Molten Salt Reactor PROGRAM

Thermophysical Properties Database Development and Supporting Measurements

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Oak Ridge National Laboratory

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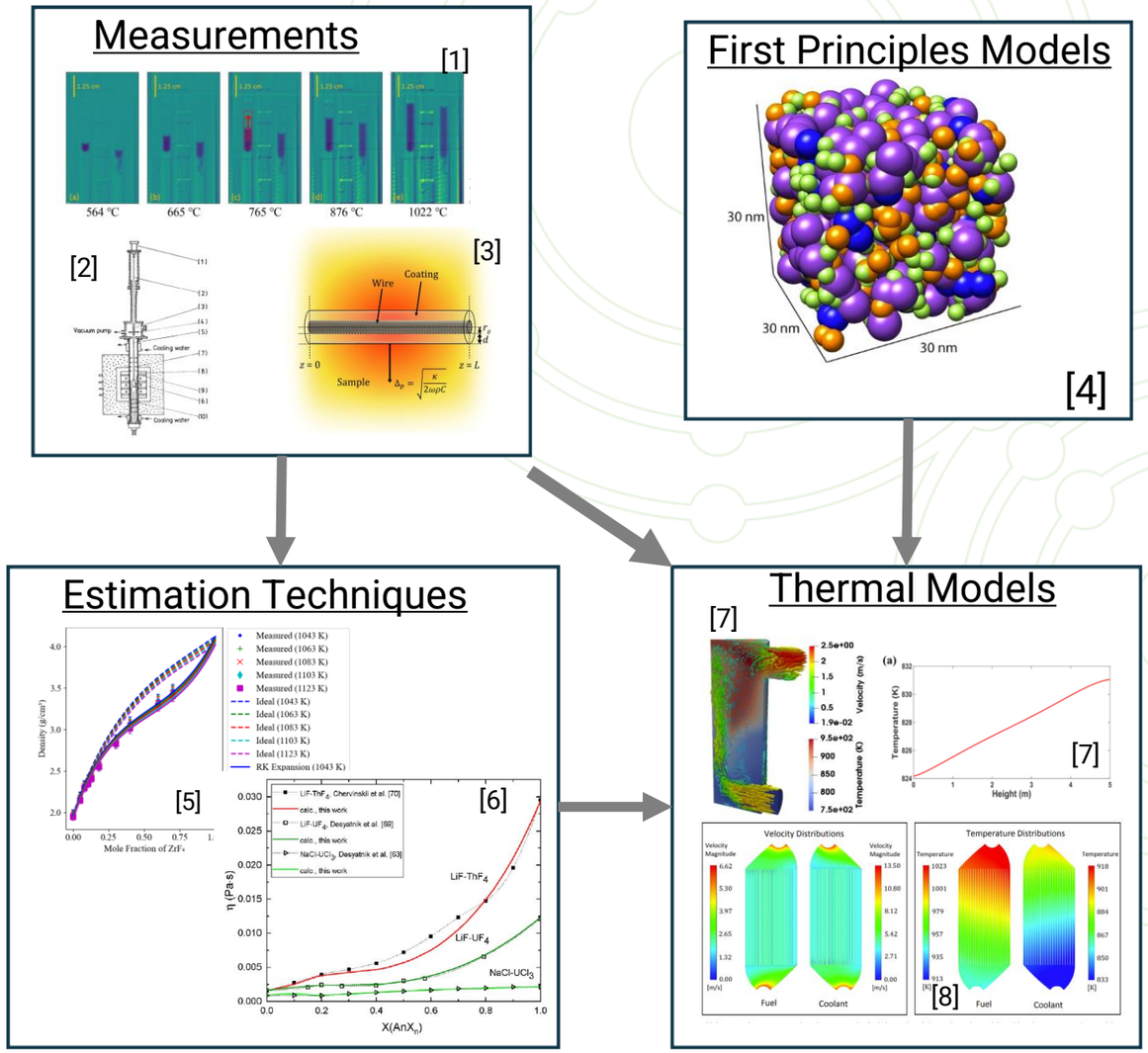
Motivation for Thermophysical Property Characterization

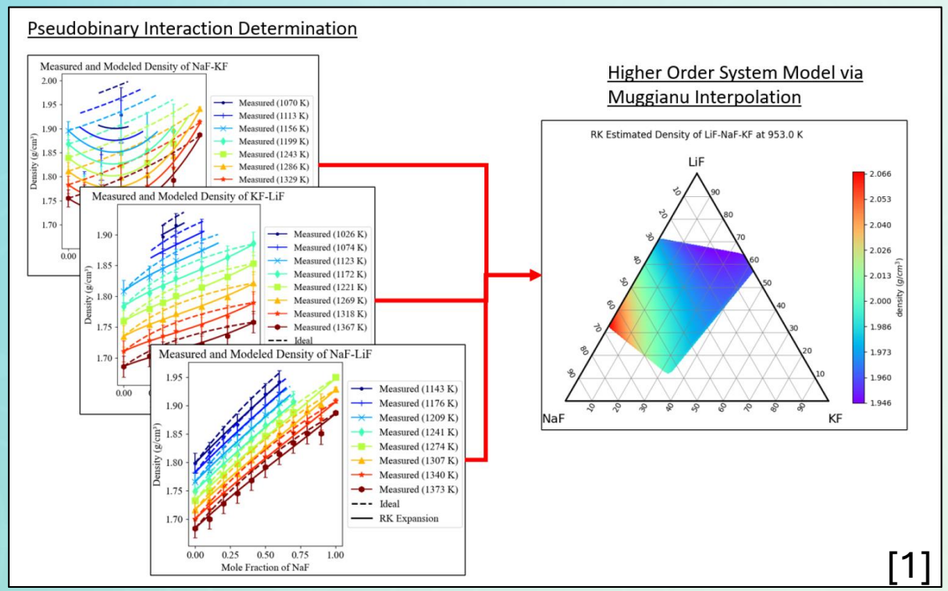
- The design, licensing, and operation of MSRs requires an accurate understanding of fuel and coolant salt thermophysical properties
  - There are a broad range of potential salt mixtures which have potential in MSRs
  - We still have limited understanding of certain properties for certain mixtures
- In order to address this challenge, we need:
  - Experiments to fill critical data gaps and target key mixtures of interest
  - AIMD to understand the relation to molecular structure
  - Predictive models to interpolate and extrapolate for rapid compositional characterization

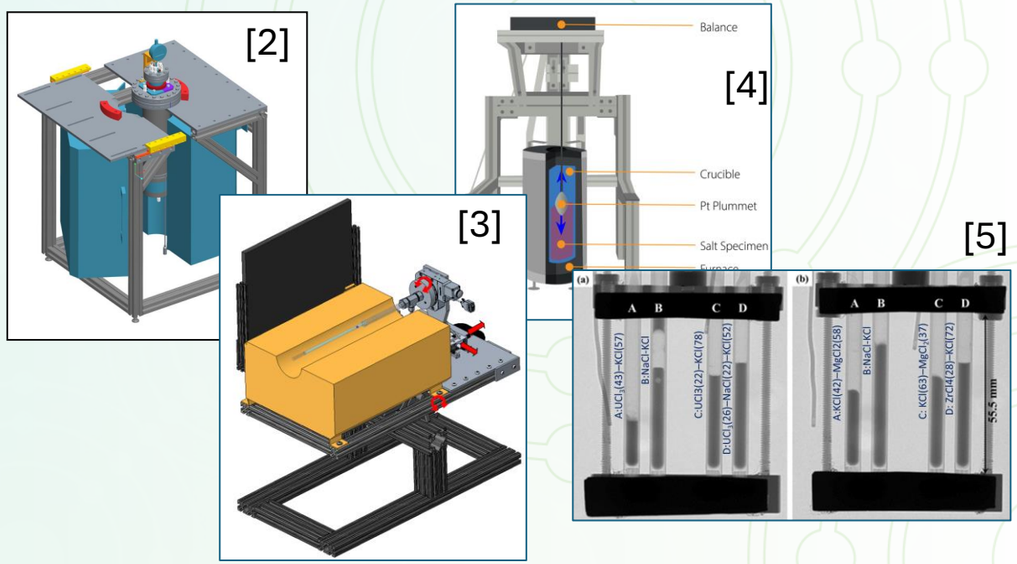


[1]:10.3390/jimaging7050088
[2]: 10.1039/F19807602531
[3]: 10.1021/acs.jced.0c00621
[4]: 10.1038/s42004-022-00684-6
[5]: 10.1016/j.ces.2022.117954
[6]: 10.1016/j.jnucmat.2022.153536
[7]:10.1016/j.nucengdes.2020.110826
[8]:10.1051/epjn/2019032

