

Selection of Carrier Salt for Molten Salt Fast Reactor

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Abstract. The paper analyzes the choice of fuel for the development of molten salt nuclear reactor (MSR) with uranium-plutonium fuel cycle and fast neutron spectrum. Some physical properties of the molten salt fluorides systems that can be used as a supporting salt to dissolve therein nuclear materials have been shown. The emphasis was focused on the solubility of the nuclear materials: uranium, thorium and plutonium fluorides in molten salt systems. The paper shows the temperature dependences of the solubility of plutonium trifluoride, uranium tetrafluoride and cerium trifluoride in molten fluoride systems, as well as discussed the dependences to change them. Also, regularities in the change in the viscosity of molten systems depending on the composition were shown and corrosive influence of fluoride molten systems on candidate materials structural core of the MSR was evaluated.

Key Words: Molten salt systems, fluorides, molten salt reactor, solubility.

1. Introduction

The choice of the carrier salt for MSR was the subject of the many research since MSRE experience (the last one is the program ALISIA [1]). The molten fluorides of the alkaline and the alkaline-earth elements (Li, Be, Na, K, etc.) are usually used as the carrier salts. They should meet the numerous requirements: the low melting temperature, the low neutron absorption, the low corrosive activity; the high heat capacity and conductivity, the low viscosity, the low cost and toxicity, the high solubility of the actinide and lanthanide fluorides is also necessary for MSR with the fast neutron spectrum.

2. The solubility of the actinide and lanthanide fluorides in the fluoride molten salts

The solubility of the actinide and lanthanide fluorides in the fluoride salts is the key point in the carrier salt choice for the fast molten salt reactor. MSR fuel composition (FC) consists of the carrier salt, the fissile and raw actinide fluorides, the minor actinide and fission product fluorides, etc. To provide the fast neutron spectrum FC should contain ~ 20 mole % of the fertile elements [2]. There are known several fluoride carrier salts with the high solubility of ThF₄ and UF₄ (LiF-BeF₂, LiF-NaF-BeF₂, etc.) and they can be used not only in thermal reactors with Th-U fuel cycle like MSRE [3] and MSBR [4] but also in reactor with the fast and intermediate neutron spectrum.

However until recently the PuF₃ solubility in all the known salts does not exceed 6 mole%. (Table I) and therefore then was the fast MSR projects with U-Pu fuel. Recently it was found that in the eutectic 46.5LiF-11.5NaF-42KF (FLiNaK) the solubility of UF₄, PuF₃, and AmF₃ reaches ~ 45, ~ 30 and ~ 40 mole% respectively at 700° C [5-7]. This observation opens the way for the development of the fast molten salt reactor with U-Pu fuel cycle [8, 9].

TABLE I: THE PuF_3 SOLUBILITY IN THE MOLTEN FLUORIDE SALTS, MOLE %

Composition, mole %	T_m , °C	Temperature, °C				References
		550	600	650	700	
67 LiF-33 BeF_2	460	0.31	0.45	0.88	-	[10]
67 LiF-33 BeF_2	460	0.23 ^a	0.66 ^γ	0.72 ^δ	-	[11]
71.3 LiF-28.7 BeF_2	-	0.57	0.82	1.35	-	[12]
68.1 LiF-31.9 BeF_2	-	0.32	0.53	0.82	-	
63 LiF-37 BeF_2	-	0.27	0.41	0.68	-	[12, 13]
56.3 LiF-43.7 BeF_2	-	0.30	0.46	0.83	-	[12]
51.7 LiF-48.3 BeF_2	-	0.38	0.60	0.92	-	
66.7 LiF-33.3 BeF_2	460	0.39 ^β	0.58	0.83	-	
66.7 LiF-33.3 BeF_2	460	0.36 ^β	0.52 ^γ	0.84	-	[14]
17.5 LiF-56.5 NaF-26 BeF_2	505	1.56	1.56	2.80	-	[12]
60.1 LiF-2.1 NaF-37.8 BeF_2	-	0.28	0.42	0.73	-	
15 LiF-58 NaF-27 BeF_2	480	1.33	1.94	2.89	-	[15]
17 LiF-58 NaF-25 BeF_2	500	1.94	3.00	4	-	
63.4 NaF-36.6 BeF_2	-	0.29	0.46	0.84	-	[12]
49.7 NaF-50.3 BeF_2	-	0.22	0.34	0.52	-	
57.0 NaF-43.0 BeF_2	-	-	0.25	0.42	0.68	
80 LiF-20 ThF_4	-	-	4.0	5.2	-	[16]
78 LiF-22 ThF_4	-	-	3.98	5.02	5.88	[17]
72 LiF-16 BeF_2 -12 ThF_4	-	1.17	1.78	2.57	3.46	[18]
75 LiF-20 BeF_2 -5 ThF_4	-	-	2.88	-	4.75	[19]
75 LiF-5 BeF_2 -20 ThF_4	-	-	3.16	3.98	4.89	[17]
75 LiF-5 BeF_2 -20 ThF_4	-	-	3.4	4.0	4.9	[20]
70 LiF-10 BeF_2 -20 UF_4	-	1.27	1.70	2.48	-	[21]
65 LiF-30 BeF_2 -5 ZrF_4	450	0.10	0.15 ^γ	-	0.19	[22]
63 LiF-30 BeF_2 -7 ZrF_4	450	0.12	0.17 ^γ	-	0.26	

