Hevesy Medal Lecture

Radiochemical Determination of Nuclear Data for Theory and Applications

Syed M. Qaim

Institut für Neurowissenschaften und Biophysik: Nuklearchemie (INB-4)
Forschungszentrum Jülich GmbH, D-52425 Jülich, Germany

Nuclear data, comprising nuclear structure, radioactive decay and nuclear reaction data, are experimentally determined via on-line physical measurement or off-line product identification. The latter involves extensive use of radiochemical separations, followed by characterisation of the radioactive product via high-resolution (occasionally low-level) counting methods. This technique is of particular significance when the matrix activity is high and the cross section of the investigated reaction is low, or when the product is a soft radiation emitter. The data obtained are important for theory as well as for practical applications. At Jülich extensive studies in both directions have been pursued over the last 30 years. In this talk some typical examples will be presented.

Fundamental nuclear reactions studies were related to complex particle emission and isomer distribution. The cross sections of complex particle emission reactions, like (n,t), (n, ^{3}He), (p, ^{7}Be), etc. are very low (nb-mb). Through extensive radiochemical work some systematic trends in the data could be established, and comparisons with statistical model calculations revealed the dominance of direct interaction processes. The isomeric cross section ratio was found to be strongly dependent on the reaction channel, and the yield of the high spin isomer increases with the increasing projectile energy.

As far as application oriented nuclear data are concerned, the emphasis has been on fusion reactor technology and medicine. Regarding the former, extensive cross section measurements were done using monoenergetic neutrons over the energy range of 5 to 20 MeV. Of particular interest were measurements related to tritium breeding, development of low activation materials and estimation of helium gas production in first wall constituents. Most of those data could be measured only through the use of the radiochemical technique.

Regarding nuclear data for medicine, the research work has been related to both diagnosis and therapy. Special attention has been devoted to development of non-standard long-lived positron emitters like ^{64}Cu, ^{86}Y, ^{124}I, etc. for their possible use in positron emission tomography (PET). In each case extensive cross section measurements were carried out on all promising and disturbing nuclear reactions induced by protons, deuterons, ^{3}He- and α-particles up to 100 MeV. The results were often validated by nuclear model calculations. In recent years, X-ray and Auger electron emitting radionuclides like ^{103}Pd, ^{193m}Pt, etc. have attracted considerable attention with respect to internal radiotherapy. With a view to increasing their specific activity, charged particle induced reactions were investigated using the radiochemical technique and X-ray spectrometry. The scope of those studies is broadening further.