Radioisotope Production and Radiation Technology

Objective

To contribute to improved health care and to safe and clean industrial development in Member States by strengthening national capabilities in the production of radioisotope products and in the use of radioisotopes and radiation technology.

Radioisotopes and Radiopharmaceuticals

Research in the field of therapeutic radiopharmaceuticals is growing, with a large number of specific antibodies being used as carrier molecules to target cancers. In recent years, several radiolabelled antibodies (for example, rituximab and ibritumomab tiuxetane) labelled with beta emitting radionuclides such as yttrium-90 (^{90}Y), lutetium-177 (^{177}Lu) and iodine-131 (^{131}I) have proved to be very effective in the treatment of non-Hodgkin's lymphomas (NHLs). Generally, these radiopharmaceuticals are very expensive and are not readily available in all Member States.

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To facilitate affordable antibody based therapeutic treatments, a CRP to investigate the feasibility of developing a kit for labelling the antibody rituximab with $^{177}Lu/^{90}Y$ was launched in 2011 with the participation of 18 Member States. A meeting was also organized to explore the possibility of labelling rituximab with ^{131}I in hospital radiopharmacies.

Another CRP, on therapeutic radiopharmaceuticals labelled with rhenium-188 (^{188}Re) and ^{90}Y, concluded in 2011. An important outcome of this project was the preparation of new agents labelled with ^{188}Re and ^{90}Y for targeted therapy, of which a biotin radioconjugate for the treatment of breast cancer and two labelled antibodies for the therapy of neuroblastoma and small cell lung cancer were highly promising. A variety of ^{90}Y labelled particulates such as hydroxyapatite aggregates, human serum albumin microspheres, plastic microparticles and colloids of citrate, ferric hydroxide, antimony sulphide and chromic phosphate were developed and employed in radiosynovectomy to alleviate pain in swollen joints resulting from conditions such as haemophilia and rheumatoid arthritis. An earlier CRP, on the development of therapeutic radionuclide generator systems, was successful in developing an electrochemical $^{90}Sr/^{90}Y$ generator system, which was produced as an automated system by a commercial vendor. With the Agency's help, the first such generator, installed in Cuba, is yielding ^{90}Y with adequate radionuclidic purity and was recently approved for human use by the national regulatory authorities.

Two of the radioisotopes most frequently used in medicine are molybdenum-99 (^{99}Mo) and technetium-99m (^{99m}Tc). Interruptions in the supply of ^{99}Mo over the past few years have had an impact on patient care, particularly after the facilities of the two largest producers in the world were shut down. While the supply situation of ^{99}Mo has improved somewhat, efforts have intensified to explore the use of alternative methods of producing ^{99m}Tc. Several Member States that have cyclotrons or are planning to build them have embarked on research programmes for the production of ^{99}Mo or ^{99m}Tc using accelerators. Recognizing that this approach could be an option for producing ^{99m}Tc for Member States, either for limited local use or as a fallback option if there is another supply crisis, a new CRP focusing on the development of accelerator based alternatives to the $^{99}Mo/^{99m}Tc$ generator was initiated. Twelve Member States have expressed interest in participating in this CRP.

The use of positron emission tomography (PET) continues to grow owing to its excellent diagnostic images. While production of fluorine-18 (^{18}F), the most widely used PET radionuclide, requires a cyclotron, gallium-68 (^{68}Ga), another PET radionuclide, can be produced from $^{68}Ge/^{68}Ga$ generators without the need for a cyclotron. The 68 minute half-life of ^{68}Ga and the long one-year shelf life of the generator, together with the well known chemistry of gallium, make it an attractive PET radionuclide. Recognizing the important role of ^{68}Ga radiopharmaceuticals,

FIG. 1. A $^{68}Ge/^{68}Ga$ generator.

a new CRP was started aimed at developing ^{68}Ga labelled somatostatin analogues for the management of neuroendocrine tumours, as well as other potential ^{68}Ga based radiopharmaceuticals. The CRP, in which 17 Member States are participating, will also address the quality assurance/quality control issues related to these developments (Fig. 1).

Carbon-11 (^{11}C) plays a unique role both in the diagnosis, monitoring and research of human disease and as a tool in drug discovery. Its short half-life (20.4 minutes) allows repeated studies to be conducted on the same subject within a day, yet is long enough to permit study of the fate of the isotope for a few hours after administration. The Agency hosted a technical meeting in September at which the status of ^{11}C radiopharmaceuticals in clinical research and future trends in labelling, automation and instrumentation were discussed. The experts identified areas where support was required for timely and optimum utilization of ^{11}C radiopharmaceuticals in Member States.