^a - at 525°C, ^β- at 575°C, ^γ- at 625 °C, ^δ - at 675 °C

2.1. Molten salts on the basis of LiF and NaF

According to the phase diagram of LiF- PuF_3 the PuF_3 solubility in LiF may be estimated as 20-40 mole % within the temperature range of 750-1000 °C. In NaF- PuF_3 melts the similar estimations give the solubility value of 25-40 mole % in the temperature range 730-850°C [12]. The addition of BeF_2 into LiF suppress the PuF_3 solubility almost by an order of magnitude: in LiF- BeF_2 the PuF_3 solubility in the temperature range of 500-700°C varies from 0.1 to 1.0 mole% [13]. The addition of ZrF_4 into NaF produces the effect similar in magnitude [23].

The addition of ThF_4 into LiF also decreases the PuF_3 solubility (in comparison with pure LiF) but less than the addition of BeF_2 . For example in the molten salt 80LiF-20 ThF_4 the PuF_3 solubility varies from 4 to 10 mole% within the temperature range of 600-800°C. The addition of UF_4 has much the same effect on the PuF_3 solubility as in case of ThF_4 addition [12].

2.2. Salt system LiF- BeF_2

The PuF_3 solubility in the most studied system LiF- BeF_2 varies from 0.2 to 1.4 mol% within the temperature range of 500-700 °C depending on the salt composition [10].

The compositions in which LiF is partially replaced with NaF are similar to LiF-BeF₂ ones with physical and chemical properties, but in this case the tritium generation in (n, α)-reaction on the ⁶Li is suppressed and the PuF₃ solubility increases ~ 3 times. The important advantage of LiF-BeF₂ melts with different content of LiF and BeF₂ components is the high solubility of UF₄ and ThF₄ which are the main fissile (²³³U) and raw (²³²Th) materials in the Th-U fuel cycle). The early measurements [21] and more late theoretical estimations [24, 25] based on the fusion diagrams of LiF-BeF₂-AnF₄ confirm that the solubility of UF₄ and ThF₄ is 20-30 mole % at the fuel composition temperature of 500-700°C and the pressure of saturated vapors does not exceed 10 Pa [26]. The high solubility of UF₄ and ThF₄ creates the good pre-conditions for using LiF-BeF₂ salt composition in the thermal reactors with Th-U fuel and in the fast breeder reactors [2].

It has been shown [27, 28] that the addition of CeF₃ in to eutectic 67LiF-33BeF₂ decreases significantly the solubility of PuF₃: the larger fraction of CeF₃ is entered into the system, the more the PuF₃ solubility is decreased. The addition of ThF₄ increases the PuF₃ solubility up to 5-6 mol%. The temperature dependencies of the PuF₃ molar solubility S is described by liner function $\log S = A + B/T$ [14].

The CeF₃ solubility as the chemical analogue of PuF₃ molar solubility S is described by many authors [29, 30, 22].

2.3. Salt system LiF-BeF₂-ThF₄

The influence of ThF₄ addition into LiF-BeF₂ on the CeF₃ solubility was studied [29]. In Table II the temperature dependencies of the CeF₃ solubility are presented. The total or partial replacement of BeF₂ with ThF₄ increases the CeF₃ solubility by 30-90%. The temperature dependencies of the molar solubility S within the range of 600-800 °C are well described by linear functions $\log S = A + B/T$. The later work [30] demonstrates a good correlation with these results.

