This project has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 661891

SAMOFAR Final Meeting

4 July 2019

SAMOFAR

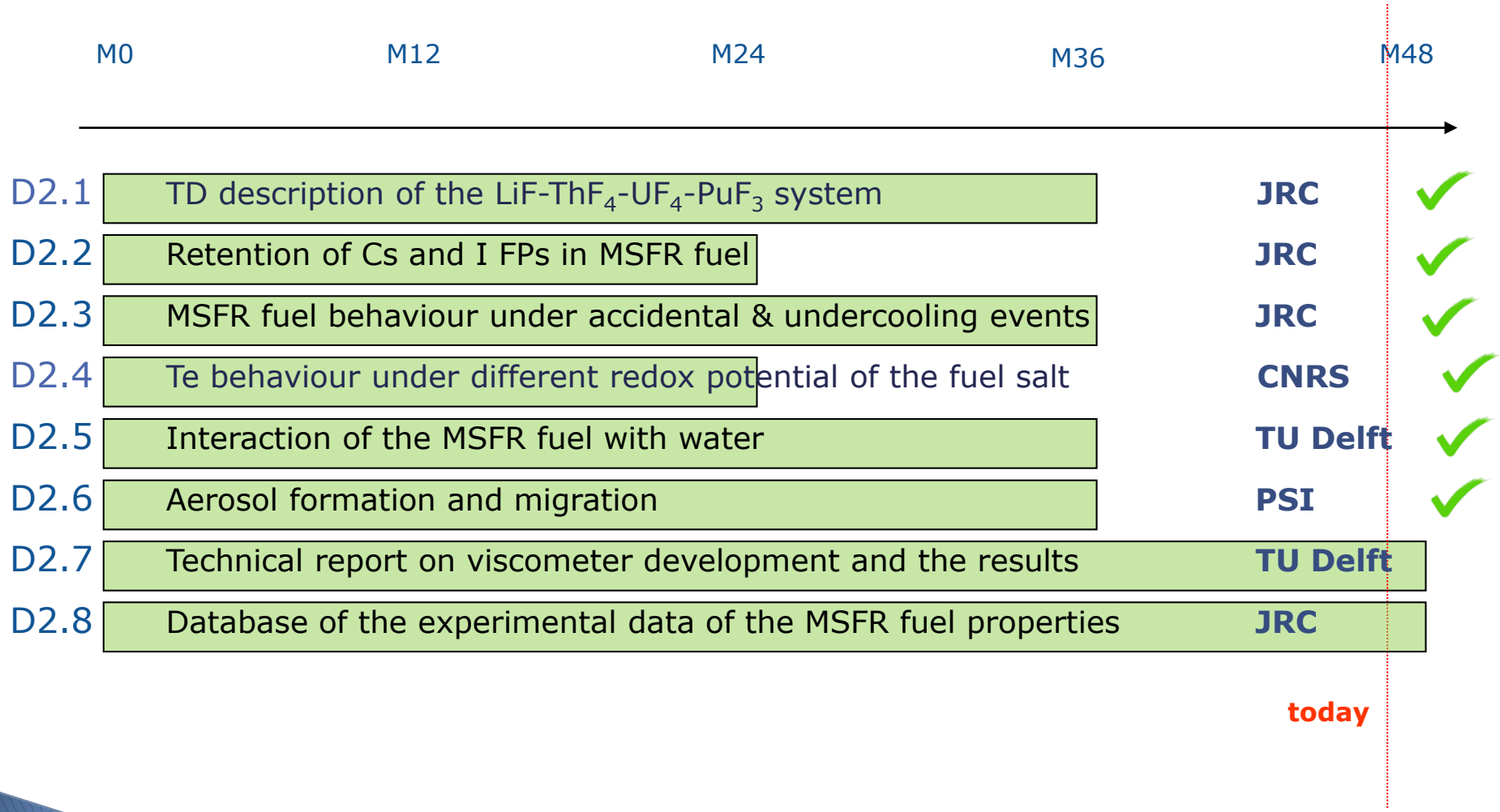
European Commission

WP2 Overview

Physical and chemical properties required for safety analysis

by Ondřej Beneš

SAMOFAR


M0
M12
M24
M36
M48
D2.1
TD description of the LiF-ThF4-UF4-PuF3 system
JRC
D2.2
Retention of Cs and I FPs in MSFR fuel
JRC
D2.3
MSFR fuel behaviour under accidental & undercooling events
JRC
D2.4
Te behaviour under different redox potential of the fuel salt
CNRS
D2.5
Interaction of the MSFR fuel with water
TU Delft
D2.6
Aerosol formation and migration
PSI
D2.7
Technical report on viscometer development and the results
TU Delft
D2.8
Database of the experimental data of the MSFR fuel properties
JRC
today

SAMOFAR

Milestone 2.1

First experimental results with PuF_3 containing salt, verified by a publication of the results in a peer reviewed journal.

