Experimental investigations and data assessment for the system Na, K // Cl, NO_3

Project:

Thermodynamics of Salt Systems for

Thermal Energy Storage

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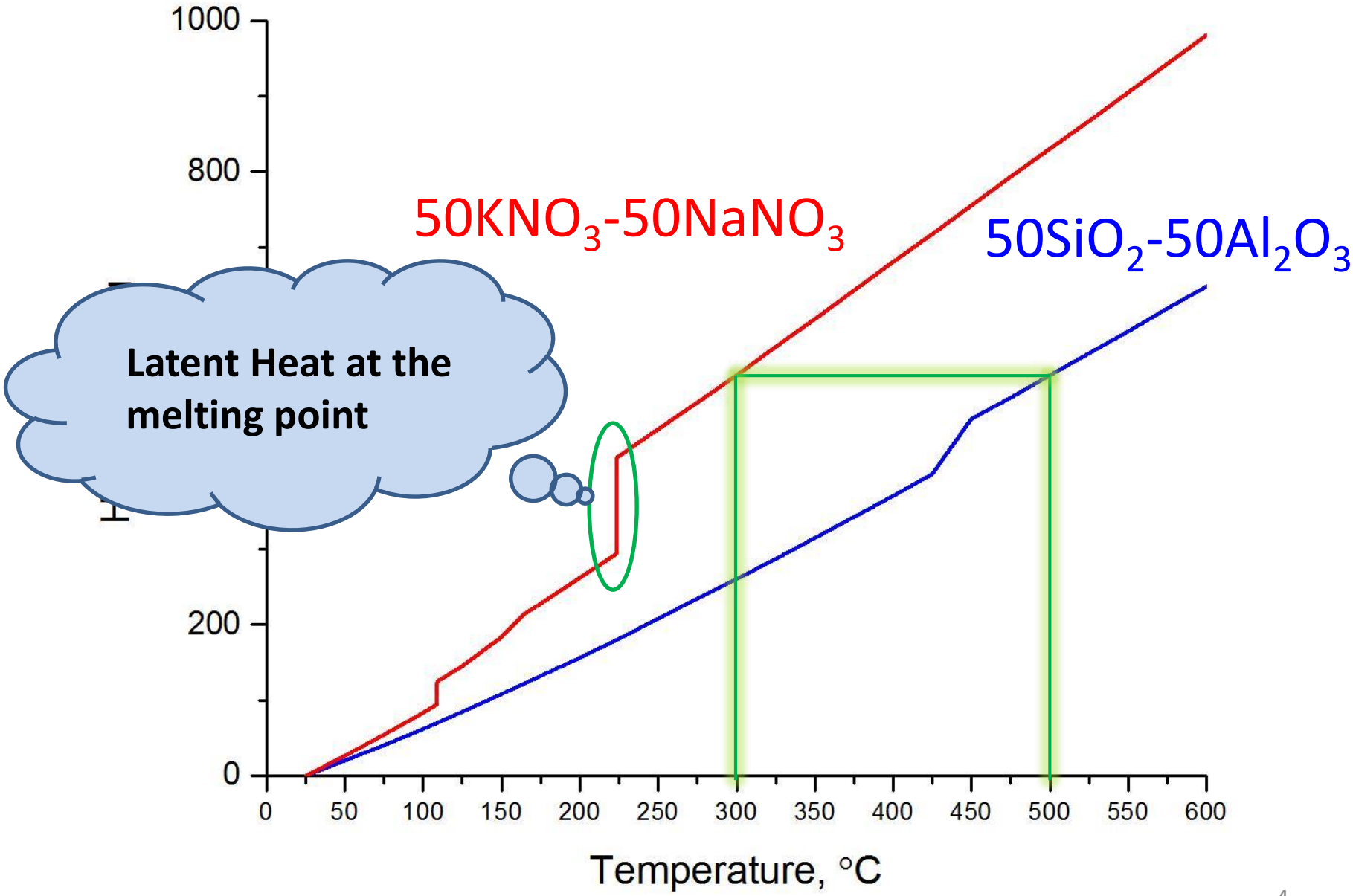
[2] - GTT-Technologies