TABLE II: CeF₃ SOLUBILITY IN SALTS LiF- BeF₂-ThF₄ [29]

Mixture No.	Salt composition, mole %			CeF ₃ solubility, mole %	
	LiF	BeF ₂	ThF ₄	600°C	800°C
1	72	16	12	1.62±0.03	5.28± 0.11
2	73	0	27	2.65±0.05	8.90± 0.18
3	72.7	4.8	22.5	2.24±0.05	8.25± 0.17
4	68	20	12	1.45±0.03	5.78± 0.12
5	72.3	11.0	16.7	2.10±0.04	5.93± 0.12
6	67.8	25.2	7.0	1.06± 0.02	4.92± 0.10
7	58	30	12	1.13± 0.02	4.43± 0.10
8	75	17.9	7.1	1.52± 0.03	6.59± 0.13
9	58.4	20.0	21.6	1.90±0.04	6.50± 0.14
10	67	0	33	2.54± 0.05	7.91± 0.17
11	80	0	20	3.30± 0.07	10.07± 0.21
12	60	0	40	2.77± 0.06	7.00± 0.14
13	66.7	33.3	0	0.60	3.7
14	72.7	27.3	0	0.95	5.7

2.4 Salt system LiF-BeF₂-ZrF₄

The CeF₃ solubility in 65LiF-30BeF₂-5ZrF₄ at 550-625-700°C is equal 1.01, 1.98 and 3.04 mole %, respectively [22]. The solubility of the other lanthanide fluorides (Table III) is also studied by in the salt 65 LiF-30 BeF₂-5 ZrF₄ which was proposed as the solvent for ADTT plant [22].

The solubility data of LnF₃, where Ln=Y, Sm, Ce, La in the salts 62.8LiF-36.4BeF₂-0.8UF₄ and 50NaF-46ZrF₄-4UF₄ [12] are presented in Table IV. The influence of the lanthanide atomic number on the lanthanide fluorides solubility has been demonstrated with the salt 62.8LiF-36.4BeF₂-0.8UF₄ [27] here the solubility is increased by a series of LaF₃<CeF₃<SmF₃, i.e. it is increased with growing the nuclear charge and decreasing the ionic radius (III).

TABLE III: SOLUBILITY OF THE LANTHANIDE FLUORIDES IN SALT SYSTEM
65 LIF-30 BeF₂-5 ZrF₄ [22]

Compound	Temperature T, °C	Solubility S, mol%	Solubility-temperature equation
LaF ₃	550	0.52±0.05	logS=2.05-3984/T±0.06
	625	1.60± 0.16	
	700	2.72± 0.25	
CeF ₃	550	1.01± 0.10	logS=0.46-2605/T ±0.04
	625	1.98± 0.18	
	700	3.04± 0.28	
NdF ₃	550	0.68± 0.7	logS=5.48-7042/T ±0.02
	625	1.62± 0.16	
	700	3.75± 0.32	
CeF ₄	550	0.62± 0.6	logS=1.36-3406/T ±0.03
	625	1.10± 0.10	
	700	2.50± 0.22	

TABLE IV: SOLUBILITY OF THE LANTHANIDE FLUORIDES [12]

Salt system	Temperature, °C	LnF ₃	Solubility, mol%
50NaF-46ZrF ₄ -4UF ₄	550-750	YF ₃	2.8-7.0
		SmF ₃	2.4-4.0
		CeF ₃	2.0-3.5
		LaF ₃	1.9-3.0
62.8LiF-36.4BeF ₂ -0.8UF ₄	500-650	SmF ₃	0.4-2.0
		CeF ₃	0.2-1.0
		LaF ₃	0.17-0.8

2.5 Salt system NaF-ZrF₄

In Table V the solubility of different fluorides in NaF-ZrF₄ and 52.5NaF-47.5ZrF₄ are presented [31] [22, 32]. The salt 52NaF-48ZrF₄ is comparable or slightly higher in the fluoride solubility as LiF-BeF₂ but less toxic, corrosive and its disadvantage is a high volatility of ZrF₄ vapours that results in formation of zirconium tetrafluoride deposit in MSR communications [33].