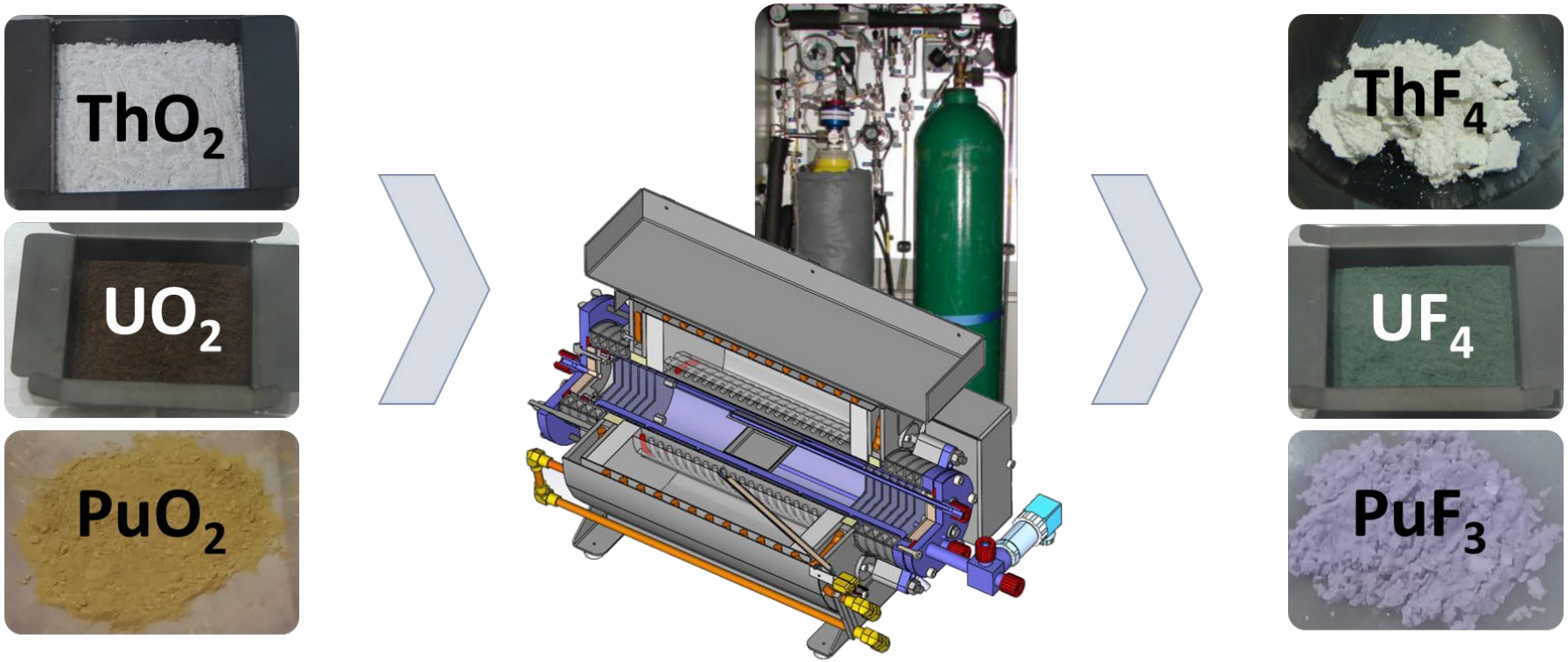
Responsible: JRC-ITU

Milestone 2.2

Viscometer prototype up and running, verified by first results on molten fluoride salts.

