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Nuclides.net: a computational environment for nuclear data and applications in radioprotection and radioecology

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Abstract

An interactive multimedia tool, *Nuclides.net*, has been developed at the Institute for Transuranium Elements. The Nuclides.net ''integrated environment'' is a suite of computer programs ranging from a powerful user-friendly interface, which allows the user to navigate the nuclides chart and explore the properties of nuclides, to various computational modules for decay calculations, dosimetry and shielding calculations, etc. The product is particularly suitable for environmental radioprotection and radioecology. Detailed descriptions of Nuclides.net and some potential applications in radioprotection and radioecology are presented.

Keywords: Nuclides.net; Nuclear data; Radioprotection; Radioecology

1. Introduction

The interactive multimedia tool, *Nuclides.net* (Magill, 2003) has been developed at the Institute for Transuranium Elements. The product is aimed at both students and professionals for reference data on radionuclides and computations based on these data using the latest internet technology. Nuclides.net offers a variety of nuclear data including cross-sections, radioactive decay data, and fission yields from internationally recognized sources with the ease of a modern visual and graphical computer interface. In this way, both experienced and non-specialist users can thus benefit from an easy and efficient access to data without complex data format manipulation. More than 3650 ground state isomers are available in the Nuclides.net database as well as more than 70,000 gamma lines and emission probabilities. Among the large amount of data available, the user can access the effective dose coefficients for the inhalation and ingestion, taken from the ICRP72 (ICRP, 1996). In addition to the data access and manipulation, Nuclides.net offers two calculation modules allowing accurate investigation of radioactive decay and dosimetry problems.

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2. Description of Nuclides.net

Nuclides.net applications run over the internet on a web server. The user interface to these applications is via a web browser. Information submitted by the user is sent to the appropriate applications resident on the web server. The results of the calculations are returned to the user, again via the browser.

The Nuclide Explorer is an interface that allows the user to navigate through the nuclide chart. The ''Data Sheets'' module shows basic data on the selected nuclide, such as the mass, half-life, abundance, spin and parity, decay mode, branching ratios, daughters, and radiotoxicity. Additional windows contain spectral information. The ''Fact Sheets'' module gives important properties derived from the basic data, such as heat, neutron, and gamma emission rates, information on radiotoxicity and nuclide transportation.

Among the modules, the ''Decay Engine'' module provides exact solutions to the differential equation for the radioactive decay of nuclides. In the main interface ''Full Decay'' the user can select the source strength (mass, activity or numbers of atoms) and the time at which the evaluation is required. The result of the calculation lists the parents and daughters, the number of atoms, their masses, activities, gamma emission rates and gamma dose rates. The choice of output quantities can be selected in the option windows, where, in addition, ingestion and inhalation radiotoxicities, spontaneous fission rate, etc. can be computed.

The ''Dosimetry and Shielding'' module allows the calculation of gamma dose rates from both unshielded and shielded point sources. All known gamma lines and emission probabilities are accounted in the calculation. Alternatively, calculations of the required shielding thickness for a given source and a desired resulting dose rate can also be performed. A choice of 10 shield materials is available. The main interface allows the user to select the source strength, the source/detector distance, the shield material and thickness. The output of the calculations includes the gamma dose rate (or shield thickness), the half and tenth value thickness of shield material and the specific gamma dose rate constant.

Finally, the ''Fission Yield'' module gives the user access to fission products and yields for 36 fissioning nuclides (data for spontaneous fission and neutron induced fission with thermal, fast, and 14 MeV neutrons) from the main international datafiles.

As described, through this powerful interface, the user can access a wide variety of nuclear data from internationally recognized sources. The basic radioactive decay data used in the Nuclides.net database are from the NUBASE evaluation. The evaluation contains experimentally known nuclear properties, and some that have been estimated from extrapolation, for approximately 3650 ground and excited states: mass, isomeric excitation energy, half-life, spin, parity, decay modes and intensities. The effective dose coefficients have been taken from the International Commission for Radiological Protection ICRP reports (ICRP72). Spectral data are from the Joint Evaluated File (JEF) version 2.2, with a few corrections for known inaccuracies in the file. An update of the spectral database is under progress to include the data from the 8th Tables of Isotopes. Averaged cross section data are based on JEF-2-2, ENDF/B-VI, JENDL-3.2, BROND-2, and CENDL-2. Additional graphs of point-wise cross-sections based on JENDL-3.2 have recently been added. Fission yields data are from: JENDL-3.2, JEF-2/FPY and ENDF/B6 data files.

3. Nuclides.net features through applications

3.1. Radiotoxicity and annual limit of intake

Radiotoxicity of an isotope refers to its potential capacity to cause damage to living tissue as the result of being deposited in the body. The damage potential is governed by the type and energy of the radioactive disintegration, the half-life, the rate at which the body excretes the material, and the radio-sensitivity of the critical organ. For the present purposes, it is suitable to define the radiotoxicity as a committed effective dose $E(\tau)$.

$$\text{Radiotoxicity} = E(\tau) = Ae(\tau)$$

where A is the intake activity and $e(\tau)$ is the effective dose coefficient per unit intake.

The time τ is the integration time in year following intake. The Annual Limit of Intake (ALI) of an isotope is defined as the intake activity required to give a particular annual dose. Publication 60 of the ICRP recommends an annual