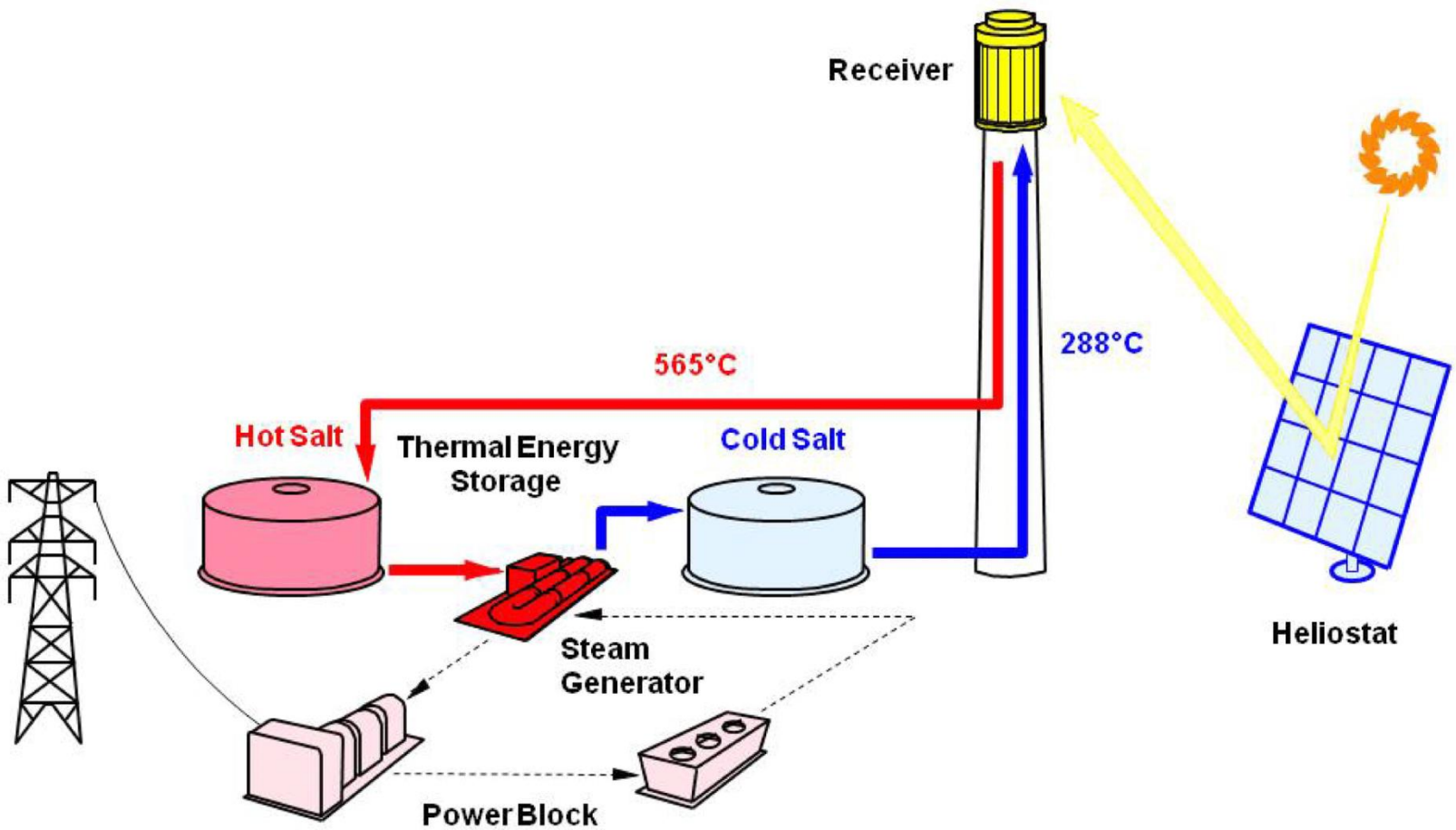
Russian Winter (-30°C)