Responsible: TU Delft

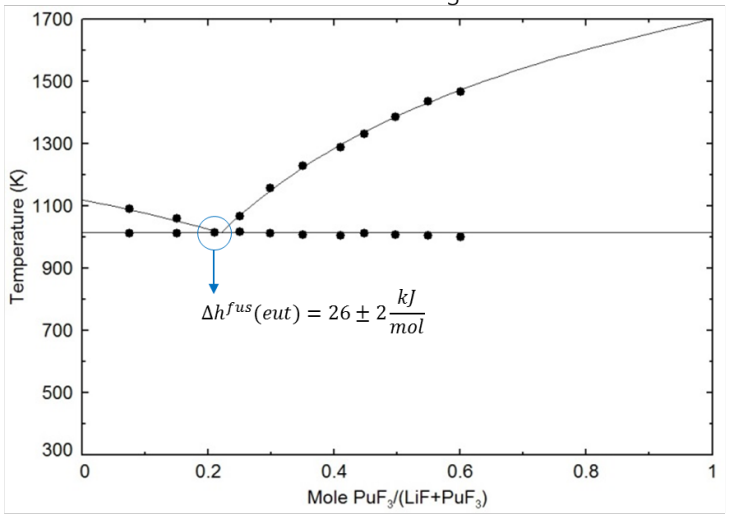
Highlights: Actinide fluorides synthesis



P. Souček, O. Beneš, A. Tosolin, R.J.M. Konings, *Chemistry of Molten Salt Reactor Fuel Salt Candidates*, Trans. Am. Nucl. Soc., 118 (2018) 114-117.

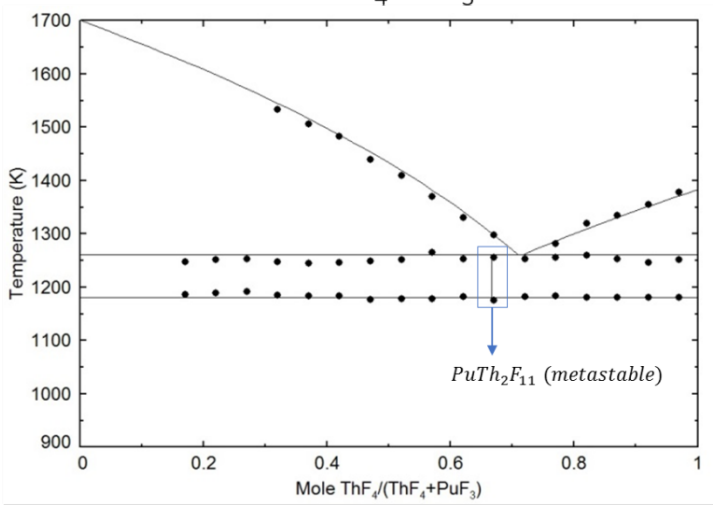
Highlights: New phase diagrams

LiF-PuF_3



A. Tosolin, P. Souček, O. Beneš, J.-F. Vigier, L. Luzzi, R.J.M. Konings, *Synthesis of plutonium trifluoride by hydro-fluorination and novel thermodynamic data for the PuF_3-LiF system*, J. Nucl. Mat. 503 (2018) 171-177.

