Radioisotope Production and Radiation Technology

Objective

To contribute to improved health care and safe and clean industrial development in Member States through the use of radioisotopes and radiation technology, and to strengthen national capabilities for producing radioisotope products and utilizing radiation technology for socioeconomic development.

Radioisotopes and Radiopharmaceuticals[1]

Progress continues around the world in the development of molecular imaging techniques using radiopharmaceuticals, with particular interest in positron emission tomography (PET). In this context, the Agency initiated a CRP on the production of fluorine-18 radiopharmaceuticals other than fluorodeoxyglucose (FDG) for application in oncology and neuroscience. The CRP is expected to develop methodologies for production of selected non-FDG fluorine-18 radiopharmaceuticals to meet the demand for new PET based diagnostic agents.

To facilitate the availability of radiopharmaceuticals in Member States, the Agency is helping to build national capacities for the development and production of radioisotope products and radiopharmaceuticals. A CRP that concluded in 2009 focused on improved high current liquid and gas targets for cyclotron produced radioisotopes. Involving laboratories in 12 Member States, the CRP helped to develop methods for using high power targets to increase the purity and specific activity of radionuclides such as carbon-11, fluorine-18, nitrogen-13 and iodine-123, while ensuring the reliability of the production of radiopharmaceuticals derived from these radionuclides. Equally importantly, these advances have helped to minimize the radiation exposure of operators.

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Therapeutic radiopharmaceuticals are important in the treatment of cancers, particularly neuroendocrine tumours, for which there are very few other therapeutic options. A CRP on the development of lutetium-177 based

[1] Molybdenum-99 related information is covered in the Nuclear Science chapter.

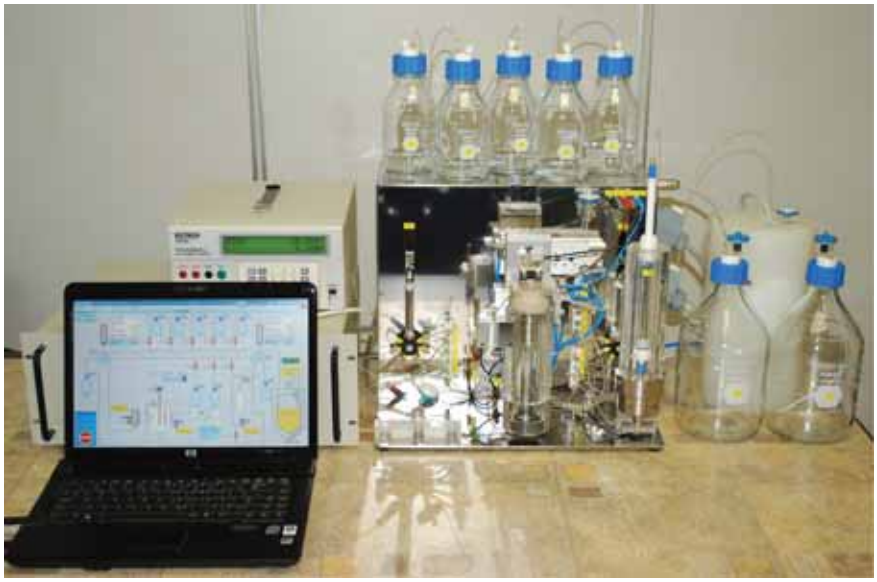

FIG. 1. 'Kamadhenu', a fully automated strontium-90/yttrium-90 electrochemical generator designed and built by Isotope Technology Dresden using technology developed through an Agency CRP. (Photograph courtesy of J. Comor.)

therapeutic radiopharmaceuticals for targeted therapy was completed in 2009. Lutetium-177 was produced in 11 of the 16 participating Member States, thereby enhancing the availability of this important radionuclide. The CRP also supported the wider application of the peptide based product ^{177}Lu-DOTATATE, and more than one thousand neuroendocrine cancer patients were treated with the ^{177}Lu-DOTATATE formulated by the CRP participants. A new therapeutic radiopharmaceutical, ^{177}Lu-EDTMP, was also developed, which is useful for bone pain palliation in cancer patients.

Another CRP resulted in the development of a strontium-90/yttrium-90 electrochemical generator. The technology was then used by a company to develop a fully automated generator called 'Kamadhenu' (Fig. 1), capable of providing up to 37 GBq (1 Ci) of high radionuclidic purity yttrium-90 each day. The first generator is being installed in Cuba under a technical cooperation project. The results of this work were published by the Agency in *Therapeutic Radionuclide Generators: ^{90}Sr/^{90}Y and ^{188}W/^{188}Re Generators* (Technical Reports Series No. 470).

Member State interest in the development and use of therapeutic radiopharmaceuticals labelled with beta emitting radionuclides is very high. A technical meeting to review the current status and challenges in the development, clinical trials and production of these therapeutic agents found lutetium-177 and yttrium-90 to be the most promising, with several countries having the capability to produce these radionuclides in large quantities and with high enough specific activities for regular clinical use.

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The Agency continues to support countries in setting up cyclotron based radiopharmaceutical production facilities for manufacturing PET and reactor based radioisotope products for diagnosis and therapy. Under a technical cooperation project in Brazil, a second cyclotron centre in Recife (Fig. 2) began routine production of FDG, the main tracer used in PET imaging. Under the same project, two national workshops, each attended by more than 300 participants, were held to develop awareness among radiopharmacists and physicians about the production and clinical application of PET radiopharmaceuticals.

