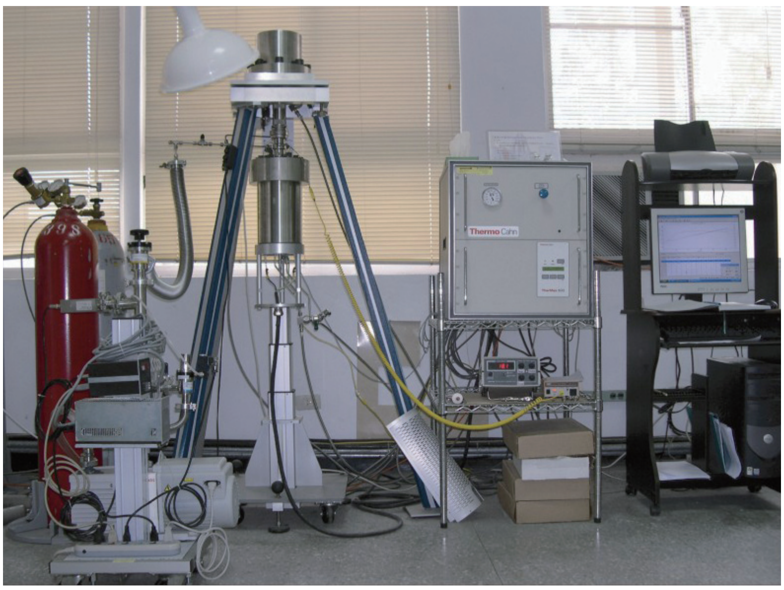
The nano materials used in this project, such as the carbon nanotube, and metal organic frameworks, share similar features: nano holes and large specific surface areas. They are regarded as potential hydrogen storage materials. Carbon nanotube is produced by catalytic cracking method, using $LaNi_5$ powder as the catalyst and CH4 as the carbon source. The original product is synthesized under suitable reaction temperature. After purification and activation treatments, the current highest hydrogen absorption rate can reach 3.3wt%. The research also discovers the relationship between hydrogen absorption rate and the structural parameters of the carbon nanotube. The result shows that besides the number of defections and specific surface area, the degree of purity seems to play an important role in improving hydrogen absorption rate. However, the reappearance problem and hydrogen absorption rate improvement still need further research efforts.

Another very important strategy is to design multi-hole material according to the physical adsorption of specific surfaces and the weak polarisability produced by scattering ion objects. Metal organic frameworks are the material currently known to have the largest specific surface that satisfies the above requirements. Besides, the specific surface can be improved through outstanding design and adjustments. The MOF-5 material with high crystal structure has been successfully synthesized under optimum control conditions and crystallization processes. The electron microscope imaging shows that this synthesized object is of cubic crystal shape with width between 1~40 μm. The X-ray diffraction result shows that its diffraction mode is quite identical to that of the standard product. The relative specific surface and hydrogen storage volume are currently under measurement.

To meet both national energy and environment requirements, our institute is actively developing new energy technologies. Through our researches, we hope to establish a good foundation for the domestic energy and environment policies, by integrating domestic energy research resources to work together on the renewable energy technology development. We confidently expect that our renewable energy researches will play a role in the development of the green industry.



Carbon Nanotube Grown by Thermal CVD Method



High Pressure TGA System Established by the Institute

Development and Applications of Plasma Technologies

Since 2004, the Center has devoted its efforts to the development and application of plasma melting technology. The achievements are: 1) the test center for high-power plasma torches 2) the development center of plasma treatment processes 3) the center of reutilization of plasma vitrified slag, and 4) the industrial application platform of plasma melting technology. Meanwhile, the Center hopes to achieve: 1) High-power commercialization of plasma torches 2) The development and application of reutilization of plasma melting slag, and 3) Plasma conversion of organic waste material to energy. These three areas are the major programs aims for future developments.

This year, the main achievements three categories: plasma melting, plasma gas treatment, and plasma surface modification technology as detailed by the following eight sub-categories:

Establishment of the Test Center for High-Power DC Plasma Torches

After factories building, DC/AC power supply systems, and high-pressure gas supply system were established in 2004, in this year, main/sub-cooling water systems, test chambers, and cooling ventilation systems were completed as well. The main cooling water system includes: the RO pure water production system, EDI ultra-pure water production system, variable-frequency cooling circulating system (10kg/cm^2), high-pressure variable-frequency cooling circulating system (30kg/cm^2), and a vibration monitor system. The sub-cooling water system contains cooling towers, the filtering system of the cooling towers, and a chemical feeding system. The main and sub-cooling water transfers heat through the heat exchange system for cooling down devices. The devices of this cooling system are distributed on a special three-layer steel platform. (Figure 1 & 2)

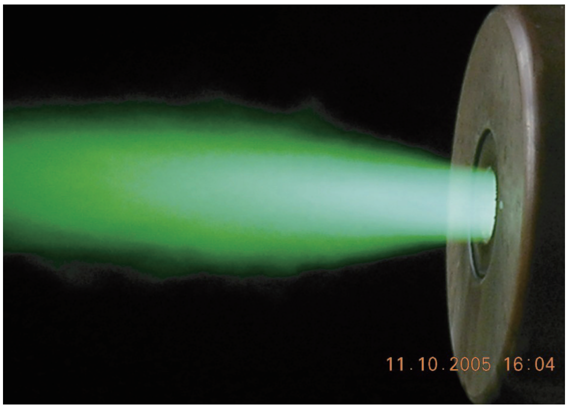
▲Figure 1

When plasma torches are operating, they emit high heat and strong light, as well as ultraviolet and high-decibel noise. Therefore test chambers are required to prevent the intervenetion of these annoying factors, and to offer a safe environment for testing plasma torches. A test chamber has multiple -windows upon which measuring instruments can be mounted, to measure properties of torches when activated. The high temperature of the operating plasma torches is controlled at 1,110°C, which, after quenching, will drop to 550°C and further down to 200°C after the second quenching. Finally, the heat will be dissipated into the atmosphere. Both transferred and non-transferred 3MW DC plasma torches, one piece of each style, have been designed and fabricated (Figure 4). Besides, the repairs of an optics lab were finished, and the lab has one SPEX 1404 spectrometer that was used to measure the spectral properties of the 100KW steam plasma torch (Figure 5).

▲Figure 2

▲Figure 3

▲Figure 4



▲Figure 5

The Development Center of Plasma Melting Process

To obtain the technology for hazardous waste treatment and to apply the plasma technology to environmental protection, since 2004 the Institute of Nuclear Energy Research constructed the Development Center of Plasma Melting Processes within 2 years, and set up a test system with disposition capability of 2 tons per day. Organic waste materials, inorganic waste materials, mixes of waste materials, waste solvents and all other hazardous wastes could be tested and researched with the required equipment.

The equipments include one plasma furnace and one plasma-gasification cracking furnace with one 100KW non-transferred plasma torch on both furnaces. The furnaces share infrastructure:, the second combustion chamber, gas-cleaning facilities, a central control system, and one continuous emission monitoring system. Flexibility and multifunction are the main points in the design. With these facilities, the center can conduct research on all kinds of residues: solid organic waste materials, waste solvents, and other sorts of wastes, and determine proper treating procedures for particular wastes, as well as the function of each unit facility. Cleaning gases (dusts, SOx丶NOx丶Dioxin), the reutilization of waste heat, zero- waste water, and other environmental protection and conservation approaches, were taken into consideration in the system's design. The unit facility and systems completed their tests. When dusts, residues, organic waste resin, and other mixes of wastes are put into a small crucible for the melting and cracking tests, delicate, fine slag-based products come out of the crucible. Besides, the volume reduction ratio and the weight reduction ratio are 3.5 and 1.3, respectively. CEMS monitored the tests and concluded that the waste-cleaning system functioned well and pushed the waste gases far below the environmental protection standards.