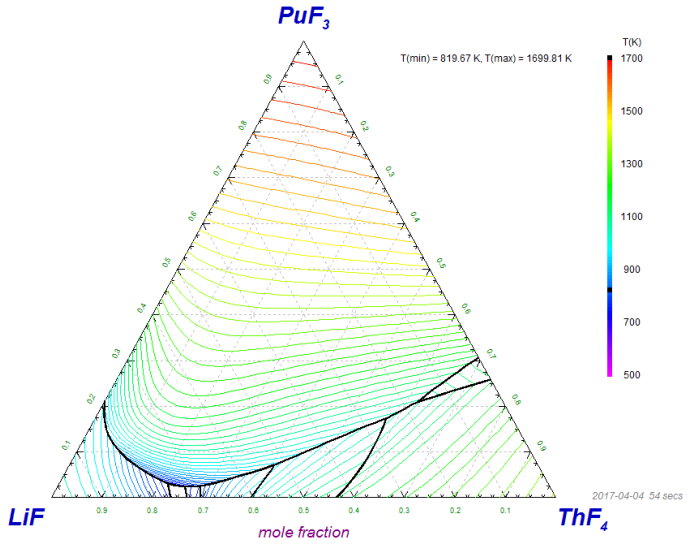
ThF_4-PuF_3



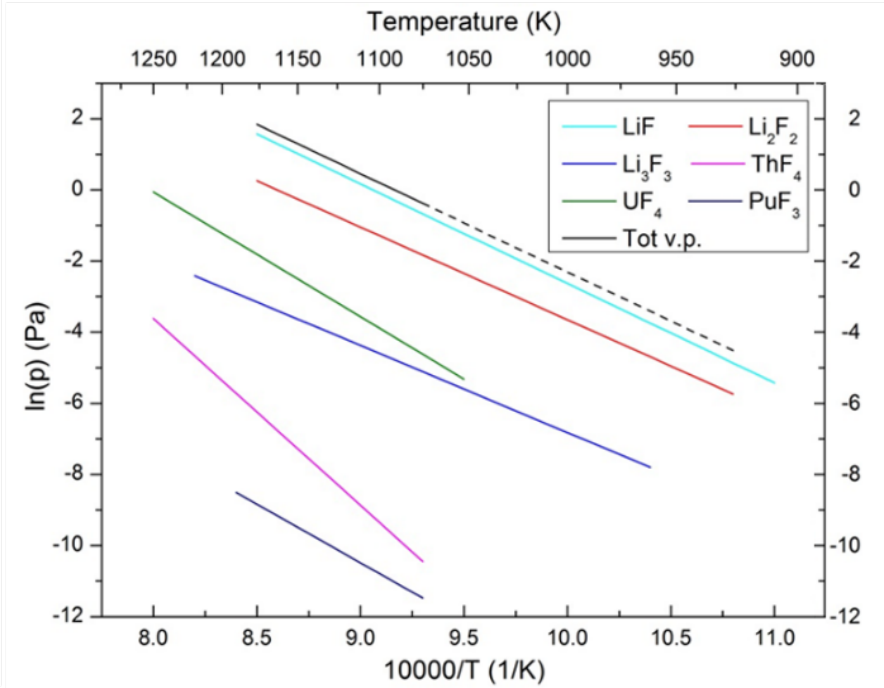
A. Tosolin, S. Mastromarino, J.-F. Vigier, L. Luzzi, R.J.M. Konings, **O. Beneš,** *Phase transitions in the ThF_4-PuF_3 system*, in preparation.

Improved thermodynamic database: JRCMSD

- fuel optimization
- properties prediction



Highlights: Properties of MSFR selected fuel compositions



$LiF-ThF_4-UF_4$
(77.5-20.0-2.5 mol%)

T_m (by DSC) = 828 ± 3 K

T_b = 2019 ± 10 K

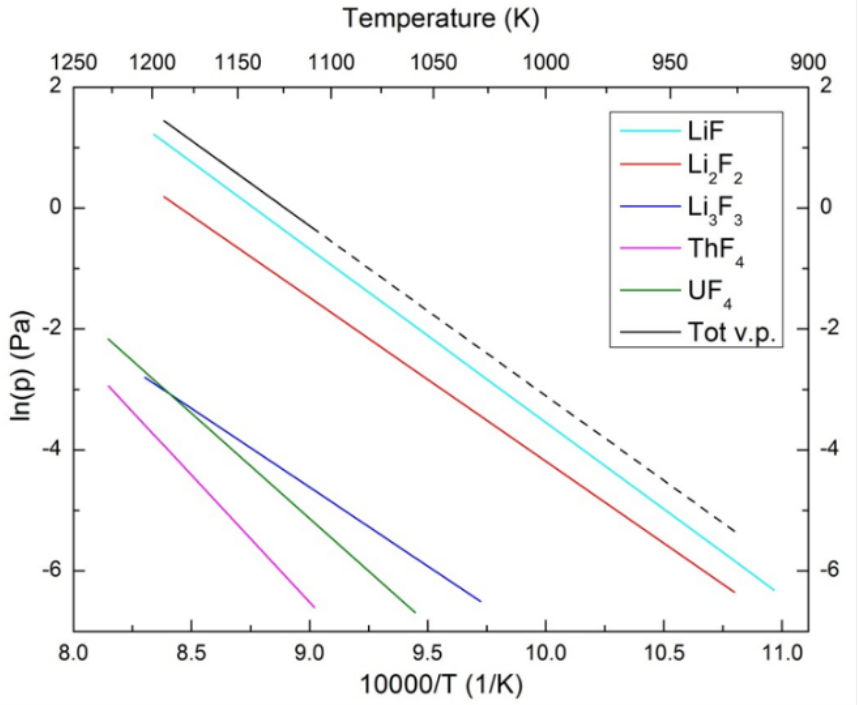
v.p. (1000 K) = 0.045 Pa ± 50%

$LiF-ThF_4-UF_4-PuF_3$
(77.5-6.6-12.3-3.6 mol%)