Overview of Thermophysical Characterization Efforts at ORNL

1. Experimental Measurements
2. Database Development
3. Predictive Modeling





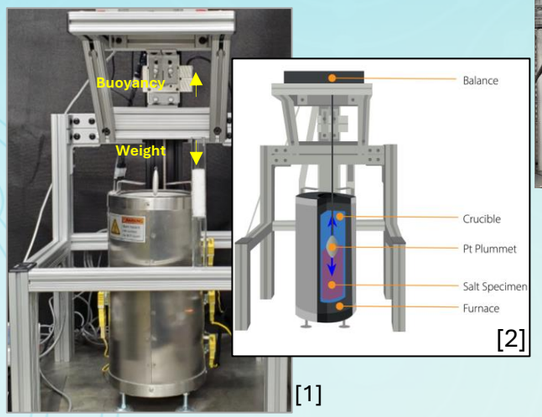
Formula	#	Molecular Weight	Composition (Mole %)	Melting T (K)	Uncertainty (K)	References	Boiling T (K)	Uncertainty (K)	References	Density
A + B*T(K) + C*T-2(K) + D*T2(K)"					Uncertainty (%)	References				
			A	B			A	B	C	D
AlCl3	1	133.3405	Pure Salt	465^	----	Kelley 1935 [74]	453s	----	Janz 1967 [66]	2.56E+00
BeCl2	2	79.9182	Pure Salt	688.2	McDonald 1965 [92]	760	----	Brewer 1963 [26]	2.28E+00	1.10E-03
BeF2	3	47.009	Pure Salt	821.2	3	Thoma 1960 [139]	1442	----	Cantor 1965 [31]	2.32E+00
CaCl2	4	110.984	Pure Salt	1045	10	Moore 1943 [96]	2230	30	Glushko 1972 [61]	2.53E+00
CaF2	5	78.0748	Pure Salt	1692	1	Mukerji 1965 [99]	2724	----	Ruff 1928 [123]	3.18E+00
GdCl3	6	263.609	Pure Salt	875	10	Dworkin 1971 [50]	1868	10	Glushko 1972 [61]	4.15E+00
GdF3	7	214.2452	Pure Salt	1505	3	Spedding 1974 [131]	2550	----	Landolt 2000 [87]	----
KCl	8	74.5513	Pure Salt	1042.7	0.5	Johnson 1958 [72]	1688	----	Ruff 1921 [124]	2.14E+00
KF	9	58.0967	Pure Salt	1131.2	0.5	Johnson 1958 [72]	1771	----	Ruff 1922 [125]	2.64E+00
LaCl3	10	245.2645	Pure Salt	1132	2	Keneshea 1961 [77]	1983	20	Glushko 1972 [61]	4.09E+00
LaF3	11	195.9007	Pure Salt	1766	3	Spedding 1971 [132]	2600	----	Janz 1967 [66]	5.79E+00
LiCl	12	42.394	Pure Salt	883	5	Haendler 1959 [62]	1655	----	Wartenberg 1921 [145]	1.88E+00
LiF	13	25.9394	Pure Salt	1121.2	1	Douglas 1954 [47]	1943	----	Ruff 1922 [125]	2.37E+00
MgCl2	14	95.211	Pure Salt	987	1	Moore 1943 [96]	1640	20	Glushko 1972 [61]	1.97E+00
MgF2	15	62.3018	Pure Salt	1534.2	2	Kojima 1968 [83]	2512	----	Ruff 1928 [123]	3.24E+00
NaCl	16	58.4428	Pure Salt	1073.8	1	Dawson 1963 [44]	1715	----	Ruff 1921 [124]	2.14E+00
NaF	17	41.9882	Pure Salt	1268.2	Cantor 1961 [30]	1978	----	Ruff 1922 [125]	2.70E+00	5.90E-04
NdCl3	18	250.599	Pure Salt	1031	2	Druding 1961 [49]	1897	10	Glushko 1972 [61]	4.26E+00
NdF3	19	201.2352	Pure Salt	1650	3	Spedding 1971 [132]	2573	----	Knacke 1991 [82]	----
NpCl3	20	343.359	Pure Salt	1075	30	Lemire 2001 [89]	1800	----	Barin 1977 [8]	----
NpF3	21	293.9952	Pure Salt	1735	30	Lemire 2001 [89]	2500	----	Barin 1977 [8]	----
PuCl3	22	350.359	Pure Salt	1040	2	Bjorklund 1959 [13]	2063	----	Barin 1977 [8]	----
PuF3	23	300.9952	Pure Salt	1699	2	Westrum 1951 [147]	2493	----	Barin 1977 [8]	----
SrCl2	24	158.526	Pure Salt	1146	2	Dworkin 1963 [52]	2310	50	Glushko 1972 [61]	3.39E+00
SrF2	25	125.6168	Pure Salt	1746	5	Kojima 1968 [83]	2762	----	Ruff 1928 [123]	4.78E+00
ThCl4	26	373.8501	Pure Salt	1043	2	Fischer 1939 [57]	1195	----	Fischer 1939 [57]	4.82E+00

[1] ORNL/TM-2023/2955
[2] Gallagher et. al, J. Chem. Eng. Data 2022, 67, 6, 1406–1414
[3] Birri et al. (2023). TSEP, 44, 102029.
[4] ORNL/TM-2020/1633
[5] Moon et al., Ind. Eng. Chem. Res. 2022, 61, 17665−17673

Thermophysical Property Measurement Capabilities at ORNL

Density

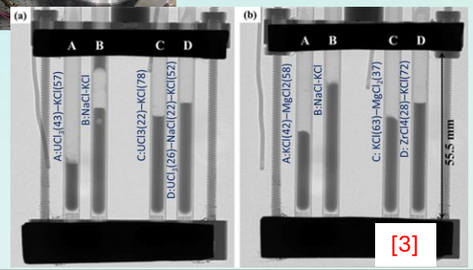
Archimedean Method



[1]

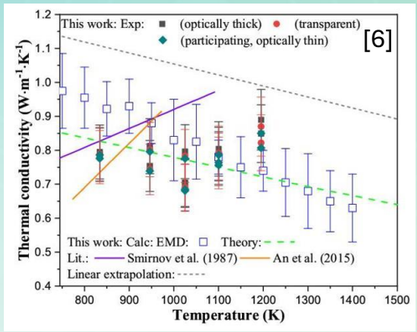
[2]

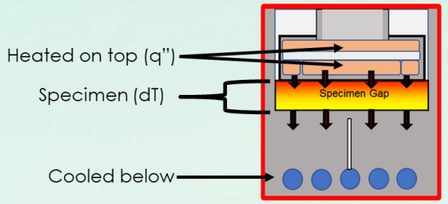
Neutron Radiography Method

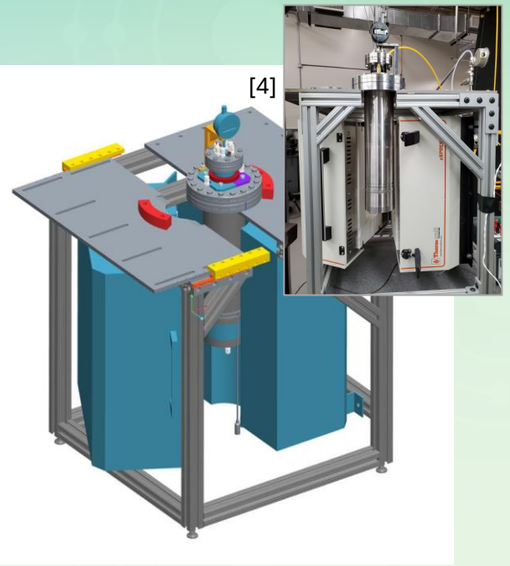


[3]

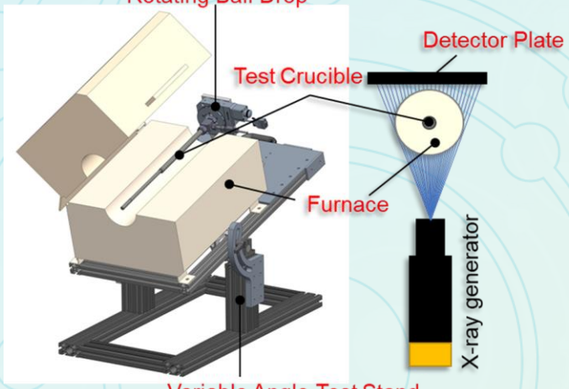
Thermal Conductivity





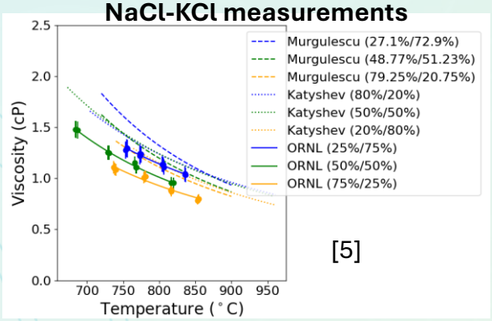


Viscosity

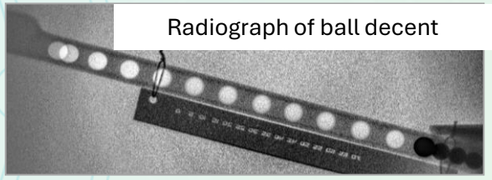


[4]

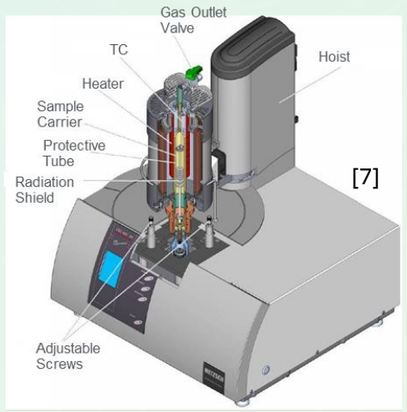
NaCl-KCl measurements



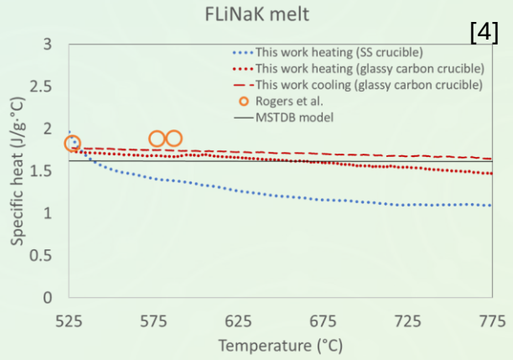
[5]



Specific Heat



[7]



[1] ORNL/TM-2020/1633
[2] Gallagher et. al, J. Chem. Eng. Data 2022, 67, 6, 1406–1414
[3] Moon et al., Ind. Eng. Chem. Res. 2022, 61, 17665–17673
[4] ORNL/TM-2021/2216
[5] ORNL/TM-2023/3048
[6] Gallagher et al., J. Mol. Liq., 2022, 361, 119151
[7] Netzch DSC 404 F3 Pegasus Manual