Development and Application of Reutilization of Plasma Vitreous Slag

With the focus on high-value products made of water-quenched slag, the center's main product of the year is foam glasses. With plasma slag as the raw material, vesicant (ex. dolomite or sulfuric nitrate), flux (ex. water glass), and foaming stabilizer (ex. sodium phosphate) are added to produce foam glasses. A research concludes that vitreous slag could be a good foaming material, and since the slag's components are more complicated than general glasses, general waste glass could be added for thermal refining in the production of high-quality foam glasses.

As for the coloring treatment technology, coloring agents or de-coloring agents can be mixed into the slag during the process of reutilization, so that the utilized slag can have various hues, high texture, and high value, with renewable potentials. A study found that TiO_2 can make pink, MnO_2 black, NiO brown, and red brick powder orange. With coloring treatment, the slag could have both selectivity and diversification, adding to the prosperity of the building materials industry.

In 2004, the water-quenched slag was tested in forging water permeable bricks and succeeded. This year, the bricks were employed in paving pavements. The area was equal to, or larger than, 90 square meters, with a width of 1.8 meters and length of 50 meters. This field is shown as Figure 1. Water-quenched slag on roads is shown in Figure 2. The Institute of Nuclear Energy Research divides the slag-based

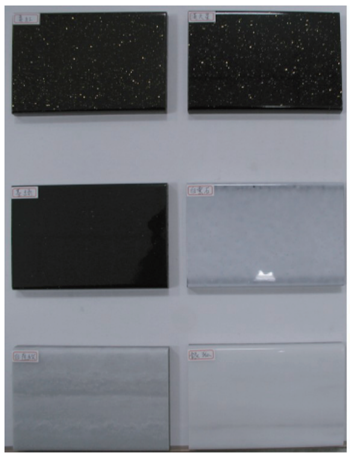
aggregates into coarse and fine aggregate that can be paved, at a certain ratio, on the road base, the bottom layer, and the roadbed. With the help of asphalt, asphalt concrete-based surface material and asphalt aggregates are derived. If the artificial aggregate could be used well, this would replace some sand and stone materials and relieve the shortage of sand and stone in Taiwan.

As for artificial stone, the center used 70% of water-quenched slag as the main raw material, and unsaturated polyester resins and a few natural stone powders as other materials, mixed, and poured into a tooling and finally produced artificial stone of plastic and non-plastic shell. Now the center, having cooperated with several companies, has 9 sorts of artificial stone materials. Later, the center did the tests (water absorption, compressive resistance, hardness, etc.), and found that water-quenched slag-based artificial stone materials are as good as natural stone powder-based materials in regard to property and basic function (Figure 3). Artificial stone material can be applied to: the outside of buildings, inside floors, panel decorations, doorsteps, window sills, stone steps, elevated floors, the most popular manufacture platform, office/ kitchen / bar counter tops and bathroom vanity tops that need acid-fast and wear-resistant properties.

In the future, to conserve energy and reduce emissions of greenhouse gases, the reutilization of plasma melting slag will be the source for high-value, light products and the relevant researches. Besides, light cement and artificial aggregates will help with the diversification of plasma vitreous slag-based products.

▲Figure 1

▲Figure 2



▲Figure 3

Establishment of the Plasma Melting Demonstration Plant for the Reutilization of Incineration Ashes

In November of 2003, the institute cooperated with the Environmental Protection Administration and proposed a "Plasma Melting Process of Urban Incinerator's Fly Ash" program, with 15 months allotted for the program. The goal aims at the researches into the properties and effects of the plasma melting process, and at the establishment of the prototype plasma plant for the melting of ashes from urban incinerators. Hopefully, this technology can be available through out Taiwan.

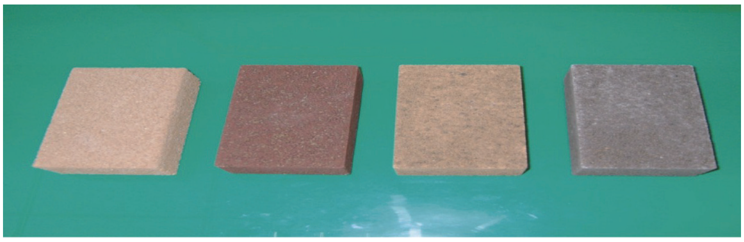
This program sampled five incinerators, respectively, in Beitou, Neihu, Shulin, Hsin-chu City, and Central Kaoushiung City. Researchers of the program analyzed the components of sampled ashes, the level of dioxin, and the heavy metal leaching elements four times a year. Furthermore, the researchers figured out a component ratio of ash melting and the conditions of melting operation. Next, after the completion of the demo factory for the plasma melting of ash residues, 19 test operations (over 1,000 hours) were conducted, including a 7 days continuous run. As a result, 66 metric tons of melted ashes produced 47 metric tons of water- quenched slag, with the weight reduction ratio of 1.4 and the volume reduction ratio of 3.0 (the volume ratio of water- quenched slag to ashes was 1:3). The water- quenched slag contained heavy metals, such as Pb, Cd, Hg, Cr, As, Se, with the levels below environmental protection standards. The level of dioxin was lower than 5.00×10^{-6} ng -TEQ/g, with a removal efficiency of 99.988%. The level of dioxin measured by the exhaust gas detection of the plasma melting system was 0.157 ng-TEQ/Nm^3, and the emitted heavy metals such as Pb, Cd, and Hg conformed to environmental laws.

When the water-quenched slag is reutilized, water permeable bricks, road-grading materials, micro-crystalline materials, and glass artifacts are the products that have high enough quality to serve as alternatives for their existing counterparts in the market. For ashes (flyash: bottom ash = 1:1), and capacity 50 tons/day, the processing cost would be $8.91/kg. However, through plasma melting, the ashes will turn into water permeable bricks made of water-quenched slag. Water-permeable bricks are worth $6 million NT dollars per month.

▲Plasma Melter

▲Off-gas Treatment System

▲Water-quenched slag d_{50}:2.24 mm

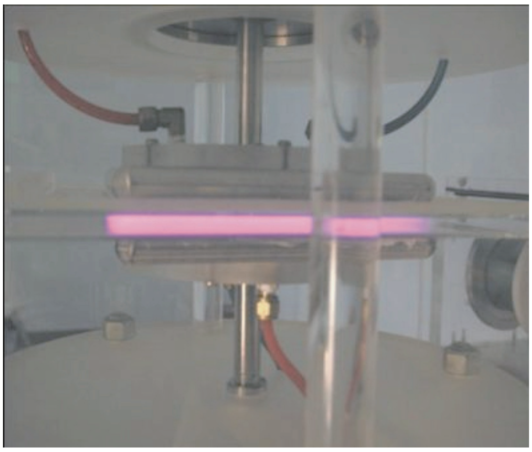


▲Water Permeable Brick

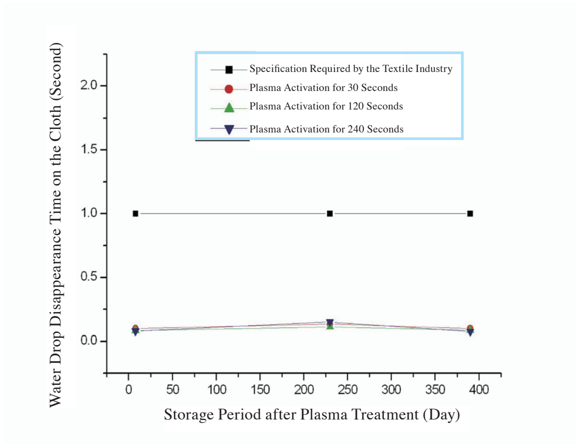
Surface Modification of Atmospheric Pressure Plasma on Functional Textile

Greater attention to daily comfort and healthful clothes accompany higher living standards. Summer sport clothes, underwear, and leisure clothes demand water absorption and repelling, the function that provides dry touch to the skin. To obtain this dry touch, the textile industry uses acid solution during the pre-processing step, or as the catalyst for the grafting of hydrophilic functional groups. However, this traditional chemical procedure has two major drawbacks: 1) the acidic waste solution can damage the environment, and 2) poor wash fastness. Therefore, to improve the wash fastness with an environmentally-friendly procedure, the institute of nuclear energy research uses self-developed atmospheric pressure plasma (Figure 1) to activate the polyester woven fabric with chitonsan hydrophilic functional group (-OH & - NH_2) grafted into it, to obtain water absorption and antibiotic functions.