T_m (by DSC) = 893 ± 5 K

T_b = 1908 ± 10 K

v.p. (1000 K) = 0.099 Pa ± 50%

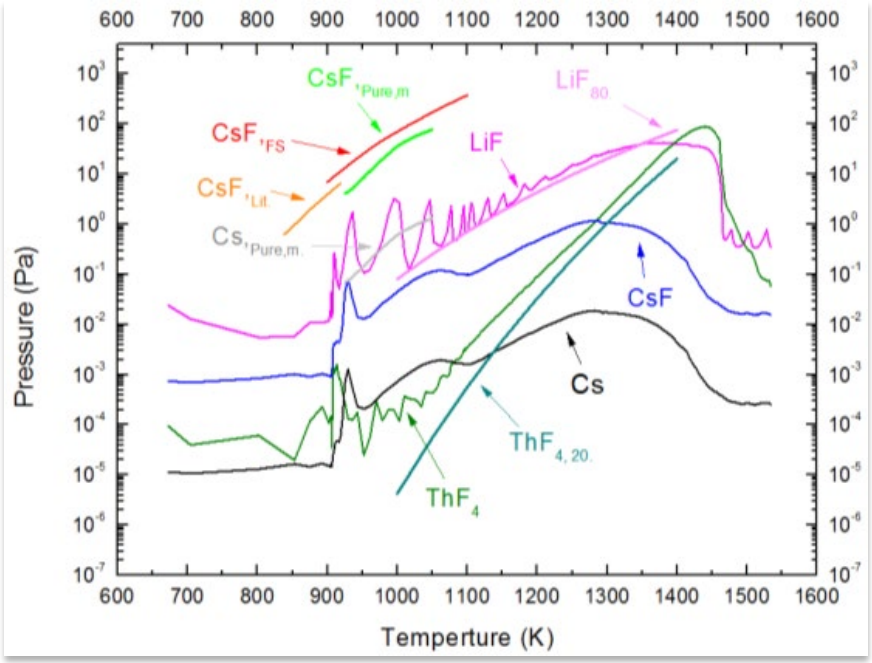


SAMOFAR

Highlights: Retention of Cs in the MSR fuel

- to demonstrate retention of FP in the fuel matrix
- to determine volatility of the fuel
- to determine thermodynamic stability
- to determine gas composition

CsF dissolved in LiF – ThF_4



CsF is one of the stable form of Cs-FP in the MSR fuel:

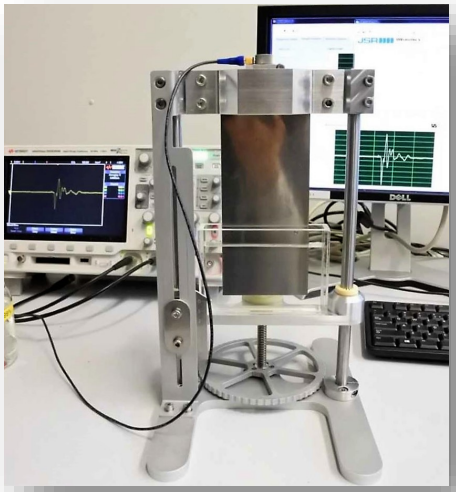
- $Cs \xrightarrow{\Delta G(F_2)\sim MSFR, T=900K} \mathrm{CsF}$

SAMOFAR

European Commission

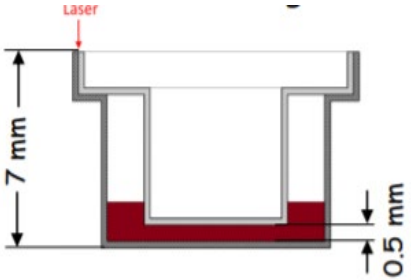
Highlights: Development of New Experimental techniques