Sensible Thermal Energy Storage

Heat Increment

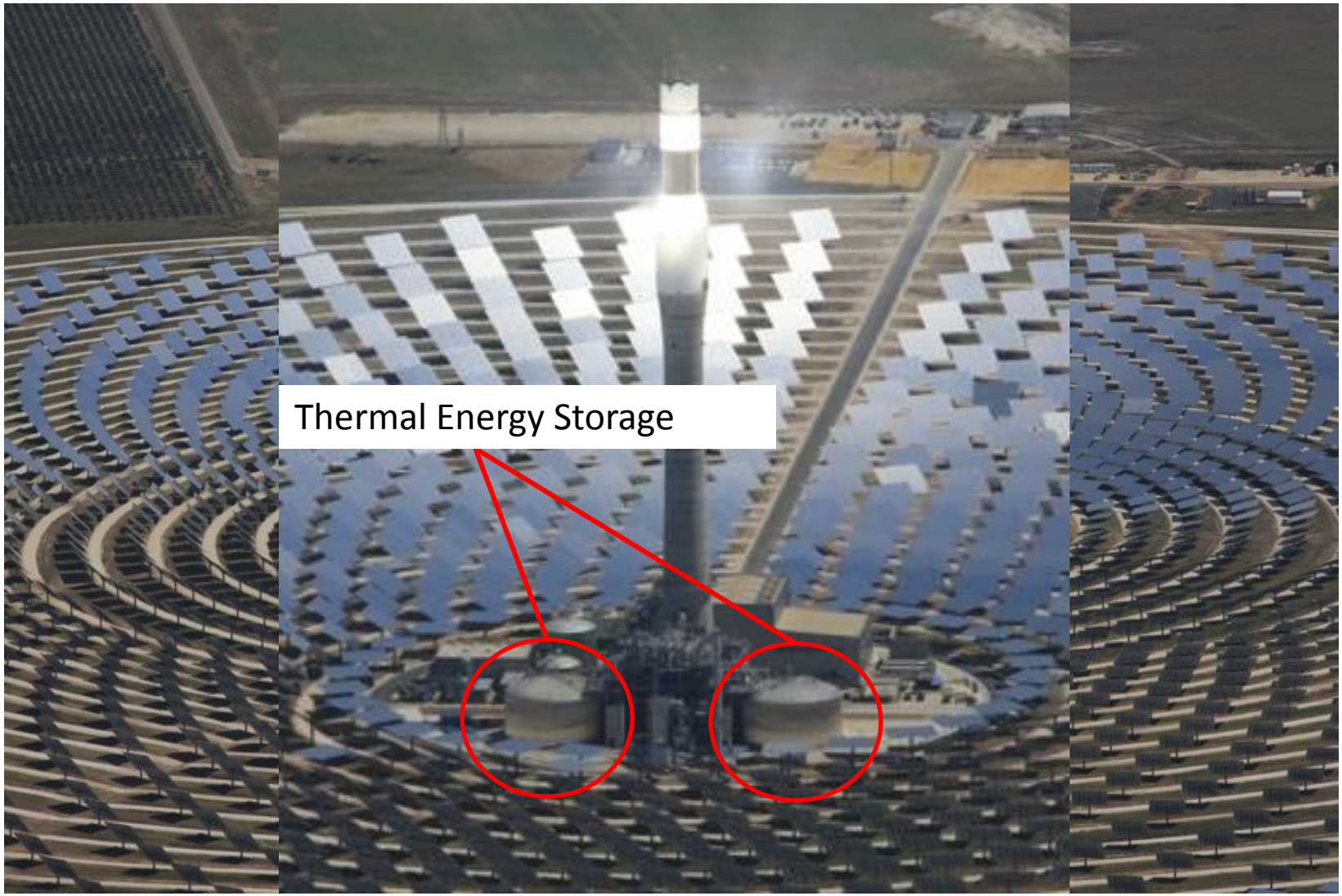


Scheme of Solar Power Plant



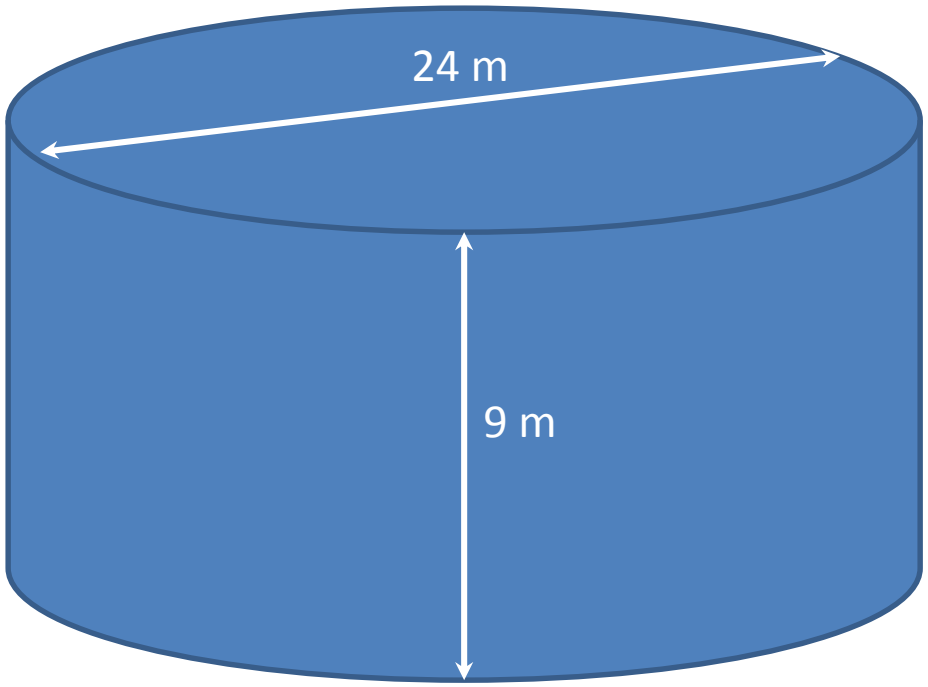
http://greenterrafirma.com/solar-thermal-for-electricity.html

Solar Power Plant



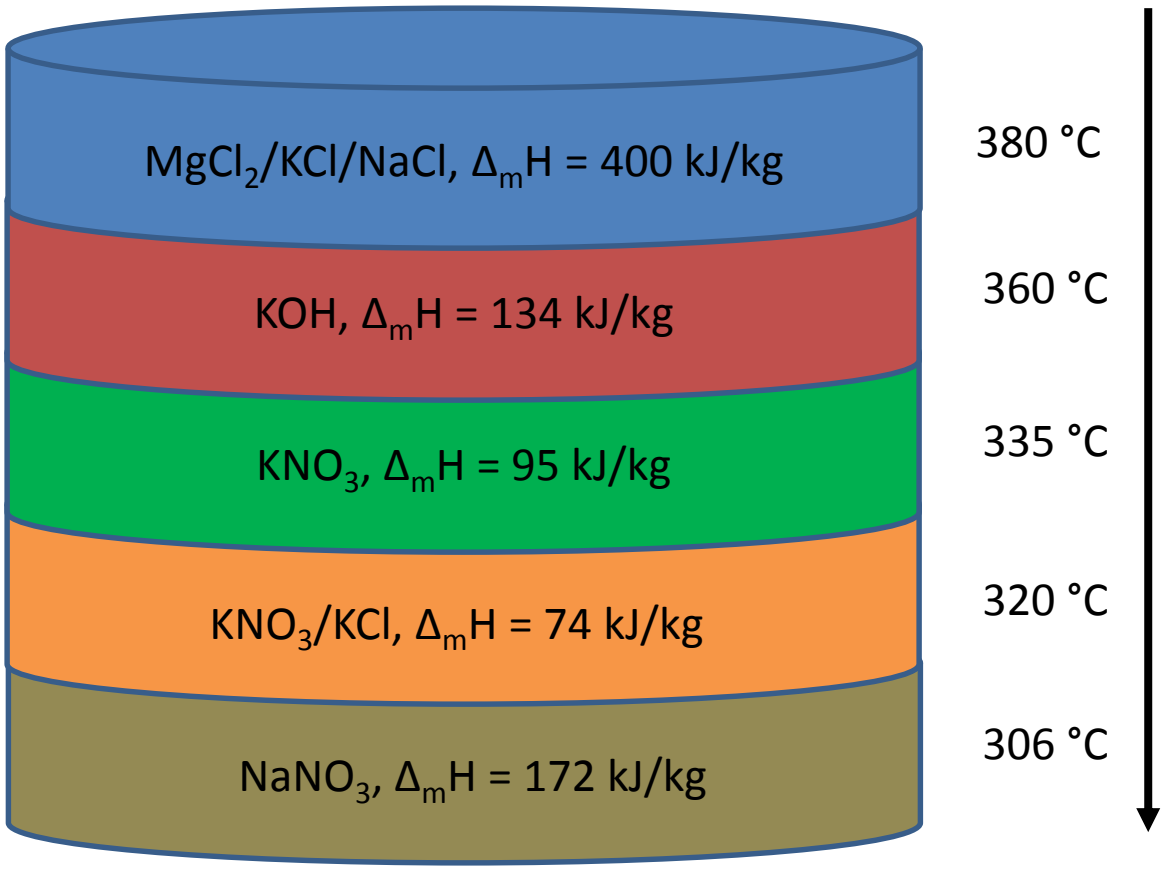
http://www.climatechangebr.org/page25.htm