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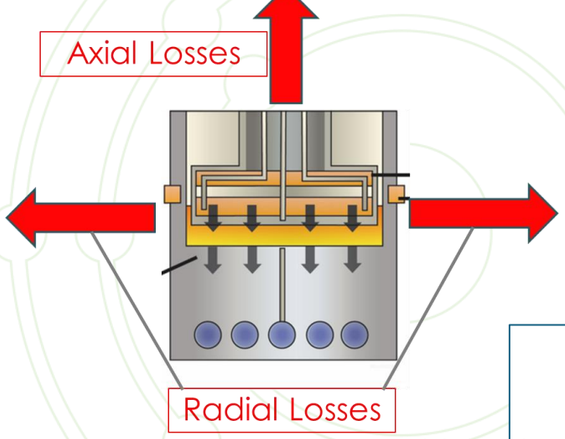
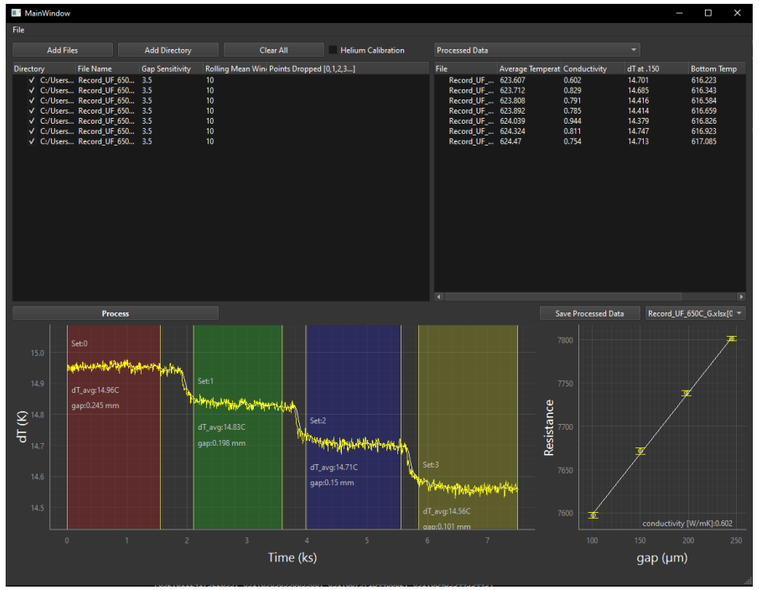
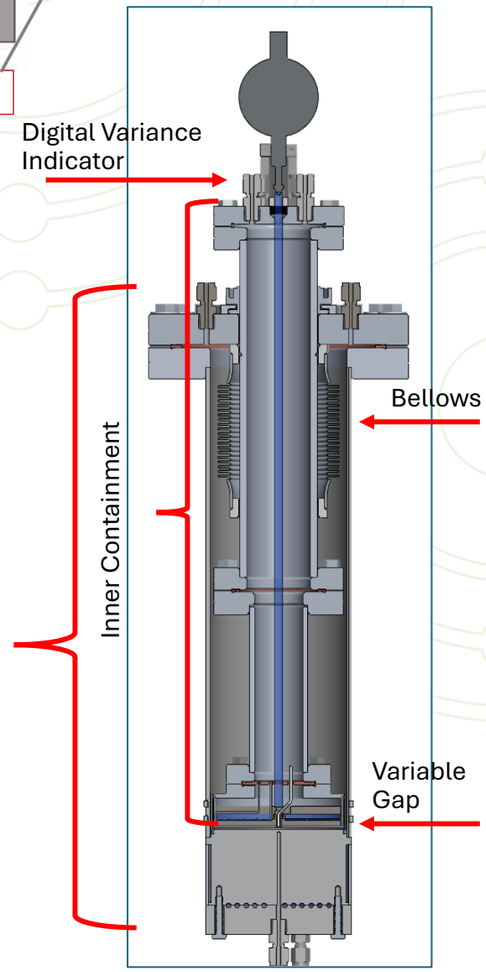
Variable Gap Thermal Conductivity System Status

- The variable gap system is a direct measurement of thermal conductivity based on driven heat flux through the sample
- Our system is compatible with fluorides, and chlorides, with and without actinides
  - Not currently set up for Be
- Calibration process with He to establish true heat flux versus temperature difference
- Consistently shown good agreement with other experiments and models for various salts
- Automated data processing software, GUI for data analysis





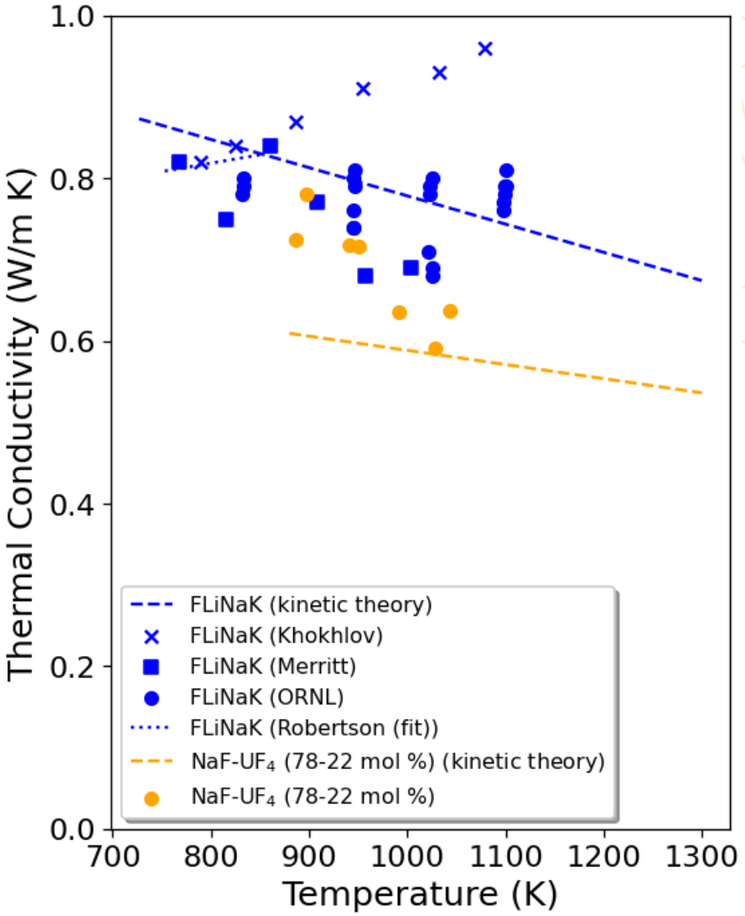


Past and Ongoing Thermal Conductivity Measurements

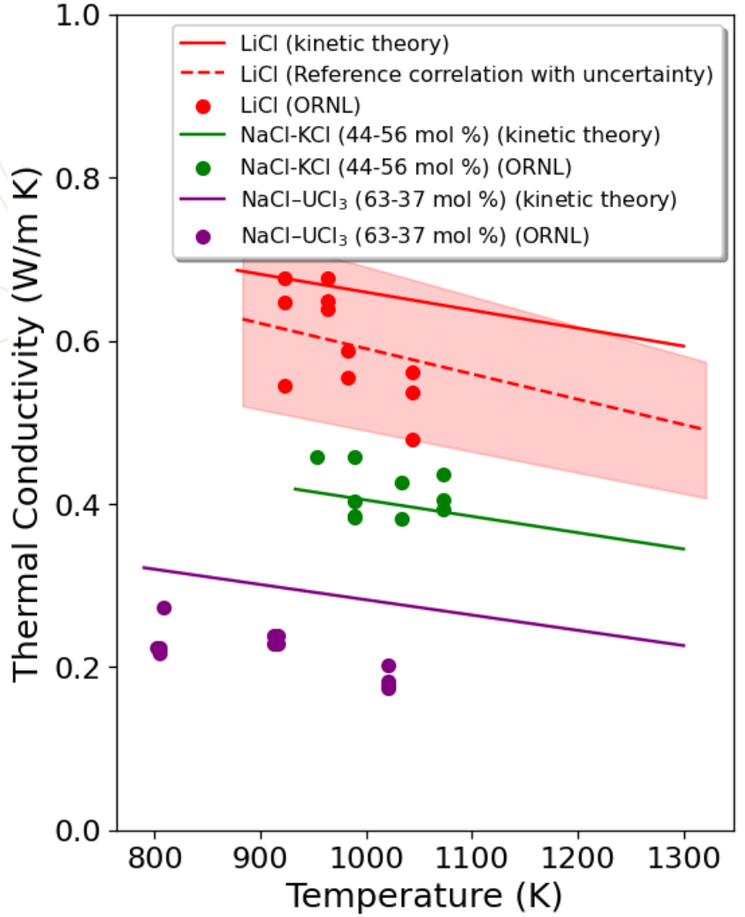
- We have measured several alkali halide systems:
  - NaCl-KCl (44-56 mol %) [1]
  - FLiNaK [2] (compared against [3,4,5]
  - LiCl [1] for benchmarking with JPCRD [6]
- We have also measured actinide halide systems:
  - NaCl-UCl_3 (63-37 mol %) [1]
  - NaF-UF_4
- We are planning to measure soon:
  - NaCl-UCl_3 (63-37 mol %) + surrogate FPs
  - NaF-KF-UF_4

Comparisons of measurements with other studies and theory

Fluorides



Chlorides



[1] ORNL/TM-2024/3650
[2] Gallagher et. al, J. Chem. Eng. Data (2022). 67(10), 1406–1414
[3] Khokhlov et. al, J. Nuc. Mat. 2011, 410(1-3), 32—38
[4] Merritt et. al, Int. J. Thermophys. (2022). 43(10),149
[5] Robertson et. al, J. Appl. Phys. (2022). 131(22), 225102
[6] Chliatzou et al. (2018). JPCRD, 47(3), 033104

Molten Salt Reactor PROGRAM

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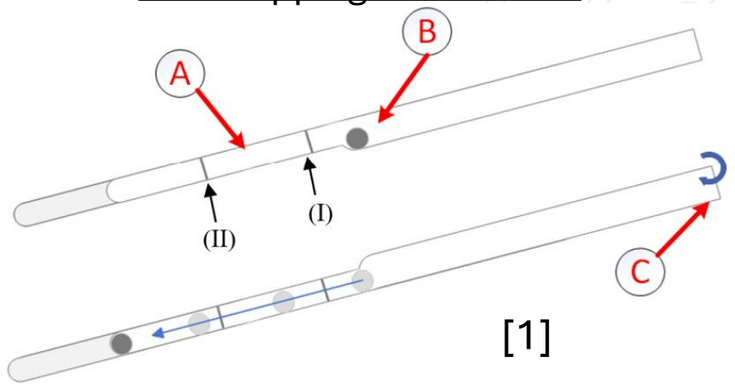
Rolling Ball Viscometer Development Status