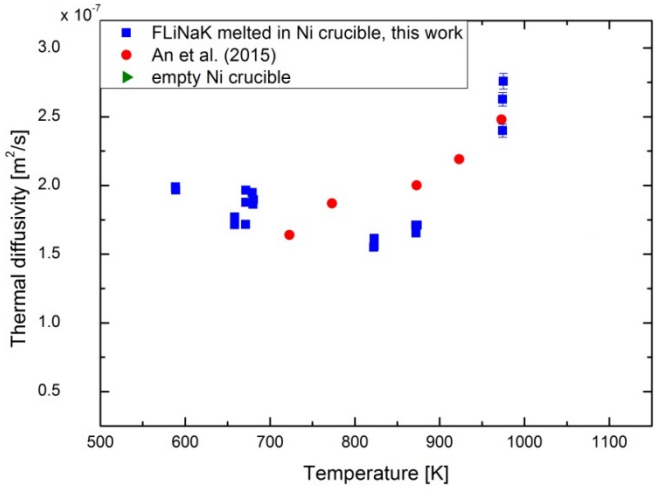
Viscosity



Fluid	T	Viscosity ultrasound	relative error to real value
	°C	mPa s	%
Water	26.3 ± 0.07	0.78 ± 0.03	0.26
	25.1 ± 0.07	0.85 ± 0.03	6.3
	25.3 ± 0.11	0.87 ± 0.02	6.7
96% Ethanol	26.3 ± 0.1	1.07 ± 0.01	–
	26.2 ± 0.04	1.19 ± 0.01	1.6
Oil	27.8 ± 0.24	42 ± 0.66	5.1
	27.8 ± 0.17	42.4 ± 0.43	6.1
Water/Glycerine 30/70 vol %	27.7 ± 0.07	20.6 ± 0.16	5.5
	26.8 ± 0.56	21.1 ± 0.9	4.6
ionic salt	27.4 ± 0.22	17.55 ± 0.43	22.5
	28.0 ± 0.11	16.88 ± 0.17	24.9

