Industrial uses of nuclear radiation

Group 3

May 2024

1 Smoke alarms

Smoke alarms alpha particles are easily absorbed. A household smoke alarm measures the movement of alpha particles across a small gap. If smoke enters the detector, it will absorb the alphas and the detector will measure a drop in the number getting across the gap. This drop in measurement will trigger the alarm to sound. Americium-241 is the most common material used as the alpha emitter in a domestic smoke alarm. Thickness monitoring Radiation is absorbed as it passes through mate- rials. This allows it to be used to gauge the thickness of a material by measuring the amount of radiation that passes through. This is commonly used with beta minus emitters in industry, for paper milling and the production of aluminum foil. If the foil is too thick it absorbs more beta particles. The detector receives less beta particles and then sends a signal to the rollers to increase the force on the foil, making it thinner. If the foil is too thin it absorbs less beta particles. The detector receives more beta particles and then sends a signal to the rollers to decrease the force on the foil, making it thicker.

1. Industrial use of α radiation :
   - Radiation is used as a smoke detector for industrial purposes.
2. Industrial use of β radiation :
   - Radiation is used as monitoring paper thickness in industries. Also, use of - radiation thickness of various coatings, such as paints.
3. Industrial use of γ radiation :
   - Radiation can be used to examine the leakages in oil pipelines. Also detecting internal defects in metal casting and welded structure.

2 Radioactive dating

Radioactive dating(radiometric dating) is an innovative method that uses radioactive elements to calculate the age of geologic material (soil, sand, organic substances, sandstone, etc...). A sample's abundance of parent and daughter isotopes can be measured and used to determine their age; examples are mainly uranium-lead dating, potassium-argon dating, rubidium-strontium dating, and radiocarbon dating. This was first published in 1907 by Bertram Boltwood and is now the absolute age of rocks and other geological features, including the age of the Earth, and can also be used to determine a range of nature-oriented or man-made substances.

1. **Uranium-lead dating**: is one of the oldest and most refined radiometric dating schemes, it can be used to date rocks from about 1 million years to 4.5 billion years ago with routine precision in the 0.1–1% range.

2. **Potassium-argon dating**: method of determining the time of origin of rocks by measuring the ratio of radioactive argon to radioactive potassium in the rock. This dating method is based upon the decay of radioactive potassium-40 to radioactive argon-40 in minerals and rocks; potassium-40 also decays to calcium-40.

3. **Rubidium-strontium dating**: method of estimating the age of rocks, minerals, and meteorites from measurements of the amount of the stable isotopes strontium-87 formed by the decay of the unstable isotope rubidium-87 that was present in the rock at the time of its formation. Rubidium-87 comprises 27.85% of the total atomic abundance of rubidium, and of the four isotopes of strontium, only strontium-87 is formed by its decay. The method applies to very old rocks because the transformation is extremely slow: the half-life, or time required for half the initial quantity of rubidium-87 to disappear, is approximately 50 billion years.

4. **Radiocarbon dating**: is a scientific method that can accurately determine the age of organic materials as old as approximately 60,000 years. First developed in the late 1940s at the University of Chicago by Willard Libby, the technique is based on the decay of the carbon-14 isotope.

3 Localized application of radioactive dating of nuclear radiation

Radioactive dating is a method of dating rocks and minerals using radioactive isotopes. This method is useful for igneous and metamorphic rocks, which cannot be dated by the stratigraphic correlation method used for sedimentary rocks. Over 300 naturally-occurring isotopes are known. Today, to benefit humankind, radiation is used in medicine, academics, and industry, as well as for generating electricity. In addition, radiation has useful applications in such areas as agriculture, archaeology (carbon dating), space exploration, law enforcement, geology (including mining), and many others.

- **Nuclear Power Plants**: Electricity produced by nuclear fussion splitting the atom is one of the greatest uses of radiation. As our country becomes a nation of electricity users, we need a reliable, abundant, clean, and affordable source of electricity. We depend on it to give us light, to help us groom and feed ourselves, to keep our homes and businesses running, and to power the many machines we use. As a result, we use about one-third of our energy resources to produce electricity. In America, nuclear power plants are the second largest source of electricity after coal-fired plants producing approximately 21 percent of USA electricity. Nuclear power plants are fueled by uranium, which emits radioactive substances. Most of these substances are trapped in uranium fuel pellets or in sealed metal fuel rods. However, small amounts of these radioactive substances (mostly gases) become mixed with the water that is used to cool the reactor.

4 Medical application of nuclear radiation

Some medial applications of nuclear radiation include :

1. **Diagnostic imaging** : Nuclear medicine imaging techniques such as positron emission tomography(PET) and single photon emission computed tomography(SPECT) use radioactive tracers to detect and visualize abnormalities in the body, such as tumors, infections or other diseases.

2. **Radiation therapy** : Radioactive sources are used in radiation therapy to treat cancer by targeting and destroying cancer cells. Techniques such as external beam radiation therapy and chemotherapy deliver controlled doses of radiation to the tumor site.

3. **Sterilization** : Gamma radiation from radioactive sources can be used to sterilize medical equipment,supplies and pharmaceutical products to ensure they are free from microorganisms that could cause infections.

4. **Radioimmunotherapy**: This treatment involves attaching radioactive isotopes to antibodies that target specific cancer cells, allowing for targeted delivery of radiation to tumor site while minimizing damage to healthy tissues.

5. **Thyroid disorders** : Radioactive iodine-131 is used in the treatment of hyperthyroidism and thyroid cancer by selectively destroying overactive thyroid tissue and cancerous thyroid cells.

These are just a few examples of how nuclear radiation is utilized in various medical applications to diagnose, treat, and mange different health conditions.

5 Academic application of nuclear radiation

Universities, colleges, high schools, and other academic and scientific institutions use nuclear materials in course work, laboratory demonstrations, experimental research, and a variety of health physics applications. For example, just as doctors can label substances inside people's bodies, scientists can label substances that pass through plants, animals, or our world. This allows researchers to study such things as the paths that different types of air and water pollution take through the environment. Similarly, radiation has helped us learn more about the types of soil that different plants need to grow, the sizes of newly discovered oil fields, and the tracks of ocean currents. In addition, researchers use low-energy radioactive sources in gas chromatography to identify the components of petroleum products, smog and cigarette smoke, and even complex proteins and enzymes used in medical research. Archaeologists also use radioactive substances to determine the ages of fossils and other objects through a process called carbon dating. For example, in the upper levels of our atmosphere, cosmic rays strike nitrogen atoms and form a naturally radioactive isotope called carbon-14. Carbon is found in all living things, and a small percentage of this is carbon-14. When a plant or animal dies, it no longer takes in new carbon and the carbon-14 that it accumulated throughout its life begins the process of radioactive decay. As a result, after a few years, an old object has a lower percent of radioactivity than a newer object. By measuring this difference, archaeologists are able to determine the object's approximate age.