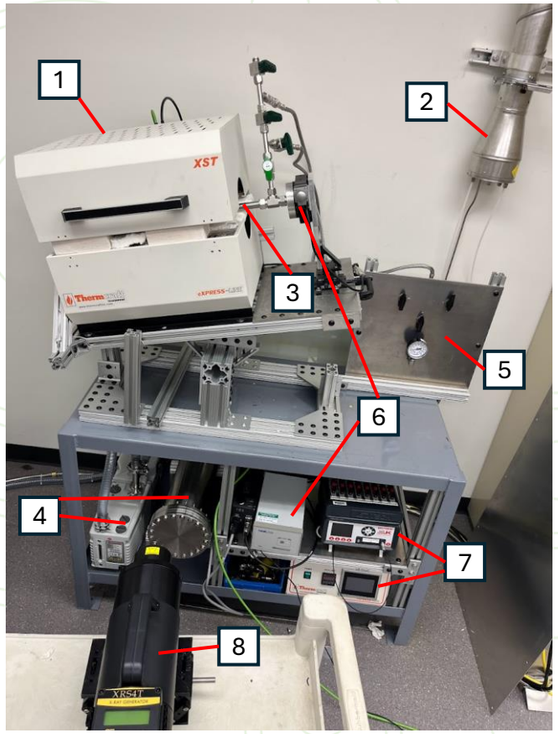
- Based on the terminal velocity of a ball rolling through the molten salt
  - Calibrated with various NIST standard oils and different ball dimensions
- Can make measurements with glass and steel alloys
  - Working to improve accuracy of measurements in steel
- Automated systems for calibration and x-ray triggering
- Our system is compatible with fluorides, and chlorides, with and without actinides

Ball dropping mechanism



[1]

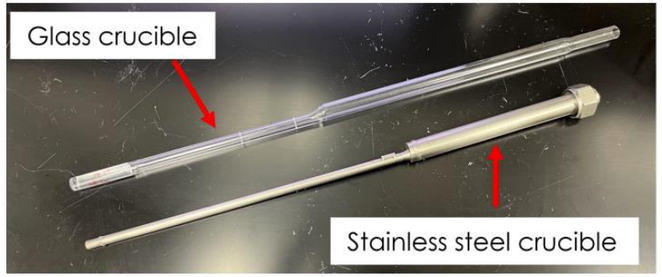
(A) the measurement section
(B) The loading section
(C) Connection to the rotational stage



1. Furnace
2. Ventilation
3. Crucible
4. Backfill/ pressure maintenance system
5. Gas control
6. Rotation control
7. Heating/temperature control
8. X-ray system (detector behind furnace

[1]

Automated calibration system

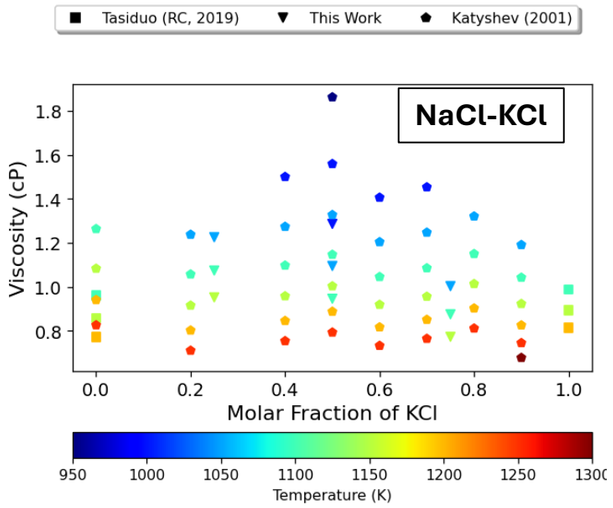


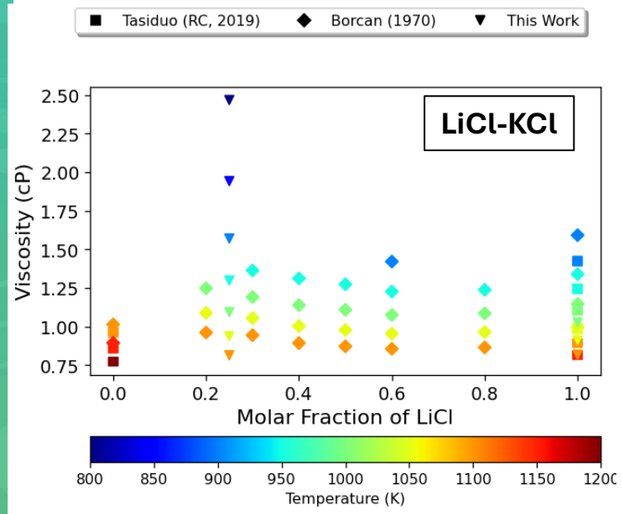
[1] ORNL/TM-2024/3650

Past and Ongoing Viscosity Measurements

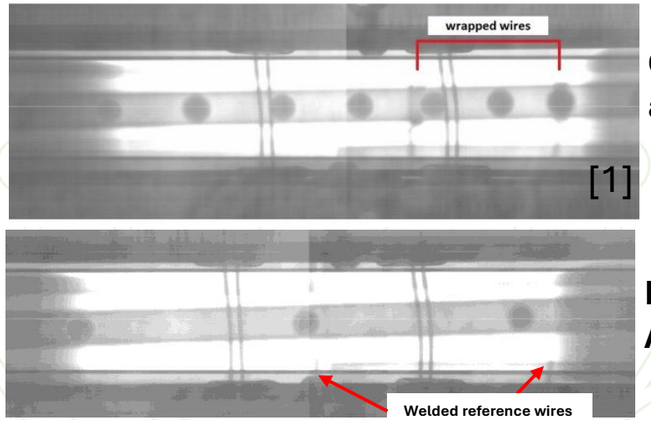
- We have measured several alkali chlorides:
  - LiCl for benchmarking in glass and stainless steel
  - Several system and subsystem measurements of LiCl-KCl-NaCl (compared against [2,3])
- We have also measured $NaCl-UCl_3$ (compared against [3])
- Planning to measure
  - $NaCl-UCl_3$ once more
  - $NaCl-UCl_3$ with surrogate FPs
  - $NaF-UF_4$

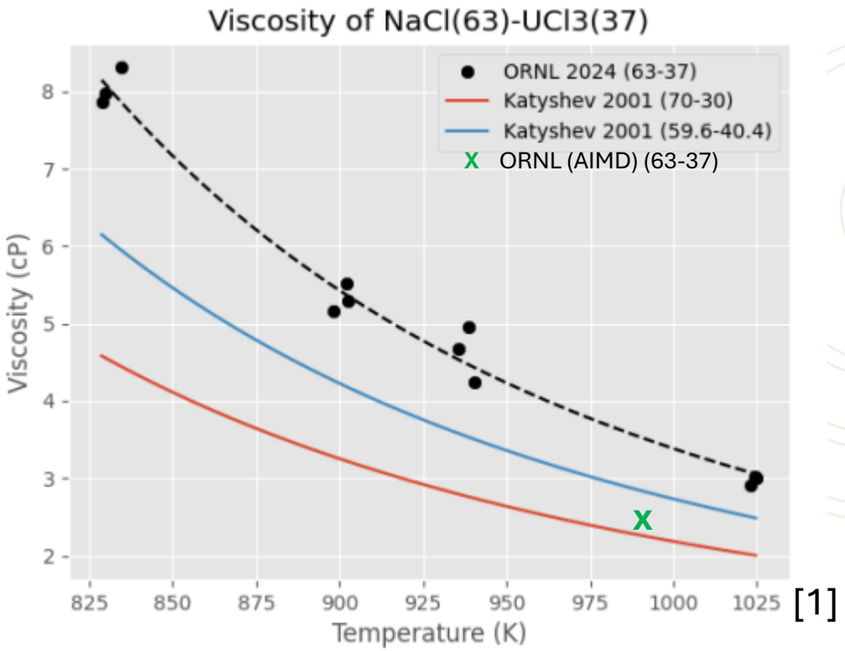
Alkali Chloride Measurements





X-ray measurement in salt





[1]

[1] ORNL/TM-2024/3650
[2] Zuca S. & Borcan R., Revue Roumaine de Chimie (1970), 15, 1681-1688
[3] Katyshev, S.F. (2001) Doctoral Thesis.

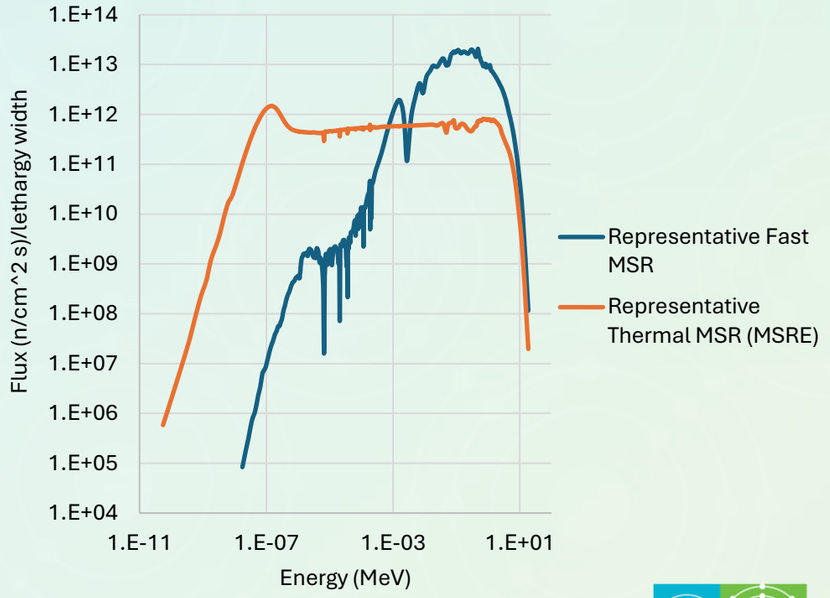
Ongoing Study of Surrogate Fission Products Effect on Transport Properties

