Radionuclide activity

Radionuclides undergo spontaneous transformation and are referred to as **unstable**. We express the rate at which a parent nuclide transforms into a daughter nuclide in terms of **half-life**, and the amount of transformation in terms of **activity**. Nuclear transformation is a **random process**, so it is not possible to determine exactly how many and which nuclei will undergo transformation. However, since very high numbers of particles are involved, it is possible to determine statistically how many conversions should take place in a certain time interval. By tracking the number of conversions over time, we obtain an activity value. The time it takes for half of the nuclei to decay (the activity halves) is called the **half-life of the radionuclide**.

Activity

The activity of a radionuclide expresses **the number of transformations over a certain time interval**. Its unit is 1 Becquerel [Bq], which represents an activity equal to one conversion per second. In practice, however, such low units are not used. The activity of medically used radionuclides is in the order of kilo [kBq] to megaBecquerel [MBq]. The former unit of activity was 1 Curie [Ci], equal to the activity of one gram of ^{228}radium - approximately equivalent to 37 GBq.

The activity value depends on the sample size (number of radionuclide nuclei) and the time elapsed since the radionuclide was produced. The more radionuclide nuclei the sample contains, the more nuclei decay per second → higher activity. Conversely, the total number of nuclei capable of conversion decreases with time → lower activity.

Activity is an important variable in nuclear medicine. It is therefore essential to know its value for the radiopharmaceuticals administered. This is both to avoid unnecessary burden on the body and to know how much activity the radiopharmaceutical will have at the time of measurement (see thyroid accumulation test).

Activity calculation

As already mentioned, activity is the difference in the number of decayed nuclei of a radionuclide in a given time. It can therefore be expressed as:

$$A = \frac{\Delta N}{\Delta t}$$

Because the law of radioactive decay applies:

$$N = N_0 \,\mathrm{e}^{-\lambda t}$$

Where N is the number of nuclei in the sample, N0 is the initial number of nuclei in the sample, λ is the decay constant and t is the time. By combining these two relations, a relation characterizing the time evolution of the sample activity can be obtained:

$$A = A_0 \,\mathrm{e}^{-\lambda t}$$

Where A is the current activity, A_0 s the activity at time t=0 and t is time.

By logarithming both sides of the expression and adjusting, we obtain the relation:

$$\ln\left(\frac{A}{A_0}\right) = -\lambda t$$

Halftime

The activity of a radionuclide is very closely related to its half-life.

For more information see Halftime.

Generators

In radionuclide generators, where the parent nuclide has a several times longer half-life, there is a balance between its production and transformation. The activity of the parent nuclide is then equal to that of the acquired nuclide.

For more information see Radionuclide generator.

Links

Related articles

- Radionuclide
- Radiopharmaceuticals
- Halftime
- Radionuclide generator

Literature used

- BENEŠ, Jiří – STRÁNSKÝ, Pravoslav – VÍTEK, Francis. *Fundamentals of Medical Biophysics.* 2. edition. Prague : Karolinum, 2007. pp. 201. ISBN 978-80-246-1386-4.

- KUPKA, Karel – KUBINYI, Jozef – ŠAMAL, Martin, et al. *Nuclear Medicine.* 1. edition. publisher, 2007. pp. 185. ISBN 978-80-903584-9-2.