Molten Salt Fast Reactor (MSFR) based on LiF-NaF-KF

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Abstract

Recently, it was discovered that the solubility of heavy metal trifluorides (~30 mol% for PuF_3 and CeF_3, and ~40 mol% for AmF_3) in the LiF-NaF-KF eutectic salt is very high (Fig. 1). This observation offers new options for MSFR use as an element of the future nuclear power.

The initial idea of the molten salt reactor (MSR) with thermal neutron spectrum, realized as the MSRE and MSBR projects at ORNL (USA) half a century ago, has been transformed in the last decade. The several types of MSFR have been suggested, based on the carrier salts LiF, LiF-BeF_2, LiF-NaF-BeF_2, etc. with the rather high solubility of ThF_4 (~20 mol%) but with the low solubility (~1mol%) of PuF_3 and AmF_3. This prevents the realization of the U-Pu fuel cycle of MSFR and the development of the effective reactor-burner. One of possible applications of new data on the high solubility of PuF_3 and AmF_3 in LiF-NaF-KF salt obtained recently is the effective subcritical molten salt reactor-burner of transuranic elements. The fuel composition of this reactor is LiF-NaF-KF (86 mol%) – PuF_3 (7 mol%) – AmF_3 (7 mol%) and its neutron spectrum is almost fast (Fig.2). In the equilibrium regime such a reactor does not need feeding by fissile nuclides (^{239}Pu, ^{235}U, ^{233}U) and is capable of burning out about ~300 kg/GW·year of Am and Cm.

The results presented in this work are obtained by the collaboration of Russian Institutes: NRC "Kurchatov Institute" (Moscow), VNIITF (Snezhinsk, Russia), NIIAR (Dimitrovgrad, Russia), INR RAS (Troitsk), IATE (Obninsk), VNIIKHT (Moscow).

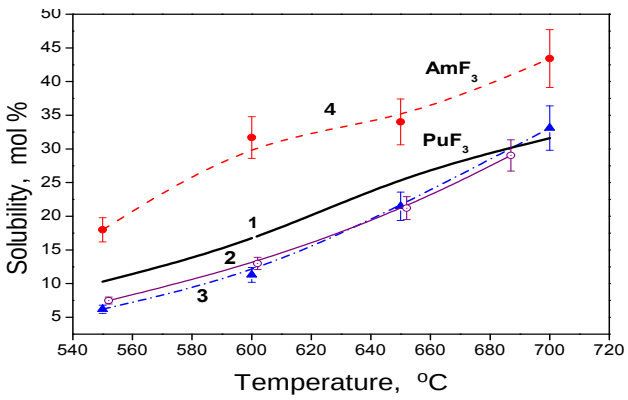

Fig.1. The calculated and measured solubility of PuF_3 and AmF_3: 1 – PuF_3 (theory, Karlsruhe), 2 – PuF_3 (NIIAR), 3 – PuF_3 (VNIITF), 4 – AmF_3 (NIIAR).

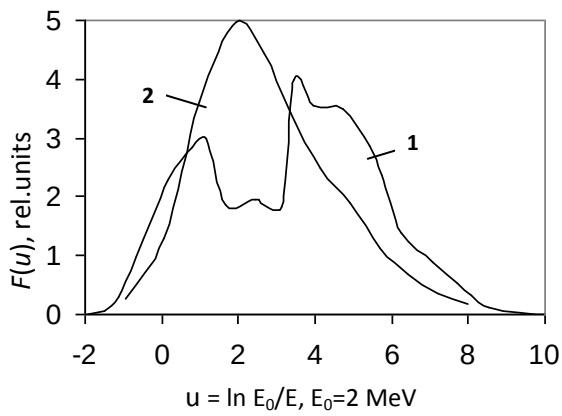

Fig.2. The neutron spectrum of the MSFR (1) in comparison with the FR spectrum (2) as a function of lethargy.