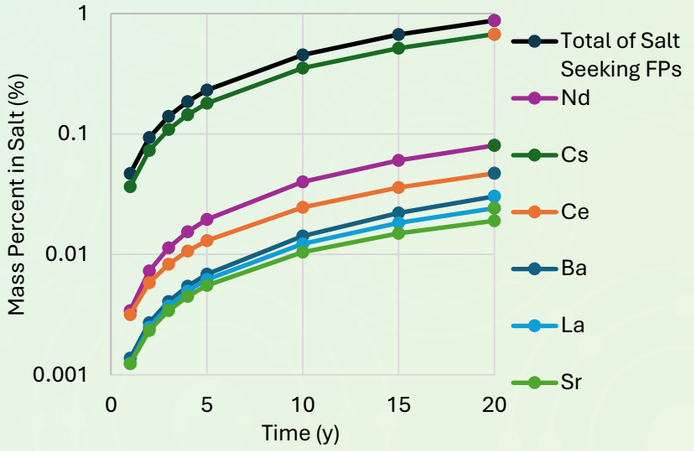
- Need to understand how fission products will affect thermophysical properties
- We are considering a high-burnup case
- Considering NaCl-UCl_3 this FY
  - Simultaneously running calculations for NaF-UF_4
- Can input respective fast/thermal fluxes into ORIGEN to calculate FP inventories
  - Only looking at salt seekers
  - This is a simplified assumption because it ignores removal terms

Major FPs [1]

Salt seekers	Noble gases	Noble metals
RE's (Nd, Ce, La, Pr)	Xe	Ru
Zr	Kr	Pd
Cs	He	Rh
Ba		Mo*
Sr		Tc*
Pu		
Cr		
Fe		
Ni		
Mo*		
Tc*		

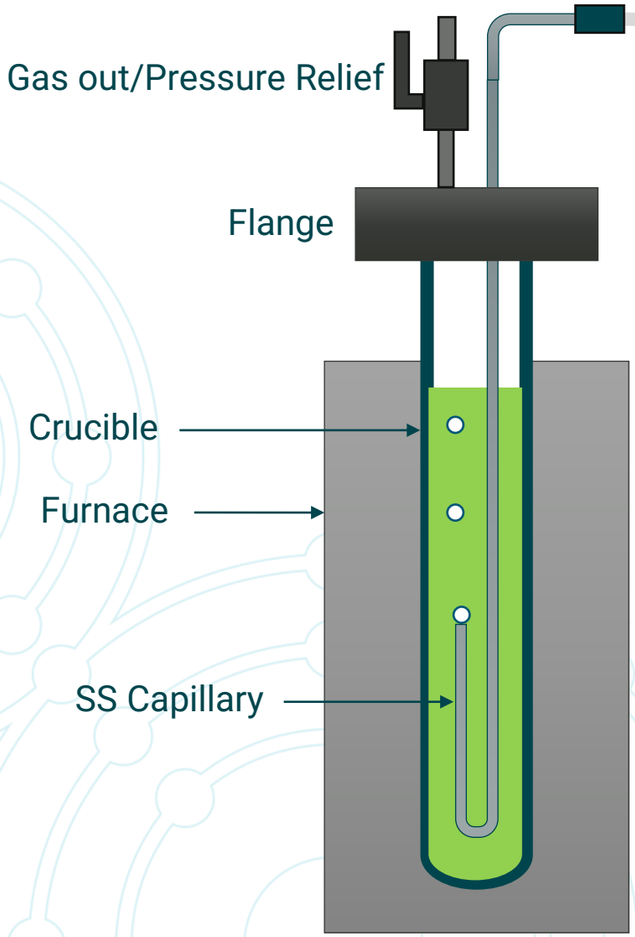
*Expected to behave as noble metals

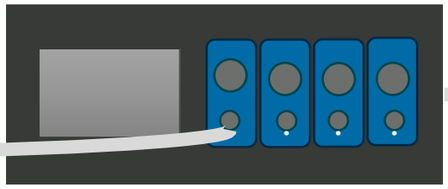


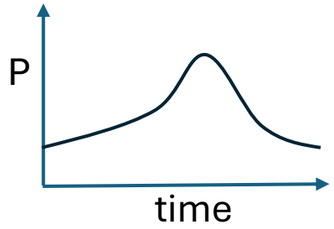


[1] ORNL/SPR-2020/1865
[2] Wargon et. al (2023). Representative Neutronics Models of MCFR Reactors
[3] Hartanto et. al (2024). PHYSOR 2024, 2058-2067

Surface Tension Measurement System Development







The surface tension, γ, can be obtained from the measured bubble pressure and radius

$$P_{st} = \frac{2\gamma}{r_{in}}$$

Air – Water
Capillary: 0.3 mm ID

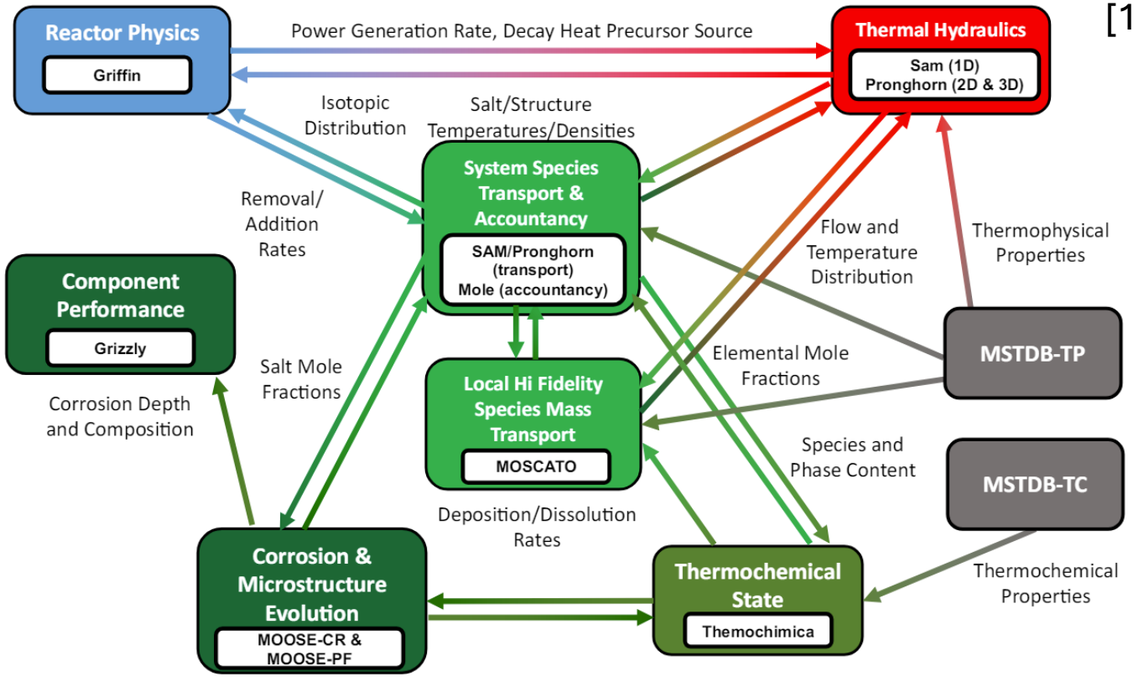
Experimental Plan

1. Test system in water - Observe bubble formation visually and compare to pressure transducer output.
2. Measure surface tension of nitrate and/or chloride salts.
3. Measure surface tension of fluoride salts.

What is MSTDB?

- The Molten Salt Thermal Properties Database–Thermochemical (MSTDB-TC) and Molten Salt Thermal Properties Database–Thermophysical (MSTDB-TP) databases are available via the ORNL/ITSD Gitlab Server.
  - MSTDB-TC contains Gibbs energy models and values for molten salt components and related systems of interest with respect to molten salt reactor technology.
  - MSTDB-TP consists of tabulated thermophysical properties and relations for computing properties as a function of temperature or composition.
- MSTDB has >320 users currently

[1]



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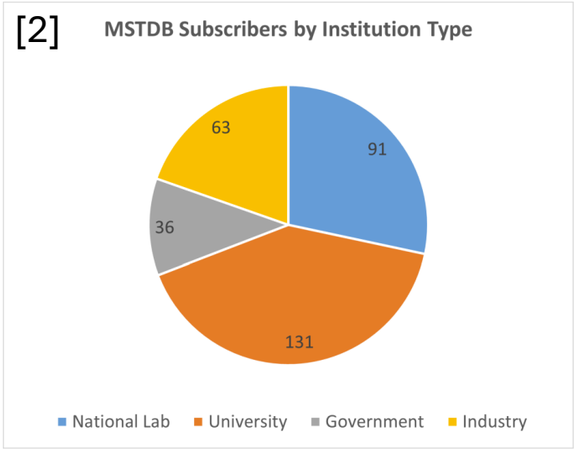