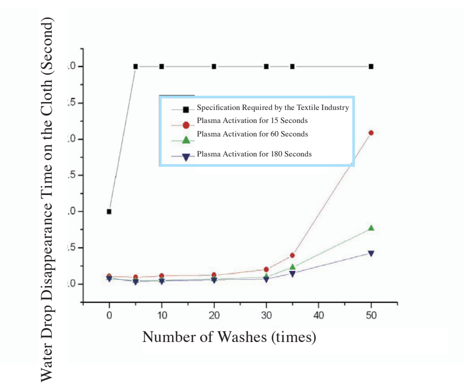
A low-frequency (~kHz), high-voltage power supply exerts the high electric field between a set of parallel electrodes, to ionize the mixing gases of helium, argon, nitrogen, and oxygen, forming atmospheric pressure plasma. After that, electrons, ions, and active groups in the plasma, can activate the surface of textile and enhance its ability to graft hydrophilic functional groups. The polyester woven fabric, when all strict requirements are fulfilled, and after the fabric is activated by the atmospheric pressure plasma and grafted with chitonsan, can sustain its water absorption capability for 390 days (Figure 2). More amazing is that this kind of polyester woven fabric can have wash fastness increased more than 50 times (Figure 3). Regular polyester woven fabric has wash fastness less than 5 times (Figure 4). This finding shows that atmospheric pressure plasma's activation capability can improve durability and wash fastness of woven fabrics. This result lives up to the textile industry's demands; meanwhile, atmospheric pressure plasma has environment-friendly and cheaper production procedures that can help corporations reach the goal of sustainable development.



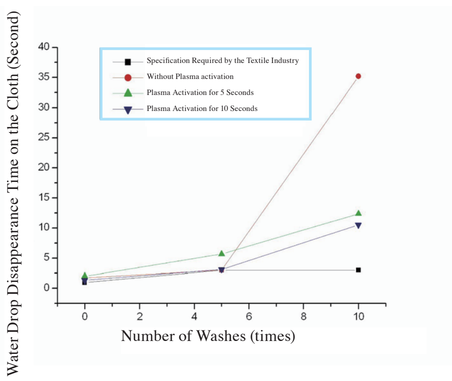
▲Atmospheric Pressure Plasma Source Developed at INER



▲Hydrophilicity of PET Fabric after Storage for 390 days



▲Wash Fastness of PET Fabric for 50 Wash Cycles



▲Wash Fastness of PET Fabric for 5 Wash Cycles

Development and Application of Plasma Processing of PFCs in the Semiconductor Industry

The gas that circulates in the atmosphere, and which can retain radiation from the sun, is called greenhouse gas. The main components are: CO_2, CH_4, and N_2O. Accompanying the advances in modern technology, SF_6, HFCs, PFCs, and other artificial gases have been released into the atmosphere, and although account for a marginal percentage of greenhouse gases, the warming potential and the lifetime of these greenhouse gases surpass those of carbon dioxide; their greenhouse effect exerts an influences on the earth that is, at the least, hundreds of thousands times greater than that of carbon dioxide. Furthermore, these greenhouse gases have stable chemical structure, so the effect is usually irreversible, a fact which has caught people's attention. In 1987, members of the United Nations signed a United Nations Framework Convention on Climate Change (UNFCCC) and passed the Kyoto Protocol. The Kyoto Protocol regulates the reduction of six major greenhouse gases and presents a reduction schedule. Among the greenhouse gases, PFCs are largely used in the semiconductor industry. This protocol came into effect on February 16 of 2005, and Taiwan's government already has assigned an agency that will hold energy forum and propose countermeasures. The reduction of emission of greenhouse gases may impacts Taiwan's economy and industries. To help the semiconductor industry successfully face the challenges of this reduction, the institute of nuclear energy research uses thermal plasma torches to clean PFCs. The institute uses a low-power (5~15kW) DC plasma torch to crack the PFCs up to 99% of this gas. This efficient reduction can help Taiwan semiconductor corporations reach the goal of reducing PFCs to 0.66 MMTCE by 2010, in an effort to protect the earth. The institute of nuclear energy research has already transferred this technology to some companies, with which the institute built a plasma scrubbing machine for tail gas. This machine was tested in several semiconductor companies and earned many compliments. This technology earned the Chinese patent in November of 2005, and excellent research prize from the Executive Yuan (Figure 2).

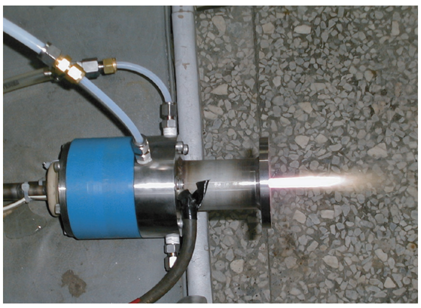


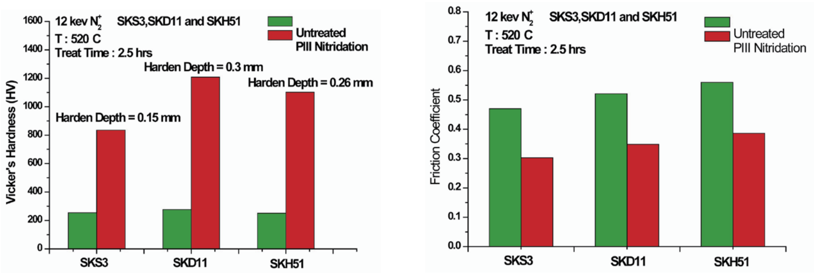
Figure 1 Small-Power (5~15kW) Non-transferred DC Plasma Torch

Figure 2 2004 Executive Yuan's Excellent Research Prize

Research of Nitriding Technology Applied on Prolonging Durability of Tooling

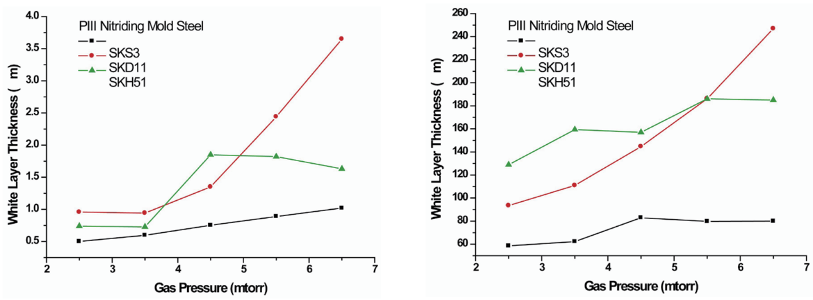
Taiwan's tooling industry is worth over $50 billion. However, since neighboring countries economies haves been growing, Taiwan's tooling industry's competitive advantages have been eroded. Prolonging the durability of tooling, cutting down costs, and developing delicate tooling should constitute the tooling industry's main program in the future. The durability of tooling depends on the improvement of the tooling materials. Traditional tooling factories use the regular gas-based nitriding technology to form a layer of nitriding modified surface. Yet, this technology takes a long time (over 70 hours), and usually has a thick white layer of nitriding (around 10μm) that increases the magnitude of hot deformation and necessitating a second processing. With the help of the facility of plasma immersion ion implantation (PIII) for the plasma nitriding on tooling surfaces, the processing time and hot deformation magnitude decrease dramatically. Meanwhile, the white layer of chemical composition also declines and machinery property experiences a distinct improvement.