TABLE V: SOLUBILITY OF THE ACTINIDE AND LANTHANIDE FLUORIDES IN 52NaF-48ZrF₄

T, °C	Solubility, mole %							
	[22]		[31]			[22]	[32]	[32]
	UF ₄	ThF ₄	NpF ₄	PuF ₃	AmF ₃	CeF ₃	LaF ₃	PrF ₃
550	9.8	0.2	5.8	2.0	1.15	0.9	1.1	0.2
600	14.8	2.8	-	-	-	1.4	1.1	0.3
650	17.1	4.1	-	-	-	1.9	1.7	0.4
700	25.1	5.9	-	-	-	2.1	2.1	0.6
750	29.4	7.3	12.3	3.2	1.20	2.5	2.7	0.6

2.6 Salt system LiF-ThF₄-UF₄

The CeF₃ and PuF₃ solubility at their joint presence in the melts 78LiF-7ThF₄-15UF₄ and 72.5LiF-7ThF₄-20.5UF₄ within the temperature range of 600-750 °C are presented in Tables VI and VII respectively [34]. These compositions meet the special requirements imposed to fuel salt of MSR launch load with cavity-type reactor core [20] where the fraction of heavy metal tetrafluorides is essential (22 and 27.5 mole %, respectively).

TABLE VI - SOLUBILITY OF PuF₃ AND CeF₃ IN 78LiF-7ThF₄-15UF₄ [34]

Temperature, °C	PuF ₃ solubility, mol%	CeF ₃ solubility, mol%
600	1.48±0.07	4.6±0.2
650	5.8±0.3	6.3±0.3
700	9.9±0.5	8.5±0.4
750	10.9±0.6	8.9±0.4

TABLE VII - SOLUBILITY OF PuF₃ AND CeF₃ IN 72.5LiF-7ThF₄-20.5UF₄ [34]

Temperature, °C	PuF ₃ solubility, mol%	CeF ₃ solubility, mol%
600	0.36±0.02	2.6±0.1
650	4.6±0.2	4.4±0.2
700	8.6±0.4	6.4±0.2
750	9.6±0.5	6.8±0.3

The joint solubility of CeF₃ and PuF₃ increases with temperature and decreases with increasing UF₄ and ThF₄. The similar behaviour is observed at the PuF₃ solubility in LiF-ThF₄ with the same fraction (22-27 mol%) of thorium tetrafluoride [20].

2.7 Salt system 46.5 LiF--11.5 NaF-42 KF (FLiNaK)

The phase diagram for LiF-NaF-KF system was obtained at first by Bergmann and Dergunov [35]. This system has the single eutectic 0.465 LiF-0.115 NaF-0.42 KF mole.% (FLiNaK) with the melting temperature $T_m = 454^\circ\text{C}$ [36]. The later experimental works confirmed these results [37].

The eutectic salt composition 46.5 LiF--11.5 NaF-42 KF (FLiNaK) has been considered earlier as perspective coolant for the fast nuclear reactors [37] and the hybrid fusion-fission systems. But the theoretical estimations [38] and experiments [5-7] have demonstrated the extremely high solubility of PuF₃, UF₄, ThF₄ and AmF₃ as well as the lanthanides fluorides. The data on the solubility of UF₄, ThF₄ and AmF₃ in FLiNaK are presented in Table VIII.

TABLE VIII: SOLUBILITY (MOLE %) OF ThF₄, UF₄ [6], AmF₃ [5] IN EUTECTIC OF 46.5 LiF-11.5 NaF-42 KF

T°C	ThF ₄	UF ₄	AmF ₃
550	23.2	15.3	18.0
600	27.9	24.6	31.7
650	32.8	34.8	34.0
700	41.4	44.7	43.4

Solubility of plutonium and americium trifluorides has been studied using the isothermal saturation [5] and local γ -spectrometry [7] methods (Tables IX-X). The AmF₃ solubility is even higher as the PuF₃ solubility.

The PuF₃ solubility is presented in Table IX. The measured values are within the range of 600-700 °C consider within the experiment errors (~ 10%) and close to the theoretical estimates [38].

TABLE IX: PuF₃ SOLUBILITY (MOLE %) IN FLiNaK

Temperature, °C	PuF ₃ [5]	PuF ₃ [7]
550	6.2±0.6	7.5± 1.0
600	11.3± 1.1	12.8± 1.7
650	21.5± 2.1	21.2± 2.7
700	33.1± 3.3	30.7± 4.0

It is well known [29] that CeF₃ solubility in various salts is close to PuF₃ solubility. In Table X the measurements of CeF₃ solubility in FLiNaK are presented confirming this survey.

