Industrial Applications of the IEA-R1 Research Reactor in Brazil

F. Genezini[1], ***W. A. P. Calvo***[1], A. J. Fernando[1], A. Marra Neto[1], and P. E. Aoki[1]

[1]*Instituto de Pesquisas Energéticas e Nucleares (IPEN-CNEN/SP), São Paulo, Brazil*

Corresponding Author: F. Genezini, fredzini@ipen.br

The IEA-R1 is an open pool type research reactor located at the Nuclear and Energy Research Institute (IPEN-CNEN/SP) site and achieved its first criticality on September 16, 1957. IEA-R1 is the largest research reactor in operation in Brazil, with a core composed of 24 fuel elements with 20% enriched uranium silicide, 4 control rods (Ag+In+Cd) and many irradiation positions supplying thermal neutron fluxes ranging from 10^{12} to 10^{14} n/cm^{2}s. Currently, IEA-R1 is operating at 4.5 MW on an 8 hours per day and 4 days per week cycle.

The IEA-R1 reactor is a multipurpose facility used for basic and applied research in nuclear and for the production of radioisotopes for industry and nuclear medicine. For industry, IEA-R1 produces radiotracers and sealed radioactive sources (^{60}Co and ^{192}Ir) for industrial γ-radiography, as well as doped silicon by neutron transmutation.

For radiotracer production, IEA-R1 has been working with a compact local staff (3 persons) and is assisted by the Radiation Technology Centre at IPEN-CNEN/SP, in which there are installed hot cells for high activity handling. Most of the radiotracers produced at IEA-R1 are irradiated in a quartz bulb inside an aluminium vessel; the only exception is for ^{41}Ar production, where a special device that doesn't require a hot cell is used. These are the radiotracers produced at IEA-R1 and their applications in industry and environment:

- ^{203}Hg: determination of the mercury mass immobilized in electrolytic cells from soda and chlorine producing industries (46.6 days and 0.28 MeV).
- ^{131}I and ^{82}Br: flow rate measurement and residence time distribution (RTD) studies in rivers, lakes and wastewater treatment plants (8.04 days and 36 h, 0.36 MeV and 0.55 MeV, respectively).
- ^{192}Ir: environmental studies, in the form of a premixed sand (glass powder plus activated iridium), to study drag sediment in river (73.8 days and 0.32 MeV).
- ^{198}Au: representative study, in real conditions, of the impact of great civil works for the construction of important artificial harbour, airport and hydroelectric reservoir, by labelling sand to be removed from the bottom with emulsion of gold (2.7 days and 0.41 MeV).
- ^{41}Ar and ^{79}Kr: study the gas phase of fluidized cracking catalytic plants (110 min and 35 h, 1.29 MeV and 0.51 MeV, respectively).
- ^{140}La: study the solid phase (catalysts) of fluidized cracking catalytic plants in petroleum refineries (40 h, 1.16 MeV).

For doped silicon production, a device that affords the best axial and radial uniformity of the neutron dose is used. These doping uniformities as well as the doping accuracy are determined using resistivity values, showing an excellent doping quality.

A recent improvement was the development of an irradiation system to produce gaseous radioisotopes (^{41}Ar and ^{79}Kr), delivering the activated gases directly into the shield bottle without handling and dose exposition for operators, instead of via small quantities (batches), through quartz ampoules containing these noble gases.