# Th-U fuel cycle in the environment of spallation neutrons

Chitra Bhatia[a,b], V. Kumar[c*]

[a]Department of Physics, Duke University, Durham, North Carolina 27708, USA
[b]Triangle Universities Nuclear Laboratory, Durham, North Carolina 27708, USA
[c]School of Basic and Applied Sciences , G.G.Indraprastha University, Delhi, India
*email: vkv1951@gmail.com

Neutronics of a reactor for accelerator driven subcritical system (ADS) based on spallation neutrons is expected to be different compared to that of a thermal and a fast reactor [1]. The spallation neutrons produced in a collision of 1 GeV proton with the lead target, upon interaction with the elements of Th-U fuel influence the fuel cycle by adding new radio-nuclides, change in cross sections, increased yield of more neutron producing and / or neutron absorbing nuclides. Also, scenario of neutron poisons may be entirely different. For the study of a fuel cycle, elementary cross sections are calculated from the TALYS-1.0 code up to 200 MeV and from the CASCADE code [2] beyond 200 MeV corresponding to the energy of a neutron. The spectrum average cross sections (sp.av.cs.) are calculated using the PREPRO-07 code. It is observed that for the original spallation neutron spectrum the values of sp.av.cs. for $^{232}$Th (n, 6n) = 7.77 mb, $^{233}$Pa (n, 3n) = 35.17mb, $^{238}$U (n, 6n) = 2.82 mb, $^{235}$U (n, 3n) = 27.8 mb and $^{237}$Np (n, 3n) = 20.8 mb. Evidently, these reactions were not possible in a thermal and a fast reactor. It is also revealed that sp.av.cs. of ( n, $\gamma$ ) reaction of fuel element is drastically reduced compared to a thermal spectrum e.g. in case of $^{232}$Th, it reduces to 90.1 mb from 3.11 b; in case of $^{233}$Pa, it reduces to 247 mb from 22.4 b and in case of $^{238}$U, it goes down to ~ 67.4 mb from 7.78 b. Detailed tables of the sp. av. cs. are discussed for a large number of reactions pertaining to the extended Th-U fuel cycle and compared with the corresponding available data in case of the thermal and the fast spectra assuming that an energetically wide spallation neutron spectrum is available in an ADS reactor. It is concluded that the fuel cycles of an ADS reactor will be extensive and the neutron poisons of the thermal and the fast reactors will be practically ineffective in case of the original un-moderated energetically wide spallation neutron spectrum.

References:

[1] Determination of neutron multiplication coefficient of the fuel elements irradiated by the spallation neutrons" Chitra Bhatia and V. Kumar, Phys. Rev. C 81, 024614 (2010).
[2] Validation of CASCADE code using the monitor reactions, V. Kumar, Chitra Bhatia , H. Kumawat and J. Adam EPJ A 40, 231-236 (2009).