Table X: CeF₃ SOLUBILITY(MOLE %) IN FLiNaK

Temperature, °C	CeF ₃ [7]	CeF ₃ [5]
550	12.9	-
600	16.6	21.6
650	23.7	-
700	29.2	31.9

Joint solubility of PuF₃ and UF₄ in FLiNaK was measured [39]. It is evident from Table XI that the joint presence of UF₄ and PuF₃ in FLiNaK results in essential decreasing of their individual solubility: at 600° C the individual solubility of PuF₃ and UF₄ 600 °C is 11.1 and 24.6 mol%, respectively; but their joint solubility is only 2.9 and 3.5 mol %. The total solubility of PuF₃ and UF₄ in the mixture is comparable with the individual PuF₃ and UF₄ solubility and this difference decreases with increasing temperature.

The measured solubility of LaF₃, NdF₃, CeF₃ and PrF₃ in FLiNaK are given in Table XII. These results are important for the organization of the MSR closed fuel cycle and the MSR fuel composition feeding and cleaning. Particularly, such a high solubility of the lanthanide fluorides in the fuel composition allows to increase the intervals between the fuel cleaning from the neutron poisons.

The high PuF₃ and UF₄ solubility in FLiNaK at first opens the way for the development of the fast MSR and U-Pu fuel cycle [9, 23].

Table XI: JOINT SOLUBILITY OF PuF₃ AND UF₄ IN FLiNaK

Temperature, °C	Individual solubility, mole% [5, 6]		Joint solubility, mole% [39]		
	PuF ₃	UF ₄	PuF ₃	UF ₄	PuF ₃ + UF ₄
550	6.1±0.6	15.3±0.8	1.2±0.1	1.8±0.1	3.0
600	11.1±1.1	24.6±1.2	2.9±0.3	3.5±0.5	6.4
650	21.3±2.1	34.8±1.7	13.2±1.6	11.0±1.6	24.2
700	32.8±3.3	44.7±2.2	19.1±2.3	17.3±2.6	36.4
750	-	-	21.0±2.5	19.0±2.8	40.0
800	-	-	22.5±2.7	20.0±3.0	42.5

TABLE XII: SOLUBILITY (MOLE%) OF THE LANTHANIDE FLUORIDES IN FLiNAK

T°C	[23]		[5]	[7]
	LaF ₃	PrF ₃	NdF ₃	CeF ₃
550	1.9	-	13.3	12.9
600	8.9	8.7	22.0	16.6
650	12.6	10.4	27.8	23.7
700	20.8	13.7	36.8	29.2

3. The other essential fluoride molten-salt properties

The fluoride molten salts have the satisfactory heat capacity, and conductivity as well as viscosity to remove effectively the heat at operating temperatures (500-800 °C) in a wide range of the salt compositions [49]. The thermal properties of these melts provide the high efficiency of heat removal even in case of the natural circulation: the factor of the “salt-wall” heat transfer is close to such of water, although the coefficient of the salt heat conductivity is ~ 100 times less than sodium one. The molten fluorides differ in high radiation resistance and relatively low corrosion activity in relation to graphite and some metal alloys.

The most studied fuel MSR composition is the salt 67LiF-33BeF₂ (99.995% ⁷Li) with the fissile (²³³U) and raw (²³²Th) isotopes fluorides dissolved. The very important advantage of LiF-BeF₂ melt is the high solubility of UF₄ and ThF₄ (~ 20 mole % at ~ 600 °C) and the saturated vapours pressure ~ 10 Pa at 700 °C [26].

The accumulation of fission products in MSR fuel compositions up to concentration of 1-2 mole % does not change significantly their physical and chemical properties and does not result in their sedimentation. These fuel compositions are acceptable as the base for MSR with Th-U cycle, including fast MSR.

The fast MSR with U-Pu cycle needs in the carrier salts with the high UF₄ and PuF₃ solubility similar to 46.5LiF-11.5NaF-42KF but they shall meet also a series of other requirements imposed to its physical and chemical properties: density, heat capacity and heat conductivity, corrosive activity, etc.

3.1 Viscosity

The viscosity of the molten mixtures of lithium, sodium, potassium, beryllium, aluminum, thorium and uranium fluorides was studied experimentally in many works [36, 40-44, 37, 20]. The method of the torsion vibration damping of the cylindrical crucible filled with the studied melt was used [3, 17]. The comparison of the experimental and estimated data at different temperatures is given in Table XIII.