Weight of TES



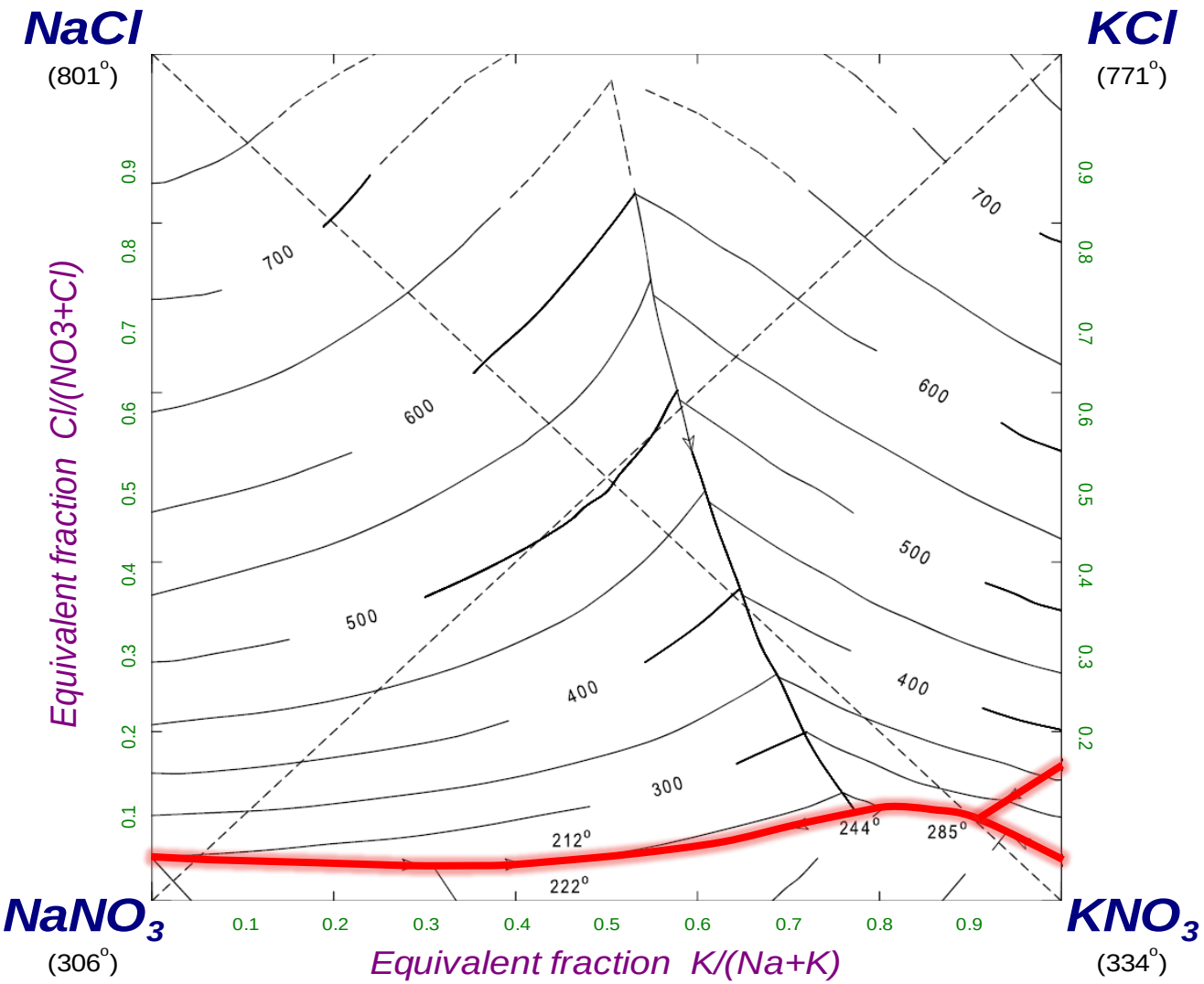
m=10 000 kg

Cascaded Latent Heat Storage



Dinter F., Geyer M., Tamme R., "Thermal Energy Storage for Commercial Applications" Berlin, Heidelberg, New York, usw.: Springer-Verlag; 1991.

Phase Diagram of the NaCl-KCl-$NaNO_3$-KNO_3 system



R.N. Nyankovskaya, *Izv. Sekt. Fiz.-Khim. Anal.*, 21 (1952) 259-270.