PIII modification capitalizes on the ability of microwave to produce high density plasma. In the microwave plasma the magnetic field is generated from a set of electromagnets and the test pieces is immersed in the plasma. After that, the feedthrough apparatus beneath the pedestal supporting the test pieces leads 20μsec impulse onto the test pieces, accelerates the charged particles of plasma into the substrates and modifies them. The modified machinery properties and the modified thickness are shown in Figures 1 and 2. Figure 1 (a) shows that the hardness of the modified surface is three times higher than the original surface. Figure 1 (b) shows that the friction factor is down to around 70%. The key point of tooling materials is to decrease the thickness of the white layer, and increase the thickness of the nitriding layer. After 2.5 hours of PIII nitriding, the nitriding layer reaches the same thickness that traditional gas-based nitriding can reach in 10 hours. Figure 2 (a) shows that SKH51 steel is exceptional. Otherwise, the white layer increases with higher gas pressure. Yet, SKH51 steel can experience an increase in the white layer under higher gas pressure. Figure 2 (b) shows that except for the SKS3, the rest of the two steels increased their nitriding layers under higher gas pressure. With different quantities of Cr content in the steels, the steels have different thicknesses of nitriding layers. The quantity of Cr contained in the steels: SKD11>SKH51>SKS3, parallel the order of the nitriding layer as well. SKH51 has its maximum thickness under 5. 5 mTorr. Both SKD11's nitriding layer and white layer increase with higher gas pressure, thus under 4.5 mTorr & 5. 5 mTorr, SKD11 has a balanced trade-off.



(a) (b)

Figure 1. PIII Nitriding Modified Steels have Better Machinery Properties: (a) hardness (b) friction factor.



(a) (b)

Figure 2. PIII Nitriding Modified Steels Vary with Gas Pressure (a) white layer (b) nitrided layer.

The Development and Application of Plasma Fuel Reforming

Hydrogen is a clean energy with great potential. Hydrogen fuel has the following advantages: 1) The blended fuel of hydrogen and gasoline can increase the combustion efficiency of engines by 15~30%, and decrease the emission concentration of pollutants. 2) Hydrogen could be used directly (hydrogen-powered vehicle) or indirectly (fuel cell-powered vehicle), and reach the goal of zero-emission. The institute uses non-thermal plasmas- assisted catalytic reforming technology to generate hydrogen. Generating hydrogen is the basic function of the technology; others are: 1) Power-efficiency. This technology generates more energy than it consumes. 2) Space-efficiency. This energy system is mobile. 3) Quick-access. The hydrogen that this system generates can be used immediately, thanks to the exclusive technology of this system. Besides, the reactor has no problem of carbon deposit that would affect chemical reaction. The institute uses methane as the raw material of reforming, at the standard of generator efficiency of gas turbines of 38%, fuel cell co-generation system of 80%, and compared the generating efficiency between methane generator and hydrogen-powered fuel cell. When energy consumption is under 1.47 MJ/kg H_2, the methane generator is efficient. According to the findings, methane conversion ratio and the rate of hydrogen production both are up to 80-90%, with hydrogen consumption per kilogram at 1.21-1.47 MJ. The consumed energy accounts for only 1% of the total energy generated. Methane, in terms of energy efficiency ratio, is 20% higher than that of the gas turbine. As for the application in motorcycles, the institute has conceptual designs of a plasma-enhanced fuel system, and is conducting research into the miniaturization of its peripheral devices.

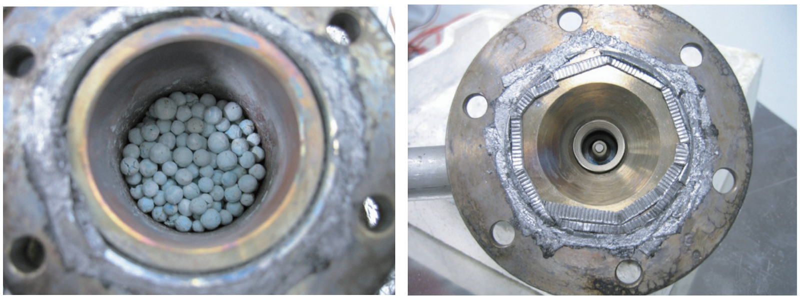


Figure 1. After Reforming, the Reactor and Catalyzer have no Carbon Deposits.

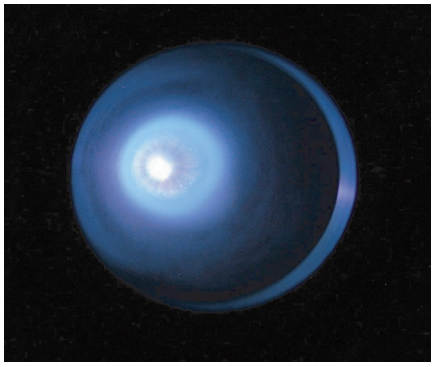


Figure 2. Discharges in Reforming Reactor

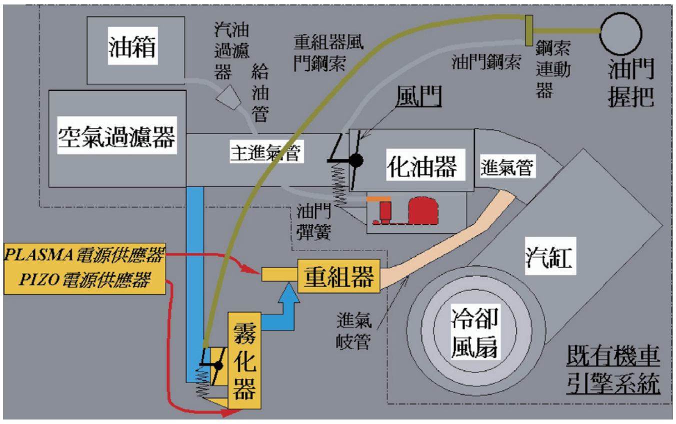


Figure 3. Conceptual Design of Plasma-Enhanced Fuel System of Motorcycles

Appendix

- Mutual Fund
- International Cooperation Projects
- INER Reports
  - Papers Published in Journals
  - Conference Papers