The Agency published *Cyclotron Produced Radionuclides: Guidelines for Setting Up a Facility* (Technical Reports Series No. 471) to assist institutions interested in setting up new cyclotron centres for SPECT and PET radiopharmaceuticals production according to good manufacturing practices. Further guidance was provided with the publication of *Cyclotron Produced Radionuclides: Physical Characteristics and Production Methods* (Technical Reports Series No. 468).

FIG. 2. A cyclotron beam extractor (left) and production hot cell (right) for manufacturing PET radionuclides in Recife, Brazil.

FIG. 3. Optimizing phosphoric acid production using radiotracer techniques at a plant in Tunisia.

Applications of Radiation Technology

Nanotechnology is a diverse and rapidly growing area where the advantages of radiation methods can be exploited to create and characterize new advanced materials. To support capacity building in this area, the Agency, together with the ICTP, and the Horia Hulubei National Institute of Physics and Nuclear Engineering and the Lucian Blaga University of Sibiu (both in Romania), organized a workshop on 'Trends in Nanoscience: Theory, Experiment, Technology' in Sibiu that was attended by more than 50 participants. And as part of a technical cooperation project for Europe, 20 participants were trained in radiation methods for the synthesis and characterization of materials at the nanoscale for applications ranging from medicine to electronics.

Radiotracer techniques are an important means of improving the efficiency of mineral processing, with potentially large energy and cost savings. Through an AFRA technical cooperation project, the Agency

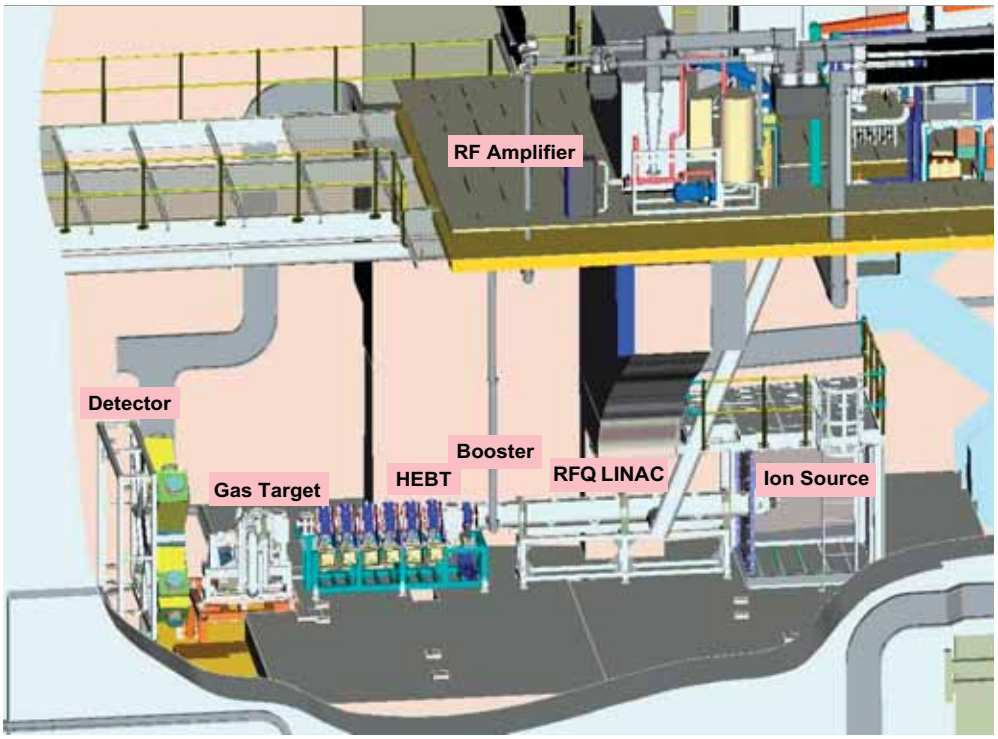

FIG. 4. An accelerator based neutron generator at Necsa (South Africa), previously used by the De Beers company to detect diamonds in kimberlite, is being adapted for use in other industrial applications such as locating and identifying organic and inorganic contaminants in wool bales.

supported Member States in applying radiotracer techniques for optimizing processing plants in the phosphate industry in Morocco and Tunisia (Fig. 3), and in the gold processing and cement production industries in Ghana. In one cement plant in Ghana, the radiotracer residence time distribution method was used to optimize the clinker grinding process, thereby increasing production by 10%. To support the training of personnel in radioisotope and radiation technology in industrial applications, the Agency published *Leak Detection in Heat Exchangers and Underground Pipelines Using Radiotracers* (Training Course Series No. 38).

An important application of neutron based techniques is the detection of illicit materials and explosives. In a CRP completed in 2009, participants demonstrated that the most successful technique for large container scanning is fast neutron radiography. As a result of work undertaken in this CRP, one fully assembled device became commercially available in 2009.

In a related technical meeting on fast neutron resonance radiography applications, participants reviewed the current status and challenges in the development of devices capable of producing elemental images (including in three dimensions) of medium to large sized objects with adequate spatial resolution for such applications as screening air cargo or unattended luggage, as well as for quality control in the textile industry (Fig. 4). Two prototype facilities, one a fixed device and the other portable, were developed.