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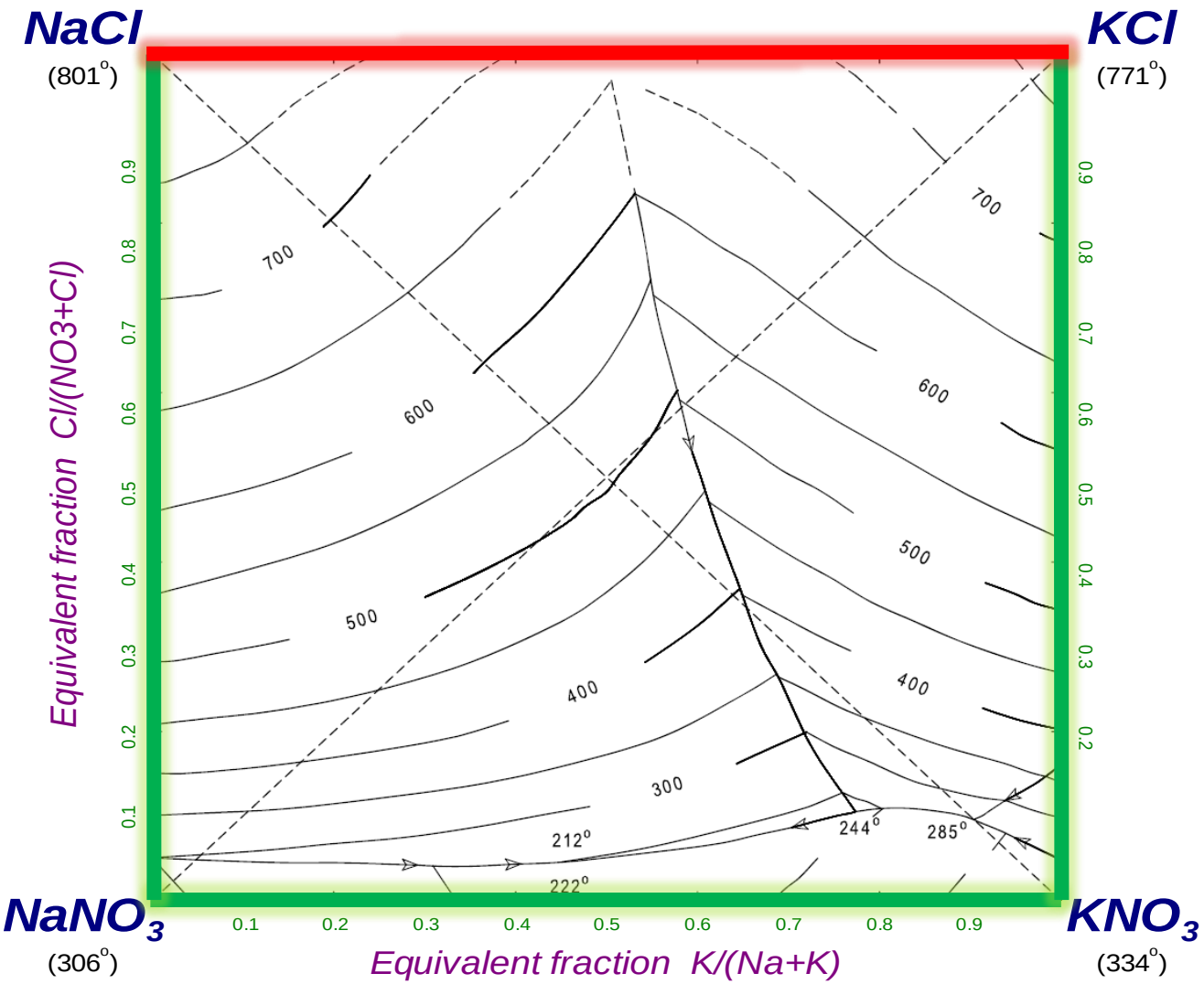
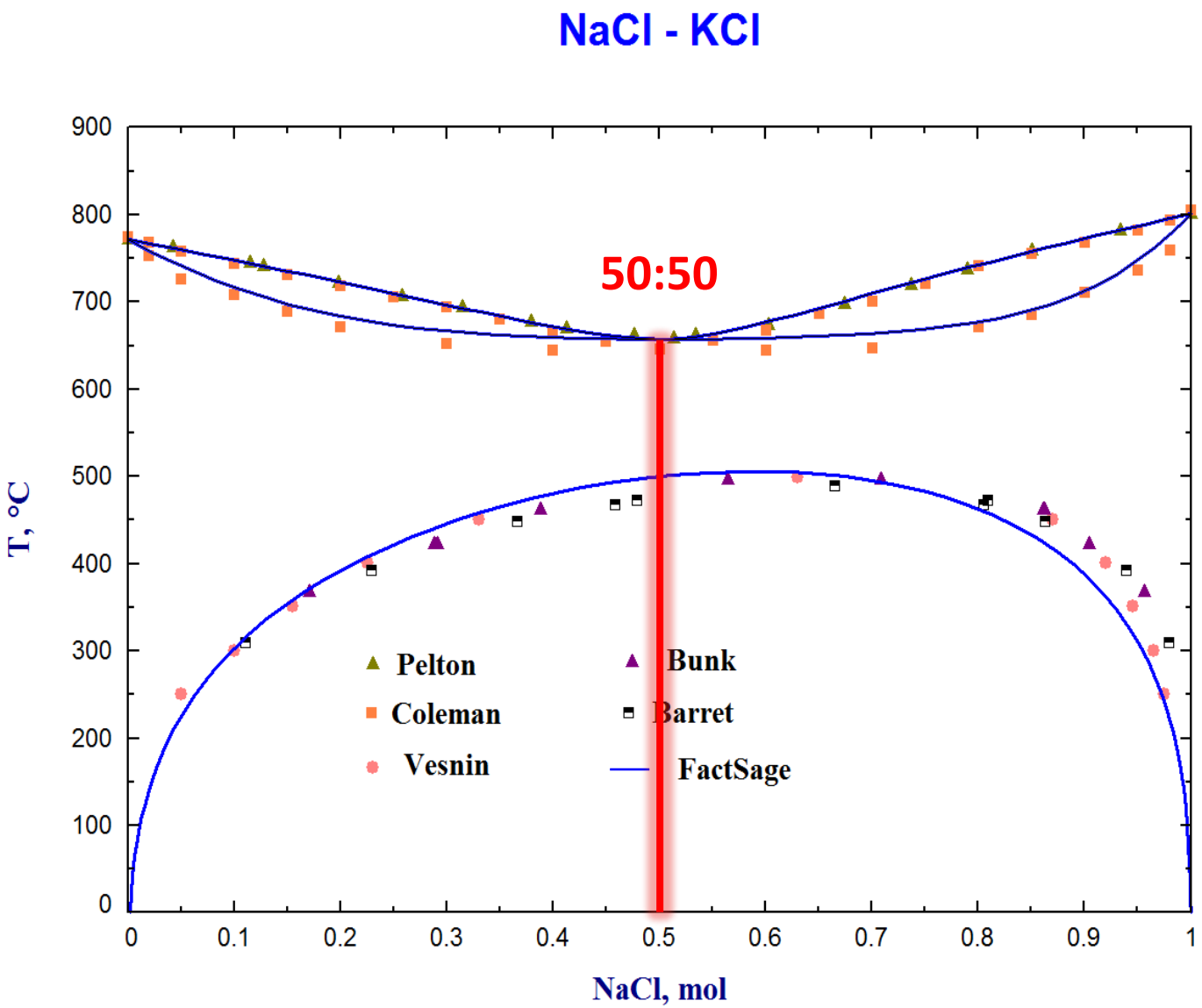