Mutual Fund

No.	Title	Implementing Organization
1	Single-crystal Thin Films by High Energy Ion Implantation	Academia Sinica
2	Application of Fallout Radionuclides to Study Water and Soil Conservation in Taiwan (1/3)	Academia Sinica
3	Aging Assessment and Risk-Informed Management of Feedwater Heaters in Nuclear Power Plants (II)	National Taiwan University
4	The Feasibility Study of Making Porous Slag with Plasma Melting	National Taiwan University
5	The Role of Dopaminergic System in Modulating Sleep	National Cheng Kung University
6	Scintigraphic Imaging of the Hypoxic Marker Tc-99m HL91 in Noninvasive Detection of Tumor Response to Hypoxia-Regulated Cancer Gene Therapy (II)	National Cheng Kung University
7	Serotonin Transporter Binding in Obesity Before and After Successful Body Weight Reduction (II)	National Cheng Kung University
8	Study and Test of Electrical Property Aging for Cable in Nuclear Power Plant	National Tsing Hua University
9	Training of Nuclear Safety Related Technical Personals	National Tsing Hua University
10	Electrochemical Behavior of ZrO_2 Treated 304 Stainless Steels in Boiling Water Reactor Environments	National Tsing Hua University
11	Optimization of Patient Dose and Image Quality for Digital X-ray Radiography	National Tsing Hua University
12	Characteristic Improvement of Si Semiconductor Interface and Device by Plasma Surface Treatment	National Tsing Hua University
13	Numerical Simulations of the Liquid-gas Phase Change Inside the Porous Media and the Estimation of the Thermal Performance of the Vapor Chamber	National Tsing Hua University
14	New Polynuclear Metal Cluster Complexes as Potential Magnetic Resonance Imaging (MRI) Contrast Agents	National Chiao Tung University
15	Kinetic Modeling Analysis for the In Vivo Quantification of Serotonin Transporter Ligands for Rat Using MicroPET	National Yang Ming University
16	Imaging the Serotonin Transporter in Affective Disorder Using ^{123}I-ADAM	National Yang Ming University
17	Evaluations on the Spent Fuel Dry Storage Interim Staff Guide ISG-11	National Taiwan University of Science and Technology
18	Study the Mechanism of Dextromethorphan on Treatment of Morphine Addiction by Radiation Technology (2)	National Defense Medical Center
19	[^{123}I] Meta-Iodobenzyl Guanidine (MIBG) Myocardial Imaging in Formosan Rock Monkeys Following Sympathectomy	National Defense Medical Center
20	Application of Ground Penetrating Radar on Fracture Characteristics of Granite	National Taiwan Ocean University
21	Experimental Study on the Water Flow of Rough Joint Surfaces	Tam Kang University
22	Study and Development of High-efficiency & Low-cost III-V Compound Semiconductor Solar Cells(II)	Chung Yuan Christian University

No.	Title	Implementing Organization
23	Stem Cell with Non-invasive Gene-assisted PET Imaging for Cancer Diagnosis and Therapeutic Application (1/2)	Taipei Medical University
24	Establishment of the Transcription Factor-Based Nuclear Imaging System for Screening the Anti-inflammatory Effects of Herbs (II)	China Medical University
25	A Study on the Synthesis of Super Paramagnetic Iron Oxide Assisted with r-ray and its Characterization on Potential Application in Molecular Imaging	Chung Shan Medical University
26	Serotonin Transporter and Suicide	Taipei Veterans General Hospital
27	Development of Positron Emission Tomography and Suicide Gene Therapy of Cervical Cancer by Way of Monoclonal Antibody Cx-99 Targeted Liposomal Delivery of HSV-tk Gene	Taipei Veterans General Hospital
28	Investigation of Mammo Site Breast-conserving Therapy (BCT) for Early-stage Breast Cancer	Taipei Veterans General Hospital
29	Plasma Gasification Research on Paper Reject Solid Waste	Yuan Ze University
30	Silicon Nanocrystals Memory Device Study	Chang Gung University
31	The Value of 2-fluoro-2-deoxy-d-glucose Positron Emission Tomography in Carcinoma of Nasopharynx with Stage M0	Chang Gung Memorial Hospital
32	Development of a Self-proving Reliable Sizing Technique for Surface Cracks in Dissimilar Metal Welds	Da Yeh University
33	γ-ray Irradiated Hydrogel/PU Composites with Multiple Functions for Wound Dressing Containing Fibroblast Growth Factor-2 Stimulates Wound Healing	Southern Taiwan University of Technology
34	The Study of Risk-Informed-Inservice Testing of Taiwan Nuclear Power Plant-The Pilot Study of Risk-I	Lunghwa University of Science and Technology
35	Conference on Application of Probabilistic and Quantitative Risk Assessment (PRA/QRA)	National Central University
36	Hydrogen Workshop	National Tsing Hua University
37	Symposium of Biomass Development and Utilization	National Taiwan University
38	The Application of Nuclear Medicine on the Diagnosis of Parkinson's Disease	National Taiwan University

International Cooperation Projects

Technology Centers	Fields	Cooperation Projects
Nuclear Safety Technology Center	Nuclear Safety	▶ USA Civil Nuclear Cooperation Projects: (AIT-TECRO) CAMP,COOPRA, NRIP, RDD ▶ USA EPEI Cooperation Projects: (INER-EPRI) NFIR, SQURTS ▶ USA National Standard Bureau Cooperation Projects: (INER-NIST) MAP ▶ Europe OECD/NEA Cooperation Projects: COMPSIS
Environmental and Energy Technology Center	Energy	▶ USA Civil Nuclear Cooperation Projects: (AIT-TECRO) PNNL(DOE), NREL (DOE), SNL (DOE) ▶ Germany JűlichResearch Center Cooperation Projects: (INER-Jűlich) SOFC (on planning) ▶ Sweden SKB Cooperation Projects: (INER-SKB) SOFC (on planning) ▶ Swiss HTC ceramix SA Cooperation Projects: (INER-HTc) SOFC (on planning)
	Plasma	▶ USA Civil Nuclear Cooperation Projects: (AIT-TECRO) INEL (DOE) ▶ Russia RFBR Research Center Cooperation Projects: (INER-RFBR) Plasma Vitrification (on planning)
	Decommission	▶ USA Civil Nuclear Cooperation Projects: (AIT-TECRO) WIPP(DOE) ▶ USA SNL Cooperation Projects: (INER-SNL) LLW (ICP) ▶ USA INEL(Bechtel BWXT) Cooperation Projects: (INER-BBWI) WOHEST ▶ France Framatome ANP Cooperation Projects: (INER-Framatome) WOHEST ▶ Europe OECD/NEA Cooperation Projects: CPD (TRR Decommission) ▶ USA NAC Int'L Cooperation Projects: (INER-NAC Int'L) Dry Storage ▶ Japan CRIEPI Cooperation Projects: (INER-CRIEPI) Dry Storage (on planning) ▶ Japan RWMC Cooperation Projects: (INER-RWMC) Final Disposal (on planning) ▶ Korea NETEC Cooperation Projects: (INER-NETEC) Final Disposal (on planning)
Radiation Application Technology Center	Nuclear Medicine	▶ USA Civil Nuclear Cooperation Projects: (AIT-TECRO) PET/SPECT/MRI (DOE)RI/RP/Regulation (DOE/NIH) ▶ Brazil San Paul University Cooperation Projects: (INER-UNIFESP) TRODAT-1 ▶ Japan Hamamatsu Photonics K.K. Cooperation Projects: (INER-HPK) PPIS ▶ Australia Radiopharmaseutical Production and Sale Cooperation Projects: (INER-ANSTO)Tl-201, Ga-67 (on planning)