TABLE XIII: VISCOSITY OF Li, Na, Be, K, Th, F MOLTEN SALTS

Composition, mol%	Measurement range °C	Dynamic viscosity mPa/s			References
		600	700	800	
46.5LiF–11.5NaF–42 KF	503 -703	4.2	2.48	–	[36]
	–	6.04	3.44	2.17	[45]
	–	5.28	3.54	2.56	[46]
	500-800	4.75	2.91	1.95	[47]
	454 - 871	5.40	3.48	2.48	[44]
46.5LiF–11.5NaF–42 KF	454 - 871	2.65	1.76	1.30	[44]
(46.5LiF–11.5NaF–42KF) +5CeF ₃	488 - 886	2.56	2.05	1.70	
(46.5LiF–11.5NaF–42KF) +10CeF ₃	551 - 875	2.70	1.91	1.44	
15LiF–58NaF–27 BeF ₂	490 - 790	3.65	2.91	2.14	[44]
(15LiF–58NaF–27BeF ₂) +1CeF ₃	469 - 797	3.07	2.35	2.00	
70LiF – 30BeF ₂	630 - 936	–	2.66	1.90	[42]
80LiF – 20BeF ₂	758 - 945	–	–	1.24	
72LiF–20BeF ₂ – 8ThF ₄	709 - 1023	–	–	1.45	
81LiF–10BeF ₂ –9ThF ₄	783 - 1038	–	–	1.35	
63LiF–30BeF ₂ –7ThF ₄	698 - 1044	–	2.09	1.68	
70.1LiF–23.9BeF ₂ –6ThF ₄	527-627	3.68	–	–	[36]
71LiF–16BeF ₂ –12ThF ₄ –1UF ₄	730-1060	–	–	1.52	[48]
75LiF–20BeF ₂ –5ThF ₄	651 -885	–	2.49	1.83	[3]
70LiF – 30ThF ₄	637 - 989	–	1.94	1.48	[42]
80LiF – 20ThF ₄	723 - 997	–	–	1.37	
80LiF – 20UF ₄	723 - 997	–	–	0.81	
80LiF – 20UF ₄	600 - 800	3.90	2.18	1.37	[36]
78LiF – 22ThF ₄	estimation	2.30	1.64	1.31	[1]
78LiF – 22ThF ₄	estimation	–	1.40	1.11	[25]
78LiF – 22ThF ₄	625 -846	–	2.46	1.73	[48]
75LiF – 20ThF ₄ – 5BeF ₂	estimate	2.21	1.74	1.37	[1]
72LiF – 18ThF ₄ – 10BeF ₂	730-1060	–	–	1.37	[42]
71LiF – 27ThF ₄ – 2BeF ₂	593 - 805	2.94	2.04	1.52	[48]
75LiF – 5BeF ₂ –20ThF ₄	578 - 820	2.81	2.25	1.88	
(75LiF-5BeF ₂ -20ThF ₄) +3CeF ₃	693-842	–	2.27	1.94	

3.2 Corrosion of the structure materials

Since the time of MSRE project several alloys were tested for corrosive properties in contact with molten fluoride salts and fission products [26, 49, 50, 17, 20]. These data demonstrate that the corrosion rate of the constructional material depends on the salt composition, impurities (especially Te, NiF₂, FeF₂, H₂O, the metal oxides and sulfates), operation temperature and melt flow rate, and especially redox potential of the fuel composition.

Recently there has been proposed [50, 17, 20] the nickel alloys with high heat resistance and high-temperature strength for the MSR fuel composition at temperature up to 800°C. The nickel-molybdenum alloys niobium-doped XH80M-BИ, aluminum-doped XH80MTЮ, tungsten-doped XH80MTB [17, 20] and the special nickel-tungsten alloy EM-721 [50] have been studied.

Olson et al. [50] have studied the FLiNaK corrosive activity. There was established that Hastelloy-N and the alloys with high content of nickel and low content of chromium, in particular, Ni-203 are the most appropriate construction materials within the temperature range up to 700°C.

4. Conclusion

The salt compositions based on the fluorides of alkaline elements (Li, Na, K) have all the necessary properties for the reliable molten-salt reactor operation. Currently available information on the molten salts properties allows to make some recommendations for the choice of the carrier salt for the fast MSR of the different types. The high solubility of the actinide and lanthanide fluorides in FLiNaK combined with its other physical and chemical characteristics allows to consider it as the perspective one for the fast MSR with U-Pu fuel cycle [8, 9, 23]. It can be used as well for MSR-burner of minor actinides with fast and intermediate spectrum of neutrons [8].

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