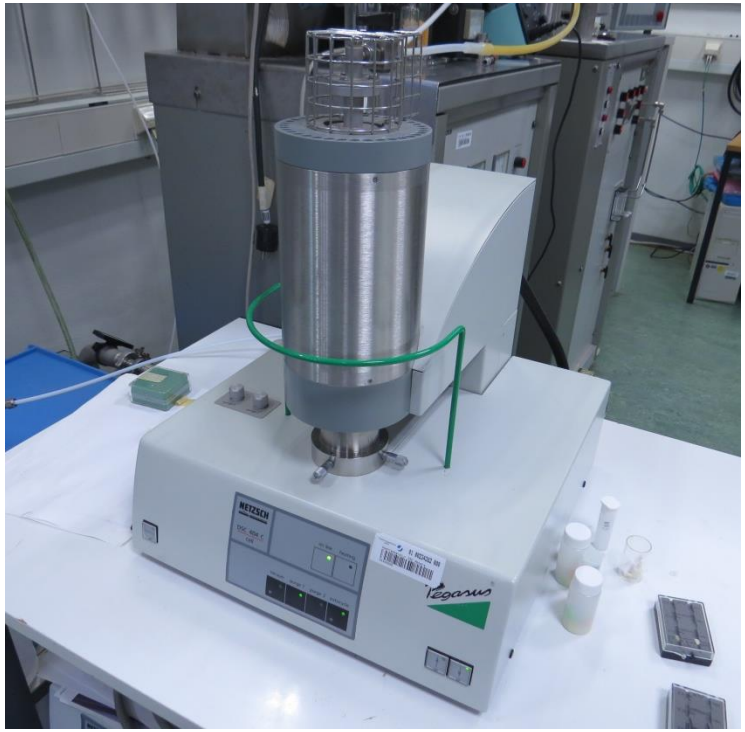
R.N. Nyankovskaya, *Izv. Sekt. Fiz.-Khim. Anal.*, 21 (1952) 259-270.