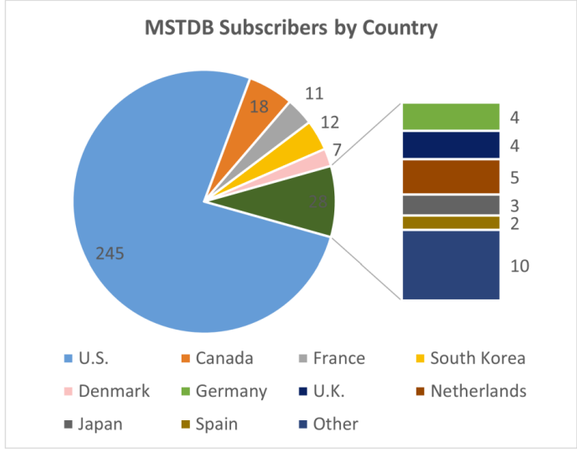

OAK RIDGE National Laboratory

UNIVERSITY OF South Carolina

NEAMS

Molten Salt Reactor PROGRAM

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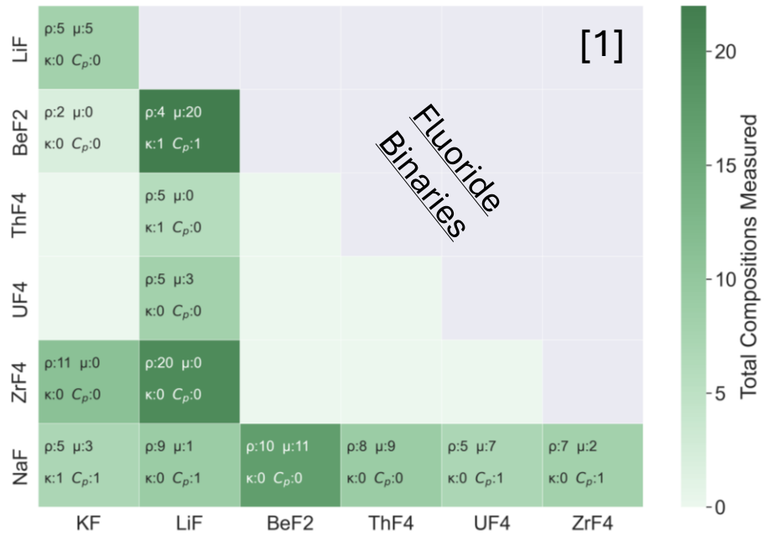
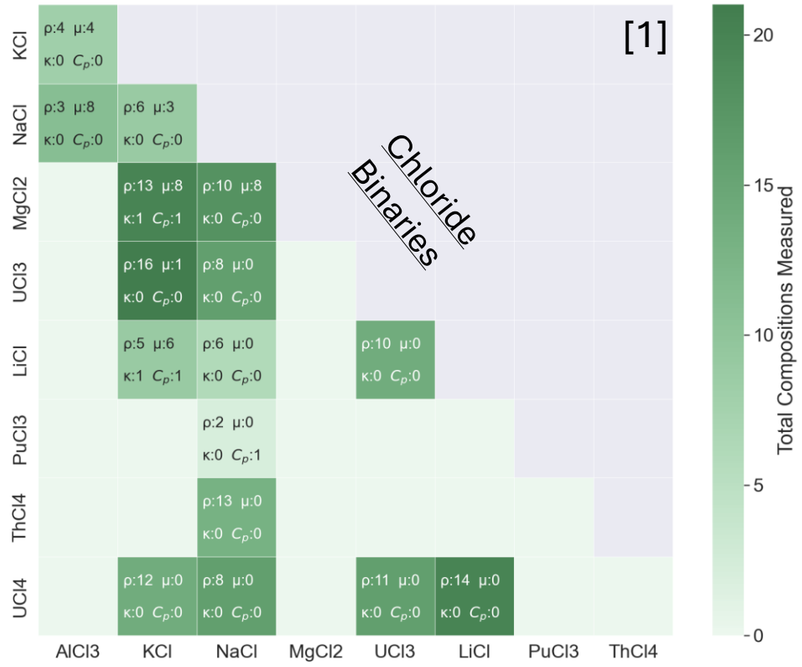
[1] INL/RPT-22-70694
[2] ORNL/TM-2024/3575

Current State of MSTDB-TP

- As per the current version release (**3.1**) There are **820 entries**, including:
  - 33 pure compounds
  - 380 pseudo-binaries
  - 395 pseudo-ternaries
  - 12 pseudo-quaternaries
- Each property entry in the database includes a margin of experimental error
  - This list is constantly expanding. The data is based on the outputs of 180+ independent experimental studies in literature.





Pure Compounds

Salt	Measurements			
	ρ	μ	κ	c_p
AlCl3	1	1	0	1
BeCl2	1	0	0	0
BeF2	1	1	1	1
CaCl2	1	1	1	1
CaF2	1	1	1	1
GdCl3	1	1	0	0
GdF3	0	0	0	0
KCl	1	1	1	1
KF	1	0	1	1
LaCl3	1	1	0	0
LaF3	1	0	0	1
LiCl	1	1	1	1
LiF	1	1	1	1
MgCl2	1	1	1	1
MgF2	1	1	1	0
NaCl	1	1	1	1
NaF	1	0	1	1
NdCl3	1	1	0	0
NdF3	0	0	0	1
NpCl3	0	0	0	0
NpF3	0	0	0	0
PuCl3	0	0	0	1
PuF3	0	0	0	1
SrCl2	1	1	1	0
SrF2	1	1	1	0
ThCl4	1	0	0	0
ThF4	1	0	0	0
UCl3	1	1	0	1
UCl4	1	1	0	0
UF3	0	0	0	1
UF4	1	1	0	1
ZrCl4	1	1	0	0
ZrF4	1	0	0	0

Ternaries

Salt	Measurements			
	ρ	μ	κ	c_p
KCl-LiCl-NaCl	4	0	0	0
KCl-LiCl-UCl3	18	0	0	0
KCl-LiCl-UCl4	18	0	0	0
KCl-NaCl-UCl3	18	0	0	0
KCl-UCl3-UCl4	32	0	0	0
AlCl3-LiCl-NaCl	10	10	0	0
LiCl-UCl3-UCl4	21	0	0	0
BeF2-LiF-ThF4	3	2	0	0
BeF2-LiF-ZrF4	1	0	0	0
BeF2-LiF-NaF	5	4	0	5
KF-LiF-NaF	1	1	1	1
LiF-NaF-ZrF4	11	2	2	2
BeF2-LiF-UF4	36	38	2	0
LiF-ThF4-UF4	1	0	0	0
KCl-MgCl2-NaCl	1	1	1	1
LiCl-NaCl-UCl3	18	0	0	0
LiCl-NaCl-UCl4	18	0	0	0
NaCl-UCl3-UCl4	26	0	0	0
BeF2-NaF-UF4	79	71	0	0
BeF2-KF-NaF	1	1	0	1
KF-MgF2-NaF	1	0	1	1
KF-NaF-UF4	3	1	0	2
KF-NaF-ZrF4	1	1	0	1
NaF-UF4-ZrF4	5	4	0	6
RbF-UF4-ZrF4	2	2	0	2

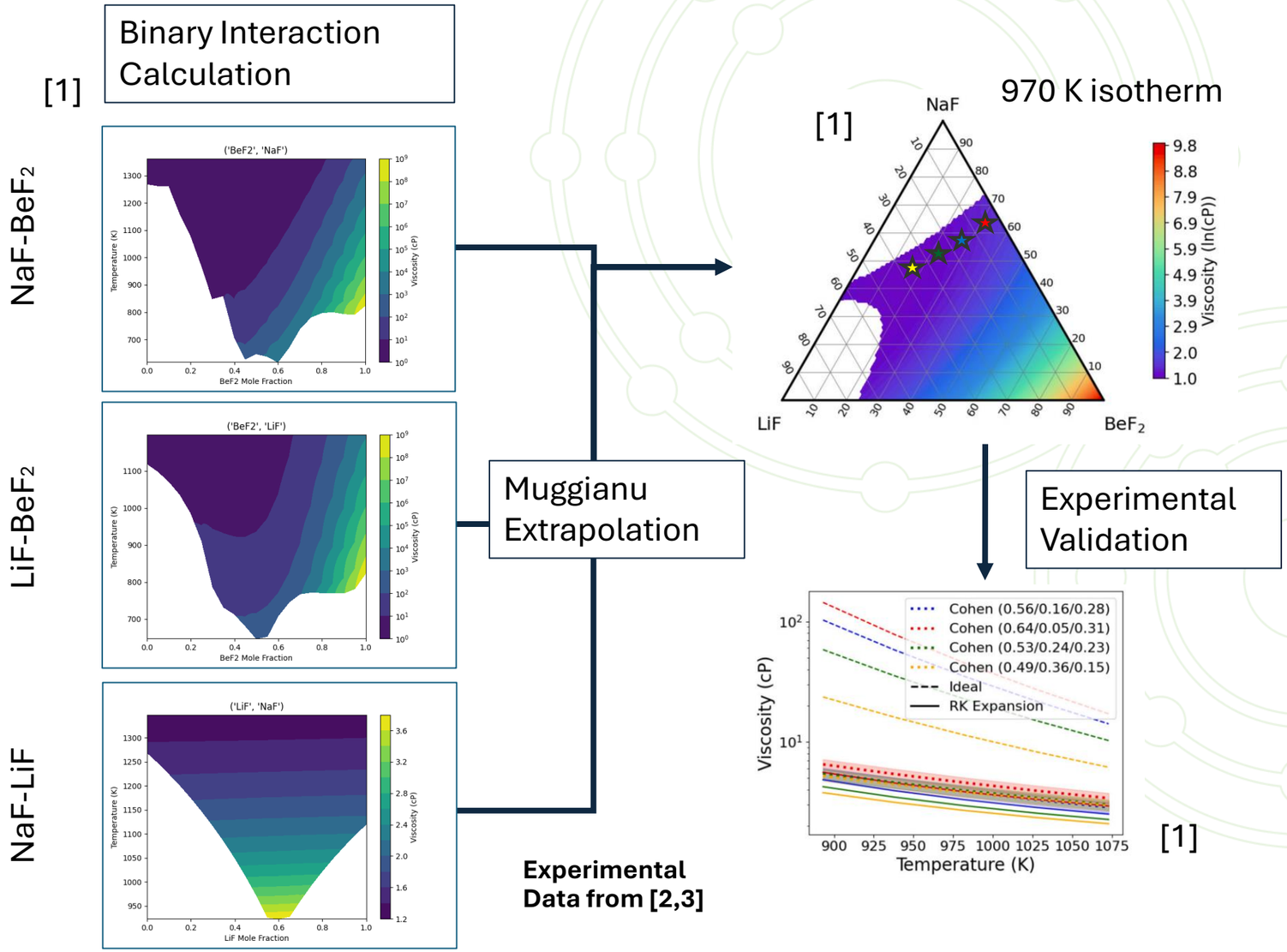
Quaternaries

Salt	Measurements			
	ρ	μ	κ	c_p
BeF2-LiF-ThF4-UF4	1	1	1	1
BeF2-LiF-UF4-ZrF4	1	0	1	0
BeF2-NaF-UF4-ZrF4	1	0	0	0
BeF2-LiF-NaF-UF4	1	1	0	1
KF-LiF-NaF-UF4	2	2	0	2
LiF-NaF-UF4-ZrF4	1	1	0	2
KF-NaF-UF4-ZrF4	0	0	0	2