Papers Published in Journals

No.	Serial Number	Title	Journal	Authors	SCI	Impact Factor
1	INER-3170	Separation Properties of High Temperature Reverse Osmosis Membranes for Silica Removal and Boric Acid Recovery	Journal of Membrane Science	Chung-Hsien Liang	SCI	2.108
2	INER-3173	Small-angle X-ray Scattering of Carbon-supported Pt Nanoparticales for Fuel Cell	Physica B	Cheng-Si Tsao Charn-Ying Chen	SCI	0.679
3	INER-3174	Integrated Thermal Engineering Analyses with Heat Transfer at the Periphery of a Planar Solid Oxide Fuel Cell	Journal of Power Sources	Yau-Pin Chyou Charn-Tung Chung Jong-Sheng Chen Jih-Feng Hsu	SCI	2.513
4	INER-3183	Ni/Pd/Au Ohmic Contact for p-GaAs and its Application in Red RCLED	Material Science and Engineering B	Chih-Hung Wu Sen-Mao Liao Kai-Cheng Chang	SCI	0.942
5	INER-3184	Fabrication Process Study of Electrocatalyst Layers for Direct Methanol Fuel Cells	Journal of Power Sources	Charn-Ying Chen Peng Yang Ying-Sheng Lee Kin-Fu Lin		2.513
6	INER-3189	A Nanostructured YSZ Film Coating by Liquid Suspension Injection into an APS Plasma Flame	Journal of Advanced Oxidation Technologies	Chang-Sing Hwang Chin-Ching Tzeng	SCI	0.451
7	INER-3194	The Value of 18F-FDG PETin the Detection of Stage Mo Carcinoma of the Nasopharynx	Journal of Nuclear Medicine	Wuu-Jyh Lin Ying-Kai Fu Tau-Chen Yen Yu-Chen Chang Sheng-Chieh Chan Tung-Chieh Chang Kun-Ju Lin Shu-Hang Ng Chen-Yu Lin	SCI	5.362
8	INER-3207	Microautoradiography of [^{123}I]ADAM in Mice Treated with Fluoxetine and Serotonin Reuptake Inhibitors	Nuclear Medicine and Biology	Hsin-Hsien Yeh Chih-Cheng Chen Jen-Hsien Liu Hsiao-Ping Wei Chun-Hsin Lee Chia-Chien Chen Ying-Kai Fu Gan Ting Cheng-Chung Huang		2.713
9	INER-3208	Effect of Hypercholesterolemia on Myocardial Function in New Zealand White Rabbits	Journal of Biomedical Science	Tsai-Yueh Luo Yi-Fan Yang Yen-Pin Liu Tsao-Chung Wu Ming-Chia Su	SCI	1.567
10	INER-3235	Performance Evaluation of Graphite Pancake Ionization Chamber by Comparing the Absorbed Dose to Water Calibration	Radiation Measurement	Jeng-Hung Lee Chiung-Yu Lin Wen-Song Hwang	SCI	0.664
11	INER-3244	Short-term Recurrent Abdominal Pain Related to Helicobacter Pylori Infection in Children	Journal of Gastroenterology & Hepatology	Jui-Cheng Lee Yao-Jong Yang Po-Hsiang Hsu Chun-Chung Wu	SCI	1.796

No.	Serial Number	Title	Journal	Authors	SCI	Impact Factor
12	INER-3248	Capsule C-13-Urea Test for the Diagnosis of Helicobacter Pylori Infection	Journal of Gastroenterology	Nan-Jing Peng Kwok-Hung Lai Ren-Shyan Liu Jui-Cheng Lee Daw-GueyTsay Ching-Chu Lo Huei-Hwa Tseng Wen-Keui Huang Gin-Ho Lo Ping-I Hsu	SCI	1.209
13	INER-3267	The Effects of Differing Nitrogen Implantation Conditions on Penetration Depth, Mechanical Properties and Tribological Behavior of Plasma-nitrided AISI 304 Stainless Steel	Surface and Coating Technology	Jen-Hui Lin Chin-Chung Wei Kuan-Wei Chen Chi-Fong Ai	SCI	1.432
14	INER-3302	Optical Properties and Deposition Rate of Sputtered Ta2O5 Films Deposited by Ion-beam Oxidation	Thin Solid Films	Der-Jun Jan Cheng-Chung Lee	SCI	1.647
15	INER-3311	Epitaxial Growth of High Quality GaN on Appropriately Nitridated Si Substrate by Metal Organic Vapor Phase Deposition	Journal of Crystal Growth	Wu-Yi Wen Cheng-Yu Lee Shan-Ming Lan Sen-Mao liao	SCI	1.707
16	INER-3352	Study on Self-Initialization Algorithm of SCDAP/RELAP5 Code and Comparison of Severe Accident Results Among SCDAP/RELAP5, MAAP and MELCOR CODES	Nuclear Technology	Te-Chuan Wang Shih-Jen Wang	SCI	0.446
17	INER-3354	Analysis of Containment Flooding Strategy for Mark-III Nuclear Power Plant with MAAP4	Nuclear Technology	Wei-Nian Su Shih-Jen Wang	SCI	0.446
18	INER-3355	A Study of High-temperature Implantation of 72keV Copper Ion Nickel	Nuclear Instruments and Methods in Physics Research B	Wen-Fa Tsai Chung-Hung Liang Chih-Chung Kai G.L. Kulcinski	SCI	0.997
19	INER-3364	Technique Improvement for Crack Depth Estimation of Steam Generator Tubes	Insight	Hung-Fa Shyu Chin-Chuan Chao	SCI	0.360
20	INER-3386	Assessment of Aflatoxin-Albumin Analysis in Serum by a Competitive Enzyme-Linked Immunosorbent Assay	Clinical Chemistry	Mei-Hui Wang Jui-Cheng Lee Tung-Chuan Chiang Shiou-Shiow Farn Ying-Kai Fu	SCI	6.501
21	INER-3399	Radioimmunotherapy and Apoptotic Induction on Ck-19-overexpressing Human Cervical Carcinoma Cells with Re-188-mAbCx-99	Anticancer Research	Chih-Hsien Chang Lai-Cheng Tsai Shui-Tien Chen Chiu-Chung Yuan Po-Tsang Hsieh Pei-Ling Chao Tung-Hu Tsai Te-Wei Lee	SCI	1.395
22	INER-3404	SAXS Characterization of the Nafion Membrane Nanostructure Modified by Radiation Cross-linkage	Polymer	Cheng-Si Tsao Hwei-Liang Chang Yu-Sun Cheng Chih-Min Lin Tsang-Lang Lin	SCI	2.433

No.	Serial Number	Title	Journal	Authors	SCI	Impact Factor
23	INER-3440	Nanoscale Nematic Aggregates in Dilute Solution of Hairy-Rod Conjugated Polymer	Physical Review E	Wen-Chung Ouyang Chi-Sheng Chang Hsin-lung Chang Derek Ho Chang-Si Tsao Kang-Yung Peng Shou-An Chen Charles Han	SCI	2.352
24	INER-3445	The Design of Automatic Preparation of High Concentrated 188 Re-perrhenate Solution	Journal of Nuclear Medicine	Tsai-Yueh Luo Ai-Ren Lo Wuu-Jyh Lin Po-Chang Hsieh Ying-Kai Fu	SCI	5.362
25	INER-3449	A Three-Dimensional Registration Technique for Automated Fusion of Micro PET-CT-SPECT Whole-Body Images	IEEE Transcation on Medical Imaging	Meei-Ling Jan Ke-Shih Chuang Geo-Wei Chen Yu-Ching Ni Chih-Hsien Chang Te-Wei Lee Ying-Kai Fu	SCI	0.426
26	INER-3456	Small-angle X-ray Scattering Study of Nanostructure Evolution of b" Precipitates in AL-Mg-Si Alloy	Scripta Materialia	Cheng-Si Tsao Yu-Sun Cheng Charn-Ying Chen Tsung-Yuan Kuo	SCI	2.112
27	INER-3465	Development and Validation of a Reversed-phase HPLC Method for the Purity assay of TRODAT-1 Raw Material	J. Chromatography B	Kung-Tien Liu Yi-Chih Hsia Chiung-Fang Huang		2.176
28	INER-3511	Spatiootemporal Intermittency Measurements in A Gas-Phase Near-Isotropic Turbulence Using High-Speed DPIV and Wavelet Analysis	Journal of Mechanics	TS Yang SS Shy Yau-Pin Chyou	SCI	0.173
29	INER-3527	Low-Molecular-Weight Organic Acid Exudation of Rape (Brassica Campestris) Roots in Cesium-Contaminated Soils	Soil Science	Jeng-Jong Wang Po-Neng Chiang Ming-Kuang Wang Pan-Ming Huang Chih-Yu Chiu	SCI	0.846
30	INER-3530	Evaluation of F-18-labeled Amino Acid Derivatives and [18F]FDG as PET Probe in a Brain Tumor-bearing Animal Model	Nuclear Medicine and Biology	Hsin-Erh Wang Shih-Yen Wu Chih-Wei Chang Jen-Hsien Liu Li-Chung Huang Te-Wei Lee Chih-Cheng Chen Cheng-Chung Huang	SCI	2.713
31	INER-3683	A Maximum Likelihood Expectation Maximization Algorithm with Thresholding	Computerized Medical Imaging and Graphics	Ke-Shih Chuang Meei-Ling Jan Ying-Tsuan Lu Ching-Han Hsu Chia-Ju Chen	SCI	0.102
32	INER-3702	Mechanical Properties of In-Situ Laminated Composutes Based on Ultrahigh Carbon Steel	Material Science Forum	Shih-Chung Cheng Sherby	SCI	0.498
33	INER-3736	Change of Plasma Transforming Growth Factor-b 1 Level in Nasopharyngeal Carcinoma Patients Treated with Concurrent Chemoradiotherapy	JPN J Clin Oncol	Ying-Kai Fu Hung-Wen Chen Yu-Kun Cheng Yun-Liang Lai Yu-Jen Chen Ming-Che Huang Yi-Hsing Lu Ling-Wei Huang		0.960