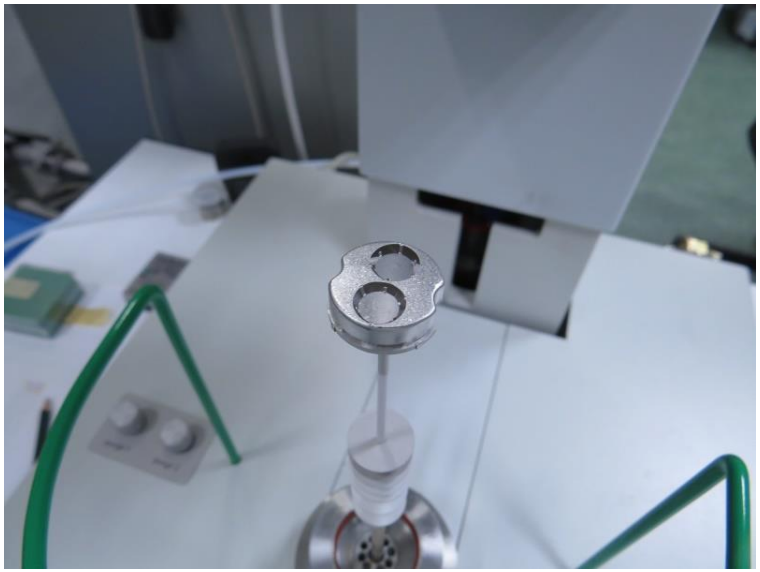
Phase Diagrams of the NaCl-KCl System



Differential Scanning Calorimetry

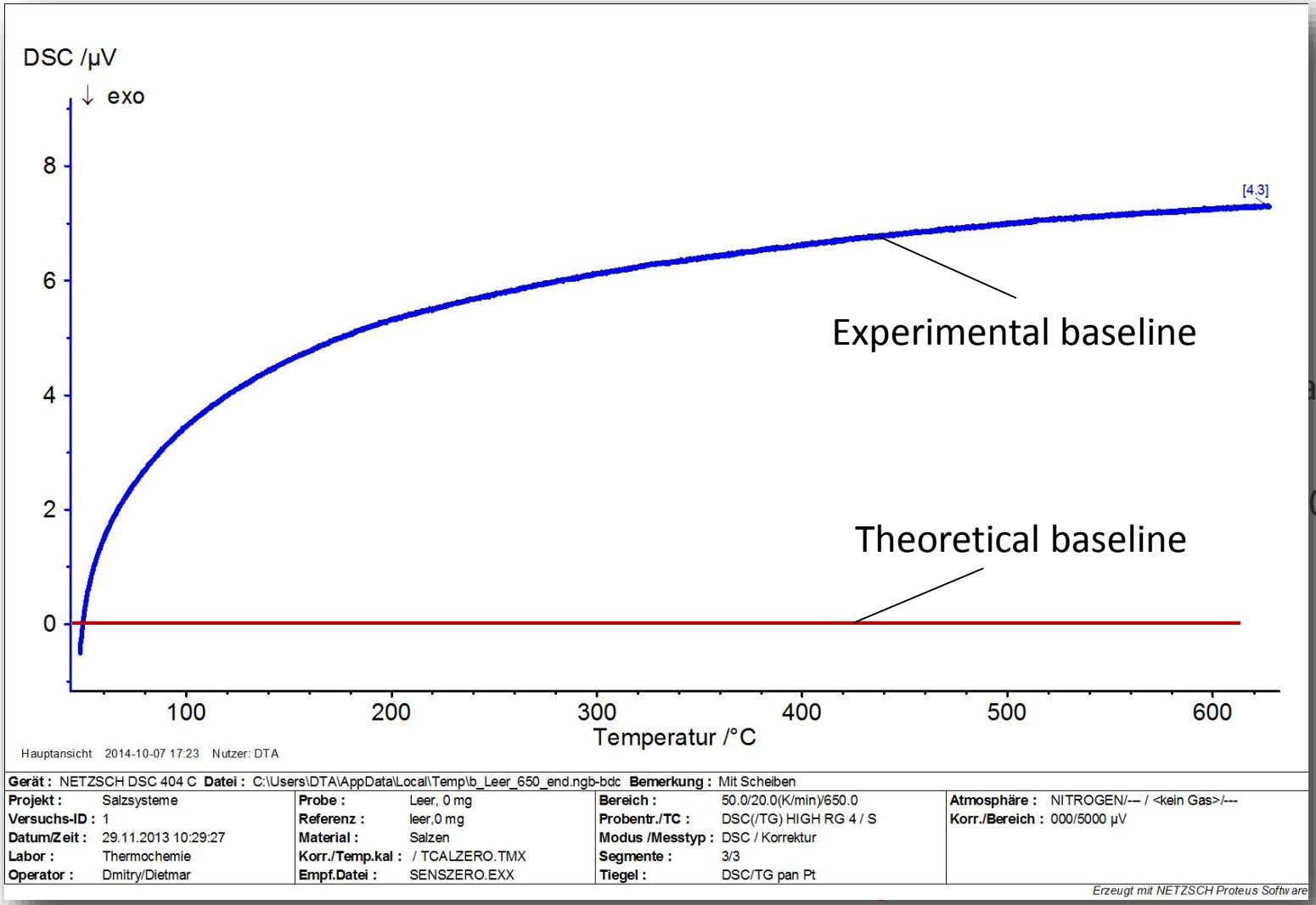
DSC 404C Netzsch





Sample holder

Differential Scanning Calorimetry



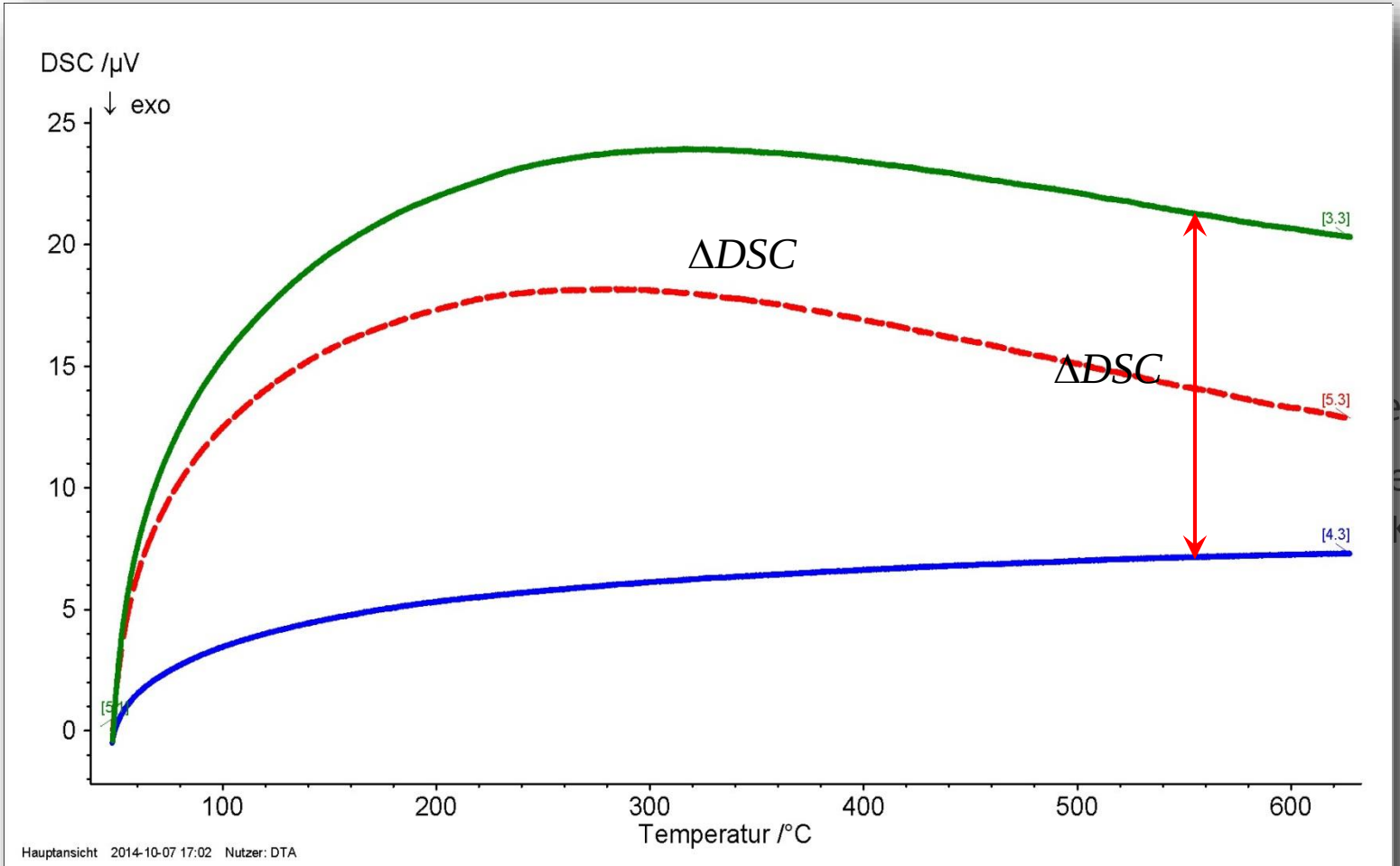
ater

heat

0 K/min

ΔT, µV

Differential Scanning Calorimetry



[#] Gerät	Datei	Datum	Versuchs-ID	Probe	Masse/mg	Segment	Bereich	Atmosphäre	Korr.
[3.3] DSC 404 C	r8_Sapphirl_650_end.ngb-ddc	2013-11-29	1	Sapphir	55.89	3/3	50.0/20.0(K/min)/650.0	NITROGEN/--- / <kein Gas>/---	---
[4.3] DSC 404 C	b_Leer_650_end.ngb-bdc	2013-11-29	1	Leer	0	3/3	50.0/20.0(K/min)/650.0	NITROGEN/--- / <kein Gas>/---	---
[5.1] DSC 404 C	r7_Sapphir_650_end.ngb-ddc	2013-11-28	1	Sapphir	55.89	1/3	45.0/40.0(K/min)/50.0	NITROGEN/--- / <kein Gas>/---	020