[1] ORNL/TM-2024/3575

Predictive Modeling with Redlich-Kister

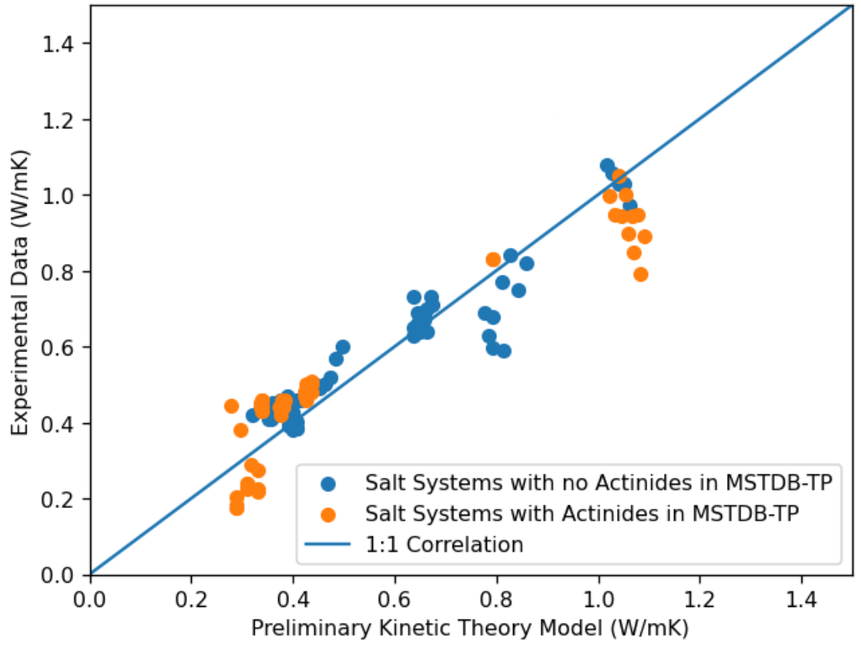
- In order to address gaps in the database, predictive modeling with the RK methodology can yield estimates
  - This method has been developed for density and viscosity [1,4,5]
- This formalism uses experimental data in MSTDB-TP to define non-ideal binary interaction parameters
  - These can be used to interpolate or extrapolate
  - Extensible to arbitrarily sized mixtures
  - Both Saline and the GUI have estimation tools built into them



[1] Birri, A., Termini, N., & Ezell, N. D. B. (2024). *Chem. Eng. Sci.*, *298*, 120391.
[2] Blanke, B. C. et al. (1958). MLM-1079
[3] Cohen, S.I., & Jones, T.N. (1957). ORNL-2278.
[4] Agca, C., & McMurray, J. W. (2022). Chem. Eng. Sci., 247, 117086
[5] Birri, A., Gallagher, R., Agca, C., McMurray, J., & Ezell, N. D. B. (2022). Chem. Eng. Sci., 260, 117954.

The Difficult Case of Thermal Conductivity Prediction…

- We need a more fundamental model for thermal conductivity prediction
  - Too little data to support RK, many endmembers uncharacterized
- Kinetic theory models have been shown to work well for alkali halides [1,2,3]
  - Modifications to deal with complexation in alkaline earth bearing melts
- Still, actinides are problematic
  - Large molar mass throws off the model
  - Collaborating with BYU to identify a strategy



Preliminary General Formalism

$$\kappa = K(1-\delta)k_B\left(\frac{N_A n}{V(T_m)}\right)C_0(T_m)\left(1-\alpha(T_m)\left(\gamma(T_m)+\frac{1}{3}\right)(T-T_m)\right)$$

- $K(1-\delta)$: Scaling factor for complexation and ionic mass differences
- k_B: Energy storage
- $\left(\frac{N_A n}{V(T_m)}\right)$: Phonon mean free path
- $C_0(T_m)$: Group velocity
- $\left(1-\alpha(T_m)\left(\gamma(T_m)+\frac{1}{3}\right)(T-T_m)\right)$: Temperature dependence (relies on heat capacity)

[1] Gheribi, A. E., Torres, J. A., & Chartrand, P. (2014). Sol. Energy Mater., *126*, 11-25.
[2] Gheribi, A. E. & Chartrand, P. (2016). J. Chem. Phys., 144(8)
[3] Gheribi et al. (2022) Sol. Energy. Mater., 236, 111478

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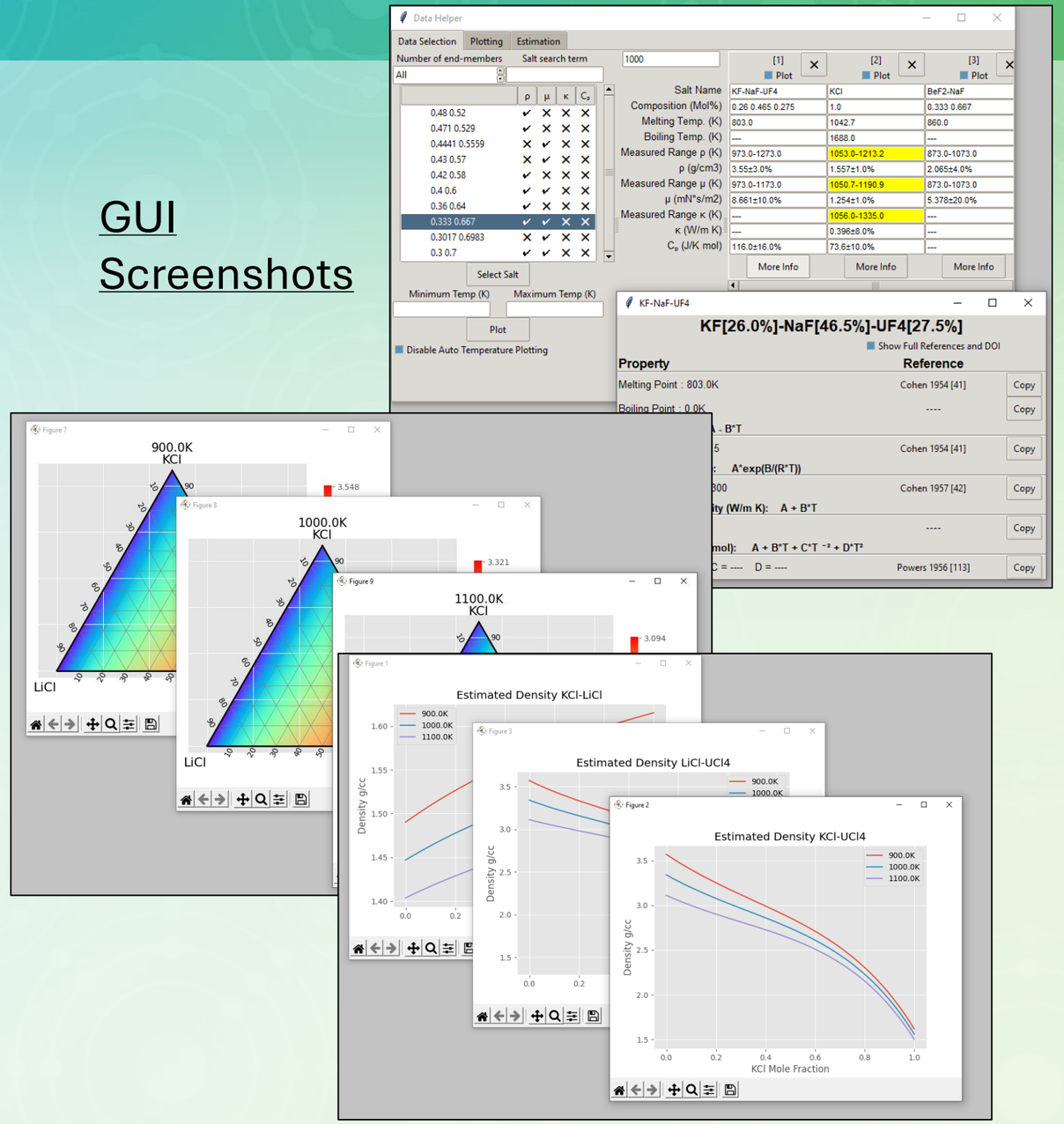
MSTDB-TP User Interfaces

- Saline is the MSTDB-TP API
  - Provides a stable C++ interface for obtaining supported properties (density, viscosity, heat capacity, and thermal conductivity)
  - Designed for integration with other NEAMS codes
- There are two different classes which serve as data models
  - Default: allows for the extraction thermophysical data for compositions in database
  - RK: allows for arbitrary salt mixtures to be estimated
- We also have a GUI which is backed by Saline for more easy access to data

GUI Screenshots



Saline API

```cpp
#include "default_data_store.hh"
#include "thermophysical_properties.hh"

// Construct the default data store object
Default_Data_Store d;

// Load the default data
d.load();

// Construct the thermophysical properties object
Thermophysical_Properties tp;

// Initialize it with the data store
tp.initialize(&d);

// Pick a composition
tp.setComposition({"LiF","NaF","KF"},{0.465,0.115,0.42});

// Obtain data using temperature in Kelvin
double density = tp.rho(900);
double viscosity= tp.mu(900);
double thermal_conductivity = tp.k(900);
double heat_capacity = tp.cp(900);
```

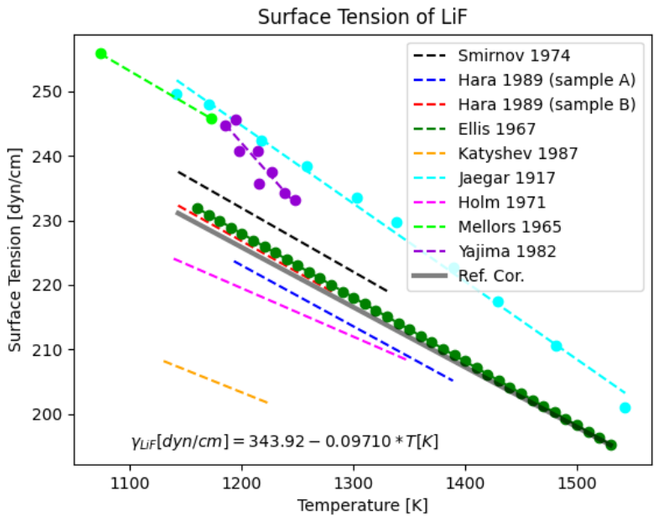
[1]