Conference Papers

No.	Serial Number	Title	Conference	Authors
1	INER-3163	Preparation of a Tri-layer Wound Dressing Material-PNIPA, Gelatin Gel and Crosslinking Agent Immobilization on PP Nonwoven	4th Asian International Symposion Biomaterials	Te-Hsing Wu Ke-Shao Chen Jui-Che Tsai Ying-Kai Fu
2	INER-3164	Thermal-Hydraulic Analysis of Planar Solid Oxide Fuel Cell Channels	2004 Fuel Cell Semina	Yau-Pin Chyou Yung-Neng Cheng Kin-Fu Lin Hsiao-Kang Wang Shih-Chuan Hung
3	INER-3165	Hydrogen Storage for Carbon Nanotubes Synthesized by Pyrolysis of Methane using LaNi5 as a Catalyst	2004 Fuel Cell Seminar	Ming-Sheng Yu Chih-Hung Chen Wen-Cheng Ho Yen-Hui Wu Hsiu-Pei Hsu Kin-Fu Lin
4	INER-3205	Study of the Tc-99m-TRODAT-1 Binding in Mice Brain by Autoradiography and microSPECT Image Analysis	The Academy of Molecular Imaging	Wei-Lun Hsu Chia-Jung Chang Cheng- Hsiang Yao Kang-We Chang Chia-Chieh Chen Lie-Hang Shen Ying-Kai Fu
5	INER-3272	The Risk Impact from Hazard Factor of Fire PROBABIKIstic Ssfety Assessment for Nuclear Power Plants in Taiwan	2005 International Conference on Advanced Power Plants,Seoul,KOREA (ICAPP'05)	Ching-Hui Wu Shih-Hsun Huang Tau-Jen Lin
6	INER-3273	A New ERA of Risk-Informed Applications in Taiwan	2005 International Conference on Advanced Power Plants, Seoul, KOREA (ICAPP'05)	Tsu-Mu Kao Ching-Hui Wu
7	INER-3280	Study on Plasma Vitrification of ASH Residues from Municipal Solid Waste Incinerators	IT3'05 Conference Galveston, Texas, USA	Chin-Ching Tzeng Tsung-Ming Hung Wen-Cheng Lee Tien-Chi Wu
8	INER-3281	Study on Plasma Vitrification of Reuse of Non-combustible Fishery Wastes	IT3'05 Conference Galveston,Texas,USA	Chin-Ching Tzeng Ta-Wei Cheng Chin Chu
9	INER-3291	Study of the Flow Field in Channels and Internal Manifolds on the Interconnect of a Planar Solis Oxide Fuel Cell	The Third International Conference on Fuell Cell Science, Engineering and Technology	Tsang-Tung Chung Yau-Pin Chyou Dung-Di Yu
10	INER-3292	Startup Strategy for Operating a Solid Oxide Fuel Cell Based on Transient Analyses	SOFC-IX	Yau-Pin Chyou Tsang-Tung Chung Jong-Sheng Chen
11	INER-3306	DC Magnetron Sputtering of Si to form SiO_2 in Low Energy Ion Beam	The Eighth International Symposium on Sputtering & Plasma	Der-Jun Jan Cheng-Chung Lee
12	INER-3322	Developing Information Management System for Decommissioning of Nuclear Facilities	Nuclear Technology 2005	I-Hsin Chou Yen-Chang Tzeng Shang-Lee Chyou
13	INER-3323	Conceptual Nuclear Decommissioning Knowledge Management System Design	IEEE NSW Section	I-Hsin Chou Yen-Chang Tzeng Chin-Feng Fan
14	INER-3325	Analysis of Chinshan Raw Water System Performance for Severe Accident	ICAPP-5	Te-Chuan Wang Shih-Jen Wang
15	INER-3332	Effect of Hydrides on the Mechanical Properties of Zircaloy-4	2004 International Meeting of LWR Fuel Performance	Roang-Ching Kuo S.Yagnik Y.Rashid
16	INER-3342	A Pilot Application of Risk-Informed Evaluation Methodology for Inservice Inspection of Piping to the RHR System at a BWR-6 Plant	ICONE-13	Jyh-Der Lin Tsao Lin Chung-Kung Lo

No.	Serial Number	Title	Conference	Authors
17	INER-3348	The Preparation and Biodistribution of Two Novel HL-91-derivative Analogs for the Application in Hypoxic Diagnosis	Society of Nuclear Medicine 52nd Annual Meeting	Chien-Chung Hsia Cheng-Hsien Lin Lie-Hang Shen Ying-Kai Fu
18	INER-3353	Development of Drywell Water Level Computational Aid and Application on Containment Flooding Strategy of Kuosheng Nuclear Power Plant	MAAP User's GroupMeeting, 2005	Wei Nian Su Shih-Jen Wang
19	INER-3366	Evaluation the Effect of Risperidone Challenge on Rat Function by F-18-FDG and Tc99m-HMPAO	The Society of Nuclear Medicine 52nd Annual Meeting	Chia-Jung Chang Kuo-Hung Wu Shih-Ying Lee Wei-Lun Hsu Kang-Wei Chang Hong-Ching Kao Hsueh-Hsuan Liu Chia-Chieh Chen Wuu-Jyh Lin
20	INER-3391	Performance Test of Wet-Oxidation Pilot System for Treatment of Spent Ion-Exchange Resin	WM'05	Ching-Tsuen Huang Jiing-Guang Tyen Tzeng-Ming Liu Yu Chao Tsye-Shing Lee Yu-Cheng Shih Chen-Fa Lan Wan-Fen Huang Ming-Liang Chiou Ping Huang
21	INER-3444	Evaluation of 18F-FET and 18F-FDG for Differentiating Lung Carcinoma from Inflammation in a Mouse Model by microPET	The Fourth Annual Meeting of the Society for Molecular Imaging	Chih-Hsien Chang Shih-Yen Wu Te-Wei Lee Hsin-Erh Wang
22	INER-3447	Plasma-induced Graft Polymerization of Chitosan on PET Fabric at Atmospheric Pressure	2nd International Workshop on Gold Atmospheric	Mien-Win Wu Tien-Shiang Hsueh Cheng-Chang Hsieh Chi-Fong Ai
23	INER-3450	Development of a Coaxial X-ray Tomography System Juxtaposed with microPET Scanner for Small Animal PET/CT Imaging	Academy of Molecular Imaging Annual Conference 2005	Meei-Ling Jan Geo-Wei Chen Yu-Ching Ni Hsin-Chin Liang Wei-Lun Hsu Ying-Kai Fu
24	INER-3466	The Preparation and Analysis of Antibacterial Nano-material Modified on Fabrics	8th International Symposium on Polymers for Advanced Technologies	Te-Hsing Wu Yi-Te Tai Chia-Chieh Chen Bin Lin Haw-Jan Chen
25	INER-3467	Absolute Counting of ^{188}Re Radiopharmaceuticals	ICRM 2005	Ming-Chen Yuan Hsiao-Fang Pang Chu-Fang Wang
26	INER-3468	Laboratory report for 21st APMP General Assembly in Jeju,Korea	21th APMP/TCRI Meeting/Workshops	Wen-Sung Huang Jeng-Hung Lee
27	INER-3508	2-((2-((dimethylamino)methy1)pheny1)-5-iodophenylamine(^{124}I-ADAM):A Novel PET Radiotracer for Serotonin Transporter	Academy of Molecular Imaging Annual Conference 2005	Ying-Kai Fu