Radiation Technology Applications

Composite materials combine properties of the individual components synergistically in an efficient and cost effective manner and have various applications, from sports equipment to the automotive and aerospace industries to food packaging and artificial organs (Fig. 2). Materials reinforced with nanoscale components have improved functional and structural properties. While utilizing the full potential of such nanofillers is challenging, these obstacles can be overcome by the radiation grafting of appropriate monomers/polymers onto the nanofiller surface. Radiation techniques also enable simultaneous synthesis of the nanofiller and cross-linking of the matrix of the composite, which is not possible with other techniques. Furthermore, the use of natural polymers in composites opens new possibilities for the development of affordable, high value, non-toxic, radiation processed composites. To investigate this potential further, a new CRP was started that is linked to a European Union project on polymer nanocomposites with novel structural and functional properties.

Addressing the need of developing Member States for training in this area, a joint Abdus Salam ICTP–IAEA workshop on 'Radiation Resistant Polymers' focused on radiation treatment for the sterilization of single use medical devices as well as biodegradable food packaging materials, cable insulators, and adhesives and sealants for use in nuclear power plants. The workshop consisted

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of lectures, discussions and a visit to the Elettra synchrotron facility in Italy.

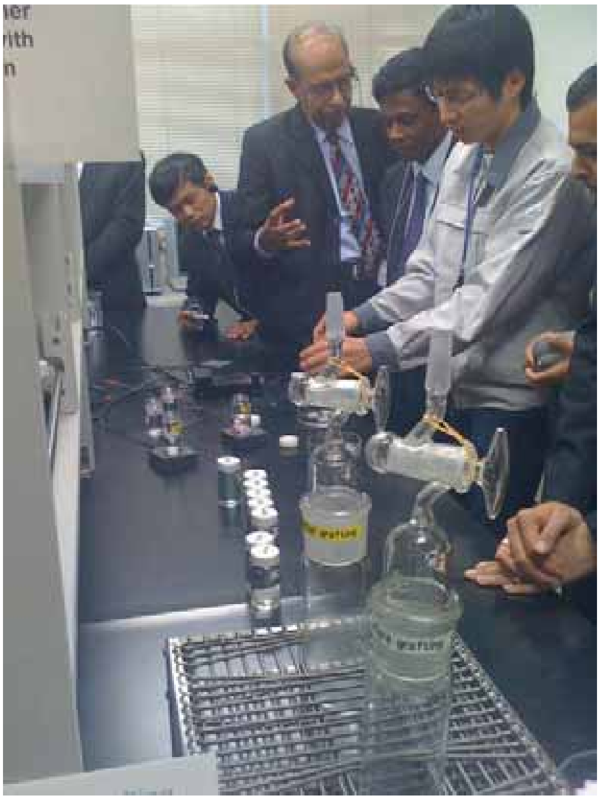

FIG. 2. Demonstration of a test of a composite absorbent.

To promote radiation technology applications in Member States, an Agency technical cooperation project assisted in the installation of a 24 000 curie (888 TBq) cobalt-60 gamma radiation source. The source was installed through a technical cooperation project at the Centre for Technology Applications and Nuclear Development in Cuba.

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Through another technical cooperation project, an institute in Bangladesh was supported in the production of biodegradable packaging materials from locally available natural polysaccharides, and in synthesizing 'super water' absorbents by combining indigenous and synthetic monomers and polymers. In addition, through combined governmental and Agency support, a new irradiation facility became operational. The facility uses locally available resources for the industrial scale production of oligochitosan, a potential plant growth promoter in agriculture.

Short lived radiotracers are used for quick trouble-shooting of complex problems in industrial fluidic systems. However, the timely access of such radiotracers from nuclear reactors is a major impediment. One solution is to use radionuclide generators that can produce tracers at the site. In this context, a CRP on potential radionuclide generators for industrial tracer applications was concluded in 2011. The project resulted in an improvement in the availability of industrial radiotracers and radiotracer services, especially in developing Member States that do not have radioisotope production facilities. Two generators, one using caesium-137 (^{137}Cs) and barium-137m (^{137m}Ba), and the other using ^{68}Ge and ^{68}Ga, were tested and validated. Case studies were performed in various fields at the laboratory and industrial scales (Fig. 3).

FIG. 3. Industrial single photon emission computed tomography system for the radiotracer visualization of ^{68}Ga and ^{137m}Ba from generators.

The Agency published *Nuclear Techniques for Cultural Heritage Research* in the IAEA Radiation Technology Series. This publication provides an understanding of the application of nuclear techniques — for example, neutron activation analysis, X ray fluorescence analysis and ion beam analysis — for non-destructive investigation of precious artefacts and materials such as ceramics, stones, metals and pigments from paintings.