The present state and future of radiation technology performed by ARTI

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1. Introduction

The Advanced Radiation Technology Institute (ARTI), an affiliate of the Korea Atomic Energy Research Institute, is the sole radiation-specialized research institute in Korea, and is aimed at creating the world's best R&D results and cultivating the nation's new radiation industry. Since ARTI was established in 2005, ARTI has led the nation in fostering and advancing radiation technology and industry by creating outstanding world-class R&D results. ARTI is developing Radiation Fusion Technology (RFT). RFT produces the best highly value-added results through the improved development of existing technology and industry, along with the development of new and futuristic technologies by utilizing radiation sources in state-of-the-art industries, such as Information Technology (IT), Bio Technology (BT), Nano Technology (NT), Environment Technology (ET), Space Technology (ST), and Military Technology, based on a deep understanding of inherent properties of radiation.

2. Research Areas

ARTI has three research divisions and one team: Industry & Environment, Biotechnology, Radiation Equipment, and Radiation Breeding. In this section their research activities are described.

2.1 Radiation Advanced Materials Egnineering

In this filed, ARTI is currently developing high-performance hybrid composites such as electromagnetic shielding materials, stimuli-responsive devices such as eletrowetting devices and cell microarray, advanced biomaterials such as artificial blood vessels, functional materials for energy devices such as fuel cells, secondary batteries, solar cells, and wind power, ecofriendly natural fibers and bioplastics, and many other advanced functional materials using RFT. For synthesizing secondary lithium-ion battery electrode materials with a limitless cyclic stability, transition metal chalcogenide precursor solutions are irradiated with a different dose of electron beam to transform nano-sized electrode-active battery materials applicable to developing high-capacity and long-term stability secondary batteries. For producing 3D printed bio-electronic materials and devices, the radiation is suitable energy to induce not only high surface-activity without toxic chemical reagents but also safety, reproducibility and biocompatibility of 3D printing materials. Now, the large scale-multipurpose electron beam irradiation center for corroborative research is under construction, which can help the researchers make advanced energy materials (solar cell, fuel cell, and secondary batteries), automotive parts, and biomaterials.

2.2 Radiation Environmental Engineering

ARTI contributes to resolving many existing social environmental issues at present and in the future. Research works on the remediation of soil and groundwater contaminated with leachate from animal carcass burial sites, the treatment of global warming gases, and the treatment of organic waste and resource recovery, of both waste reduction and resource saving, are underway. To reduce the secondary particulate matter, NOx and SO_2 emitted from a stack should be controlled. So, an electron beam hybrid system is being developed that can remove various air pollutants simultaneously at low energy level.

2.3 Radiation Biotechnology

ARTI is carrying out several projects pertaining to biotechnology, such as radio-genomics for analyzing the radiation response of organisms, development of novel bio-molecules for utilization as drugs against aging and obesity, radiation transformation technology (RTT), the mechanism of radiation-resistant microorganisms, and radiation biodosimetry. An herbal composition, “HemoHIM”, was developed to enhance the immunity of the elderly and cancer patients and successfully commercialized. “Maysin” is a multi-functional natural compound isolated from grass, which exhibits various biological functions such as anti-diabetic, anti-cancer, anti-Alzheimer, immune stimulation, hair growth promotion effects, etc. Radiation can be used for production of inactivated bacterial vaccines. The major advantage of inactivation method using γ-radiation is its ability to penetrate the surface cell wall and membranes and to destroy nucleic acids without causing structural changes in surface antigenic proteins. The RI-Biomics center is located in ARTI, which has radioisotope-based total analysis system and molecular imaging platform to evaluate new drug candidate and to develop novel materials for diagnosis and therapeutic uses. Based on radiation sterilization technology, ARTI has developed special

purpose foods (space food and patient food) and the quarantine procedures of imported and exported agricultural commodities. Now, ARTI is trying to apply the radiation sterilization technology to preservation and disinfection of various cultural heritage artifacts.

2.4 Radiation Breeding Research

ARTI has focused its efforts on the development of valuable genetic resources for floricultural crops, functional food and medicinal crops, and eco-friendly bio-industrial crops through mutation technique with radiation. A total of 26 new cultivars of rice, soybean, rose of Sharon, Chrysanthemum, and kenaf were developed through mutation breeding. Now, to change the paradigm of classical breeding method, ARTI intends to explore new breeding technology through ICT-based automatic selection/analysis system. Some researches for commercialization using the mutant varieties are under way. 'Antisperil' varieties (Perilla frutescens) with increased anti-inflammatory activity have been developed. Human application tests with their extracts have been successfully completed and private company is being sought for technology transfer.

2.5 Radiation Equipment

ARTI is developing original core technologies for radiation equipment widely applicable to nuclear security, medical industry, and the environment. The development of radiation equipment mainly consists of two parts: the radiation detection systems with an appropriate electronics and the radiation generation system by using an electron accelerator. The radiation equipment research fabrication center (FAB center) is running to secure a bridgehead to accelerate the industrialization of radiation equipment for security, defense, medical science, space and NDT (Non-destructive Test) applications. For scanning a wide range of threats, including explosives, narcotics, and contraband materials, the next-generation security system, which is combining the high space resolution of dual-energy X-ray (6/3 MeV) and the high material discrimination capability of neutron (14 MeV), is being developed in the FAB center. The major advantage of this system is 16-class material discrimination capability without any material radio-activation. A 3-D radiation surveillance camera on an unmanned robot, which use stereography imaging technology, is very useful for radioisotope (RI) mapping. Multi-radiation detecting sensors on drones is another good way to identifying RI remotely. This two types of RI identification system is underway. The RFT-30 Cyclotron is an accelerator, which generates 30 MeV proton beams. By irradiating the proton beams onto target materials, medical and industrial RIs are be produced, such as radiopharmaceuticals for the early diagnosis of cancers, Alzheimer's disease and so on. Currently, the development of production technologies of several isotopes (Zr-89, Ge-68, Sc-44 and Sc-47) is under way.

3. Conclusions

The advancement of radiation technology can upgrade the nation's status and profile. ARTI is making an effort to strengthen the competitive edge of national RFT industries by generating cutting-edge radiation R&D. In order to expand the radiation industry, ARTI is planning to set up big data in radiation technology named radiation reaction map (RRM), which provides information about radiation reaction of organic/ inorganic materials and living organisms. If the big data is established successfully, various user including researchers and companies can predict final products in radiation reaction and radiation response of living organism by modeling and simulation based on the RRM. This system will generate new ideas and open new frontiers in the radiation technology field.