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DON'T BE AFRAID OF RADIOACTIVITY: TRACING AND THIN LAYER ACTIVATION WITH RADIOACTIVE ISOTOPES

Introduction

Nowadays, mainly due to a kind of over-regulation and the caused public fear of radiation and radioactive sources the industrial use of radio-isotopes and radioactive isotopes is decreasing in many countries in spite the fact that their medical use is increasing. That's why the IAEA (International Atomic Energy Agency) launched a regional program in Europe for the "re-discovery" of radioactive sources and nucleonic control systems in industry, agriculture, etc. Its newest program (RER1023 2022-2026) involves 23 member states and among others Hungary.

Radioactive tracer applications

When one speaks about radioactive tracers, thinks about an additive in solid, liquid or gaseous form, which is added to the process to be investigated or the tracer radioisotopes can be produced directly in the material in question. The radioactive isotopes can be produced in experimental channels of a nuclear reactors by placing the proper target isotope there and irradiate with neutron for a while. This process is long but being parasite, it is a low-cost method. Afterwards, gaining the radioisotopes in proper usable forms physical and/or radiochemical separation is necessary. Many commercially available radioisotope products are produced this way.

The other possible way to produce tracer radioisotopes is the charged particle activation (see Figure 1), which is regularly performed in the ATOMKI cyclotron laboratory. The ATOMKI cyclotron can accelerate protons, deuterons, ^{3}He and ^{4}He (alpha) particles up to 2.5-18, 1-10, 4-27 and 2-20 MeV beam energies, respectively. Several experimental beam lines and installed equipment serve for the isotope production and direct irradiation. For processing the additive tracers, a radiochemical laboratory is working in the ATOMKI with direct connection to the production beam lines of the cyclotron. For the initial determination of the types and activities of the produced radioisotopes an analytical laboratory is established, containing among others several high-resolution gamma detectors (High Purity Germanium) connected to spectrometers.

The produced radioisotopes or the material activated are processed and used later in the ATOMKI laboratories or delivered by a licensed company to our research and/or commercial partners. All the activities out of the territory of ATOMKI require to keep the radiation protection rules.

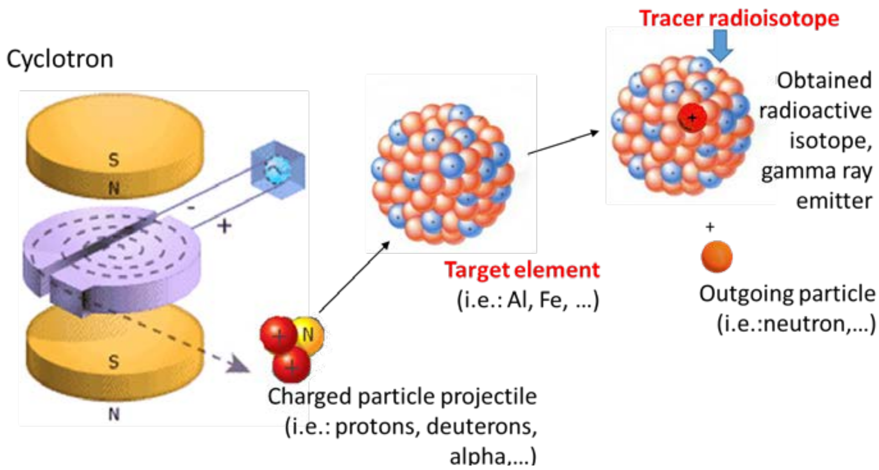

Fig. 1: Radioisotope production by using the charged particle beams of a cyclotron accelerator (by courtesy of Enrico Corniani).

Radioactive tracers and nucleonic control systems are used in many areas of medicine (1, 2), industry and agriculture. In this paper I deal only with industrial (3) and agricultural (4) applications, because the medical use is much better known in the public and has large literature for professionals. In Figure 2 the areas of industry are shown, where the radiotracers and nucleonic control systems are most frequently used.

Thin Layer Activation (TLA)

The Thin Layer Activation method is a special case of radioactive tracer applications. During TLA the radioactive isotopes are produced by neutron or charged particle irradiation at the place where they are used, i.e. in a thin surface layer (charged particles) or in the whole volume (neutrons) of the samples to be investigated (5). The most frequently used construction material in industry is the iron, and fortunately from iron a number of proper tracer radioisotopes can be produced by proton or deuteron irradiation (^{56}Co, ^{57}Co, ^{58}Co). These radiotracers can be used by iron or iron containing alloy parts. For a series of elements, we have elaborated a database and calculation program, where even an un-experienced user can design a TLA activation and measurement. This database is publicly accessible on the IAEA (International Atomic Energy Agency) home page under the URL https://www-nds.iaea.org/tla. The most of the tasks emerged for Thin Layer Activation are coming from the automotive industry (6).

Fig. 2: Industrial areas, where the radiotracers and nucleonic control systems are used (by courtesy of Jovan Thereska)

In Figure 3 a typical setup of TLA wear measurement is shown. The activated parts to be investigated containing the radioactive tracer isotopes in their surface – currently the piston rings and/or roll bearings – are assembled back into their original place and run the machine with controlled load, temperature, rotation, lubrication, cooling, etc.

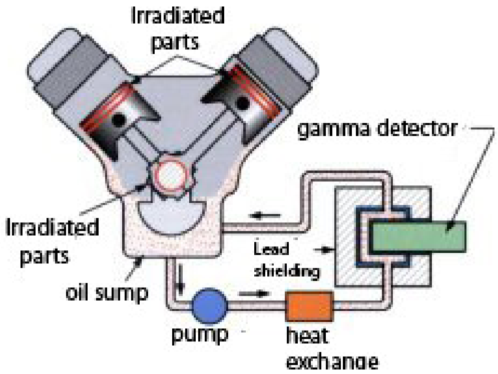

Fig. 3: Typical setup for wear measurement using TLA.

Future outlook of radio-tracer applications (7)

1. For some applications, radioactive tracers will be progressively replaced by non-radioactive tracers because of the public fear. However, for the foreseeable future, there will be many tasks that can only be carried out with radioactive tracers.
2. Column scanning applications will become increasingly more common as a result of "globalisation" of the chemical and refining industries.
3. Techniques offering process visualisation, such as tomography will be widely used.
4. Neutron techniques for inspection and analysis will continue to be refined and developed
5. There will be increased uptake of the technology by industries other than oil and gas. Minerals processing appears to offer the most promise
6. Radiotracer studies will become increasingly wider in scope and more detailed.

The International Atomic Energy Agency (IAEA) promotes the application of radio-tracers and nucleonic control systems (NCS) in several fields of industry and agriculture in the frame of a series of regional programs. The newest project is the RER1023 Harmonizing Implementation of Radiotracer and Sealed Sources Techniques for Efficient Use of Natural Resources and Environmental Monitoring, project duration: 2022-2025. Project outcome: Radiotracer methods and nucleonic control systems (NCS) implemented for efficient, safe, and sustainable industrial operation and environment protection.

Project output

1. Trained and certified personnel in radiotracer (RT) and sealed source applications in industry and environment available.
2. Regional resource units (RRUs) for review, development and demonstration of major technologies established.
3. Natural radioactivity to investigate environmental and industrial processes applied.
4. Towards a zero-pollution ambition for a toxic free environment - RT and NCS as a meaningful tool for pollution emission control.
5. Circular economy -development of recovery methods of the deficit metals from mine tailings and industrial waste with the use of RT and NCS.

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