No.	Serial Number	Title	Conference	Authors
28	INER-3529	Imaging Serotonin Transporters in Rat Brain by (^{123}I) ADAM/micro SPECT	Academy of Molecular Imaging Annual Conference 2005	Cheng- Hsiang Yao Kang-Wei Chang Wei-Lun Hsu Chia-Jung Chang Chia-Chieh Chen Lie-Hang Shen Ying-Kai Fu
29	INER-3535	Parametric Study of the Nitrided AISI 304 Austenite Stainless Steel Prepared by Plasma Immersion Ion Implantation	The 8th International Workshop on Plasma-based Ion Implantation and Deposition	Cheng-Hung Liang Wen-Fa Tsai Chao-Hsien Wang Chi-Fong Ai
30	INER-3537	A High Reproducibility and Low Dosed ^{13}C-Glycine Breath Test for Solid Gastric Emptying Measurement with a Novel Designed Kit	2005 World Congress of Gastroenterology	Wen-Ming Wang Shui-Cheng Lee Mei-Hui Wang Shiou-Shiow Farn Ying-Kai Fu Yu-Cheng Su Huang-Hui Wang Chien-Chien Chen
31	INER-3545	Improved Targeting of 5-[^{125}I/^{131}I]iodo-2'-deoxyuridine to Rat Hepatoma by using Lipiodol Emulsion	ITBS 2005	Hung-Wen Yu Hsin-Erh Wang Kuang-Liang HuangKuo-Tang Chuang Wuu-Jyh Lin
32	INER-3546	Internal Radiotherapy and Dosimetric Study for ^{111}In/177 Lu-pegylated Liposomes Conjugates in Tumor-bearing Mics	ITBS 2005	Hung-Wen Yu Hsin-Erh Wang Kuang-Liang HuangKuo-Tang Chuang Wuu-Jyh Lin
33	INER-3553	Performance Evaluation of the INER Micro-CT System for Small Animal Imaging	The Society for Molecular Imaging	Yu-Ching Ni Meei-Ling Jan Kuo-Wei Chen Yen-Ting Cheng Hsin-Chin Liang Ying-Kai Fu
34	INER-3554	Integrated CT-PET System for Small Animal Imaging	The forth Annual Meeting of the Society for Molecular Imaging	Meei-Ling Jan Yu-Ching Ni Kuo-Wei Chen Hsin-Chin Liang Ke-Shih Chuang Ying-Kai Fu
35	INER-3559	Preparation and Analysis of Poly(acrylic acid)-clay Nanocomposites Hydrogel	6th International Gel Symposium 2005	Chih-Wei Chou Shan-Hui Hsu Yen-Jen Chang Te-Hsing Wu Nini-Chen Tsai
36	INER-3561	Validation of RCS Bleed-and-Feed Strategy for the SAMGs of kuosheng Nuclear Power Plant	2005 CSARP/MCAP Meeting	I-Ming Huang Shih-Jen Wang
37	INER-3574	Evaluation of INER's Serum Aflatoxin-Albumin Testing kit	XIX International Congress of Clinical Chemistry	Mei-Hui Wang Shui-Cheng Lee Tung-Chuan Chiang Shiou-Shiow Farn Ying-Kai Fu
38	INER-3575	Analysis of PWR Station Blackout Accident Using MAAP4	NURETH-11	Kwang-Sheng Chiang Shih-Jen Wang I-Ming Huang

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39	INER-3577	Magnitude and Effects of X-ray Scatter of a Cone-beam Micro-CT for Small Animal Imaging	ITBS 2005	Yu-Ching Ni Meei-Ling Jan Kuo-Wei Chen Hsin-Chin Liang
40	INER-3578	A Combined Micro-PET/CT Scanner for Small Animal Imagine	ITBS 2005	Meei-Ling Jan Yu-Ching Ni Kuo-Wei Chen Hsin-Chin Liang
41	INER-3585	Photo-oxidation Measurement of Total Organic Carbon in Radwaste Sample Tank and Feedwater for kuo-Sheng Nuclear Power Plant	Symposium on Water Chemistry and Corrosion of Nuclear Power Plants in Asia 2005	Tung-Jen Wen Szu-Chieh Shen
42	INER-3587	Study of Deposited Crud Composition on Fuel Surface of A Boiling Water Reactor Plant	Symposium on Water Chemistry and Corrosion of Nuclear Power Plants in Asia 2005	Chung-Hsien Liang Chun-Ching Chien
43	INER-3588	Pilot Study of Reverse Osmosis System in Primary Coolant Purification for PWRs	Symposium on Water Chemistry and Corrosion of Nuclear Power Plants in Asia 2005	Chung-Hsien Liang
44	INER-3610	The Statistical Assessment for Fuel Pool Cooling and Cleanup System of Nuclear Power Plant on HFE Validation Computer Platform	ISOFIC 2005	Hao-Wu Huang Tzu-Chung Yenn
45	INER-3611	Kuosheng BWR Hot Channel Model Transient Analysis	4st International Conference on Computational Heat and Mass Transfer	Yang-Kai Chiu Jan-Ru Tang Hon-Chin Jien Yu-Chen Kung
46	INER-3616	LAPUR5 BWR Stability Analysis in KUOSHENG Nuclear Power Plant	NURETH-11	Chang-Lung Hsieh Hao-Tzu Lin Jong-Rong Wang Chun-Kuan Shih Show-Chuyan Chiang Tong-Li Weng
47	INER-3626	The Rmoviscoelastic Analysis for a Bonded Dissimilar Anisotropic Media under Time-Dependent Heat Flux	6th International Congress on Thermal Stress	Jui-Ching Chang Jhy-Jen Shyr
48	INER-3654	The Current Status of Performance Demonstration Program in Taiwan	ASNT 2005 Fall Conference	Hung-Fa Shyu Wei-Ja Shong
49	INER-3689	Synthesis of Carbon Nanotubes by Pye\ rolysis of CH_4 using $NaNi_5$ as Catalyst and Their Hydrogen Storage Studies	Word Hydrogen Technologies Convention 2005	Ming-Sheng Yu Kuei-Miao Chang Cheng-Yu Wnag Tsui-Yun Chung Yan-Hui Wu Hsiu-Pei Hsu Kin-Fu Lin
50	INER-3696	Development of the NIST Scaweed Standard Reference Material	15th International Conference on Radionuclide Metrology and its Applications	Hwa-Jou Wei
51	INER-3711	A Finite Element Analysis for A BWR Fuel Assembiy Drop Event	2005 Water Reactor Fuel Performance Meeting	Huang-Jau Wu Che-Chung Tseng Shih-Chung Cheng
52	INER-3712	Effect of Radial Hydrides on Mechanical Properties of Zircaloy-4 Cladding	2005 Water Reactor Fuel Performance Meeting	Hou-Chin Chu Ken-Feng Chien Roang-Ching Kuo Shih-Chung Cheng

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