Thermal conductivity

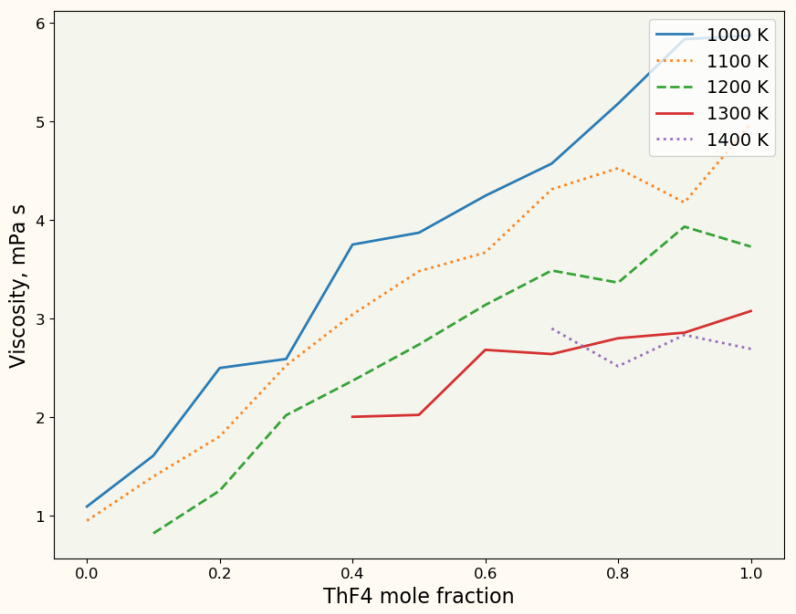




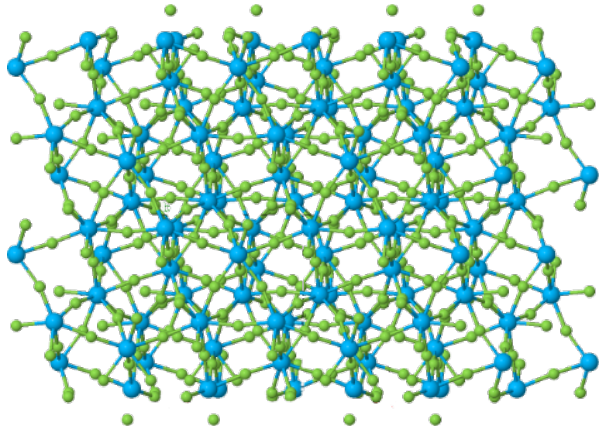
SAMOFAR

Highlights: Molecular Dynamics

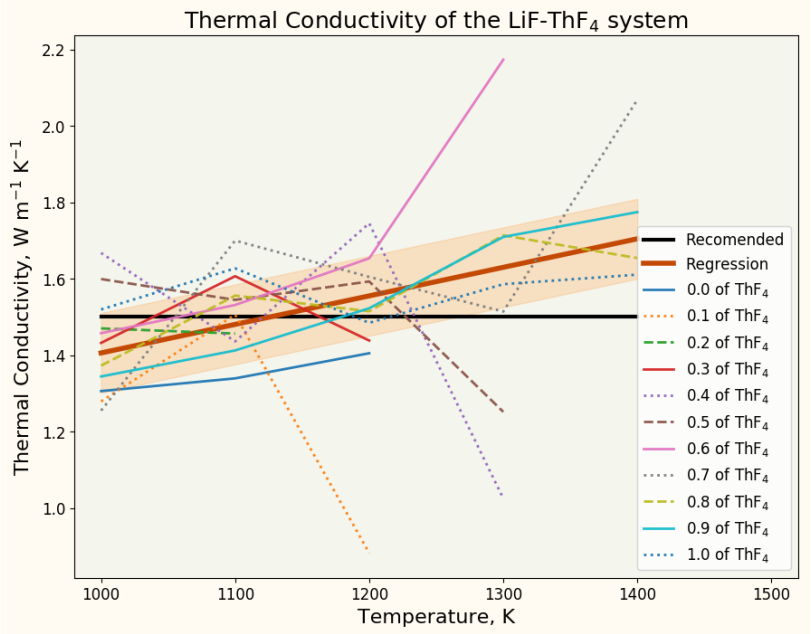
Calculated viscosity of LiF–ThF_4 system as a function of composition



Structure of ThF_4



Thermal conductivity of LiF–ThF_4 system as a function of temperature



PAUL SCHERRER INSTITUT

PSI

SAMOFAR

Total scientific output up to date:

- 2 / 2 Milestones Achieved
- 6 / 8 Deliverables Done
- 3 Peer review articles Published (2 by Alberto lead)
- 2 Papers in press – to be submitted within 1 month (2 Alberto lead, 2 Sara co-author)
- 3 Papers to be submitted by the end of 2019 (1 Alberto lead, 1 Sara lead)
- ... and of course 2 PhD students granted with great output and effort

Stay in touch

- EU Science Hub: ***ec.europa.eu/jrc***
- Twitter: ***@EU_ScienceHub***
- Facebook: ***EU Science Hub - Joint Research Centre***
- LinkedIn: ***Joint Research Centre***
- YouTube: ***EU Science Hub***

SAMOFAR

Task 2.1 – Thermodynamic data of salts

- Synthesis of UF_4, ThF_4 and PuF_3 done
- Re-evaluation of UF_4 melting point done

} → **Published in *JFC* 200 (2017) 3340**

- Phase diagram on LiF-PuF_3 done → **Published in *JNM 503 (2018) 171***
- ThF_4-PuF_3 is finalized (**Publication drafted** by Alberto, additional help by Sara)

Delivered (D2.1)

Task 2.2 – Thermal properties of salts

- viscometer under development – construction and testing ongoing
- heat capacity of ThF_4 and LiF-ThF_4 measured (interpretation phase) →

Publication in press(Alberto presentation)

- melting point determination of Option 1 (**Published in *JNM 508 (2018) 319***) and Option 2 **done** (Alberto & Sara presentation) (**Publication in press**),
- thermal conductivity – crucible design done with first tests on LiF (presentation Alberto)
- viscosity will follow
- MD simulations

Task 2.3 – Phase segregation of salts

- estimations of primary crystallization phases have been done for both fuel compositions
- final results done and **Delivered (D2.3)**

Task 2.4 – Thermal conductivity of solid crust

- Being developed and measured – according to plan. Tests on LiF and PuF_3 done (Sara presentation).

Task 2.5 – Salt interaction with water

- Measurements being performed at TUD with and W/O Co-source **Delivered (D2.5)**
  Publication in preparation

Task 2.6 – Retention properties of elements in the fuel salt

- KEMS measurements with LiF-UF_4-ThF_4 salts containing Cs and I done
- supported by Thermodynamic modelling – Done and **Delivered (D2.2), Publication in Preparation**
- Te study with respect to redox potential – done by CNRS and **Delivered (D2.4)**

Task 2.7 – Vaporization behaviour under accidental conditions

- KEMS measurements of Option 1 and 2 compositions **Delivered (D2.3)**
  (Option 1: Published in *JNM 508 (2018) 319*, Option 2: Paper in press)
(Alberto presentation)
- Aerosol particle distribution simulated with and without LiF influence **Delivered (D2.6)**