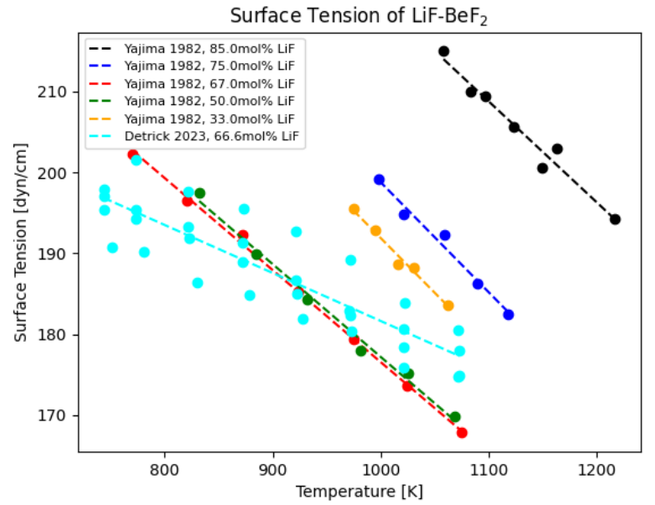
[1] ORNL/TM-2021/2239

Ongoing Surface Tension Addition Effort

- Collected pure and multi-component surface tension data for fluorides
  - Chlorides are the current effort
- Evaluated data using ANL quality ranking system
  - This enabled reliable dataset selection
- Follow on effort involves:
  - Reference correlation determinations
  - Development of predictive models

Example data collected:

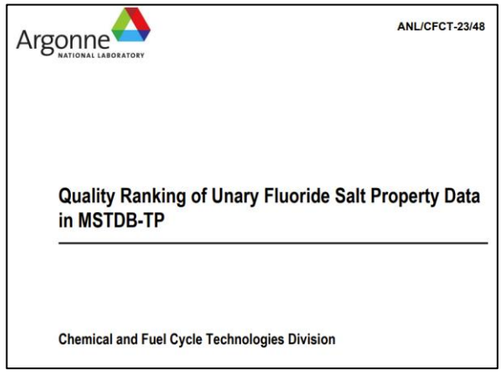




Pure Component	# Studies	Multi-component	# Studies (# Comps)
LiF	**9**	**LiF-KF**	**1 (4)**
NaF	**10**	**LiF-NaF**	**1 (1)**
KF	**5**	**LiF-BeF_2**	**3 (7)**
RbF	**5**	**LiF-UF_4**	**1 (12)**
CsF	**4**	**LiF-ThF_4**	**1 (5)**
BeF_2	0	**NaF-UF_4**	**1 (11)**
MgF_2	**4**	**NaF-KF**	**1 (1)**
CaF_2	**6**	**NaF-BeF_2**	**2 (3)**
SrF_2	**3**	**NaF-ZrF_4**	**1 (5)**
BaF_2	**4**	NaF-$NaBF_4$	1 (1)
ZrF_4	2	**KF-BeF_2**	**1 (9)**
LaF_3	0	**LiF-NaF-KF**	**4 (1)**
ThF_4	1	**LiF-NaF-CaF_2**	**1 (1)**
UF_3	0	**LiF-NaF-ZrF_4**	**1 (11)**
UF_4	1	LiF-KF-ZrF_4	1 (10)
UF_6	1	**LiF-BeF_2-UF_4**	**1 (1)**
		LiF-BeF_2-ThF_4	**2 (49)**
		NaF-BeF_2-UF_4	1 (1)
		NaF-ZrF_4-UF_4	1 (1)
		LiF-BeF_2-UF_4-ThF_4	2 (33)
		NaF-BeF_2-UF_4-ThF_4	2 (33)

MSTDB-TP Quality Rankings Collaboration

- ANL has put out two reports [1,2] on the QA process for MSTDB-TP
  - One detailing how the rankings work
  - Another on application to pure fluoride compounds for density and viscosity
- The MSTDB-TP incorporates quality rankings into the dataset selection and uncertainty characterization as updates are generated
- A continuation of this effort has enabled reference correlation determinations for fluoride density and viscosity
  - Journal manuscript in review for JPCRD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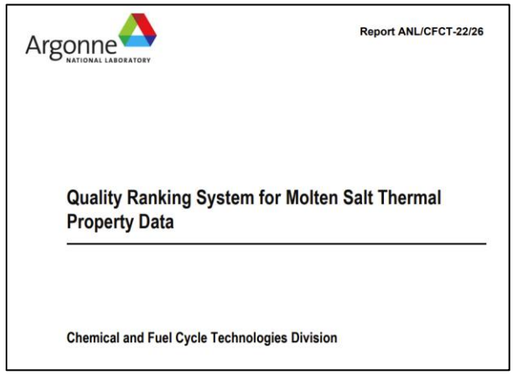
ANL/CFCT-23/48

Quality Ranking of Unary Fluoride Salt Property Data in MSTDB-TP

Chemical and Fuel Cycle Technologies Division


Argonne NATIONAL LABORATORY

Report ANL/CFCT-22/26

Quality Ranking System for Molten Salt Thermal Property Data

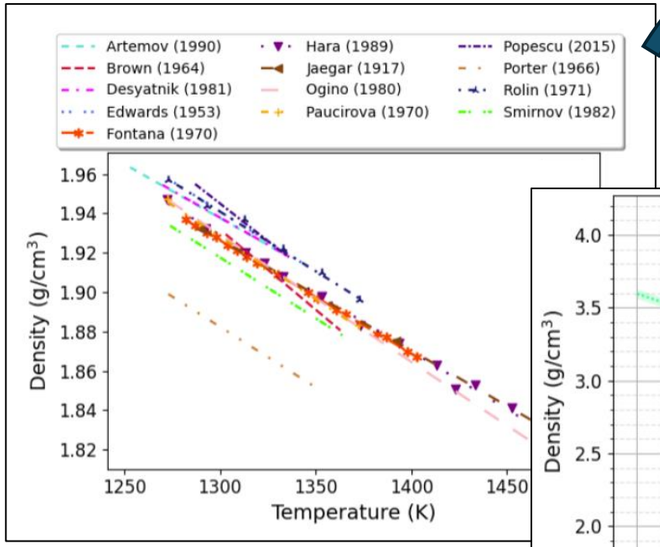
Chemical and Fuel Cycle Technologies Division

Quality Rankings

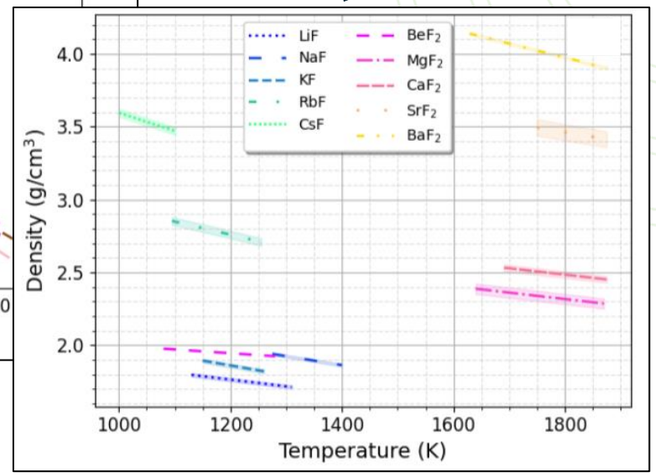
Table 2. Quality Ranking of the Sources of Unary Fluoride Salt Density Data Compiled in MSTDB-TP V 2.1.0.

Author, Year [citation]	Salt Systems Studied	Overall Rank	Method	Calibrations	Composition Analysis	Environmental Controls	Measurement Precision	Verifiability
Jaegar, 1917 [2]	LiF, NaF, KF, RbF, CsF	U	**M** - Hydrostatic method	**M** - Measured a variety of organic liquids at RT, surface tension effect quantified ~0.0001 g/erg	**I** - No discussion of salt purity, source, or measurements of composition	**I** - No information provided on control of temperature or atmosphere	**M**- Reported accuracy to two decimal places in erg	**I** - No raw data provided, reports densities and a correlation
Edwards, 1953 [3]	NaF	U	**I** - Hydrostatic method, not enough detail to determine if method is correctly applied	**I** - No information provided on calibrations.	**I** - Salts were dried appropriately, No composition analysis	**I** - No information provided on control of temperature or atmosphere	**I** - No information on uncertainty or precision provided.	**I** - No raw data provided. Reports a correlation only
Yaffe, 1956 [4]	LiF, KF, CsF	U	**I** - Hydrostatic method, not enough detail to determine if method is correctly applied	**I** - No information provided on calibrations.	**I** - No information on source materials or analyses of salts.	**I**- No information provided on control of temperature or atmosphere	**I**- No information on uncertainty or precision provided.	**I** - No raw data provided. Reports a correlation and a standard deviation for the correlation.
Kirshenbaum, 1960 [5]	CaF_2, BaF_2, SrF_2, MgF_2, LaF_3, CeF_3	U	**M** - Hydrostatic method	**I** - No information provided on calibrations.	**M** - Salts dried appropriately, measured carbon, oxide and carbide post-test	**H** - Argon atmosphere, Temp controlled to ±15 K	**I** - Did not report measurement uncertainty, temperature uncertainty of 2 K.	**I** - No raw data provided. Reports measured density and a correlation.

Dataset Comparison



Reference Correlation Determination



[1]ANL/CFCT-23/48
[2]ANL/CFCT-22/26

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Summary

- ORNL is striving to meet the challenge of thermophysical property characterization for MSR relevant salts with a multi-pronged approach
- Experimentally, we are focused on performing transport property measurements, primarily on actinide-bearing salts
  - We are also studying the effect of surrogate FPs
- From a modelling standpoint, we are developing predicative models for rapid characterization of many salts, informed by experimental measurements
- We are collecting and assessing, as exhaustively as we can, thermophysical property data to compile into MSTDB-TP

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- Ted Besmann and Juliano Shorne-Pinto at USC for collaboration between TC and TP
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Thank you

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