er

eat

K/min

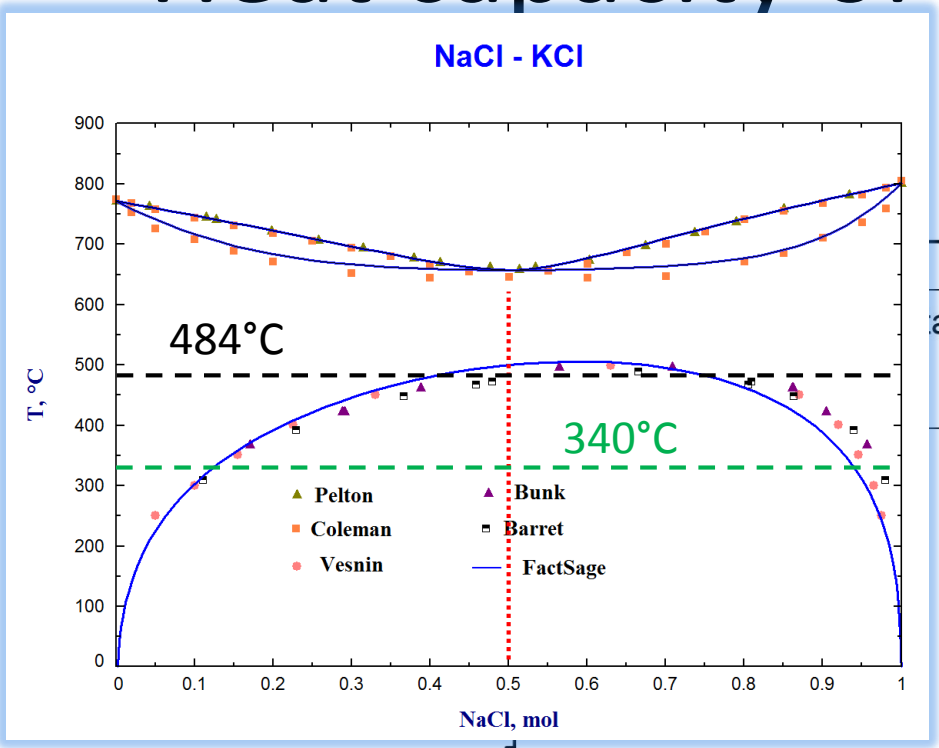
ΔT, µV

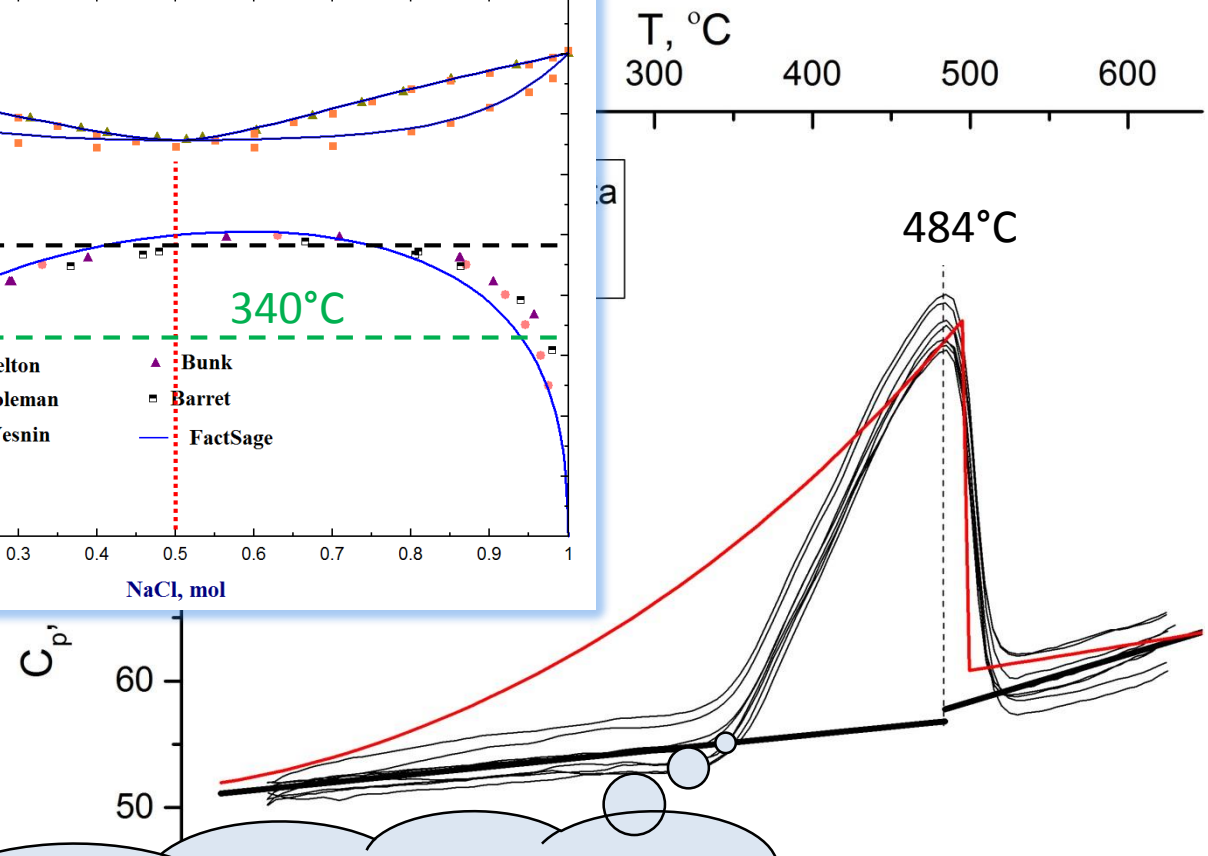
Heat Capacity

$$C_{p(s)}^{\circ} = \frac{m_r}{m_s} \cdot \frac{\Delta DSC_s}{\Delta DSC_r} \cdot C_{p(r)}^{\circ}$$

where *m* – mass of the substance (g), ΔDSC – difference signal (μV), $C_{p(r)}^{\circ}$ – heat capacity of a reference.

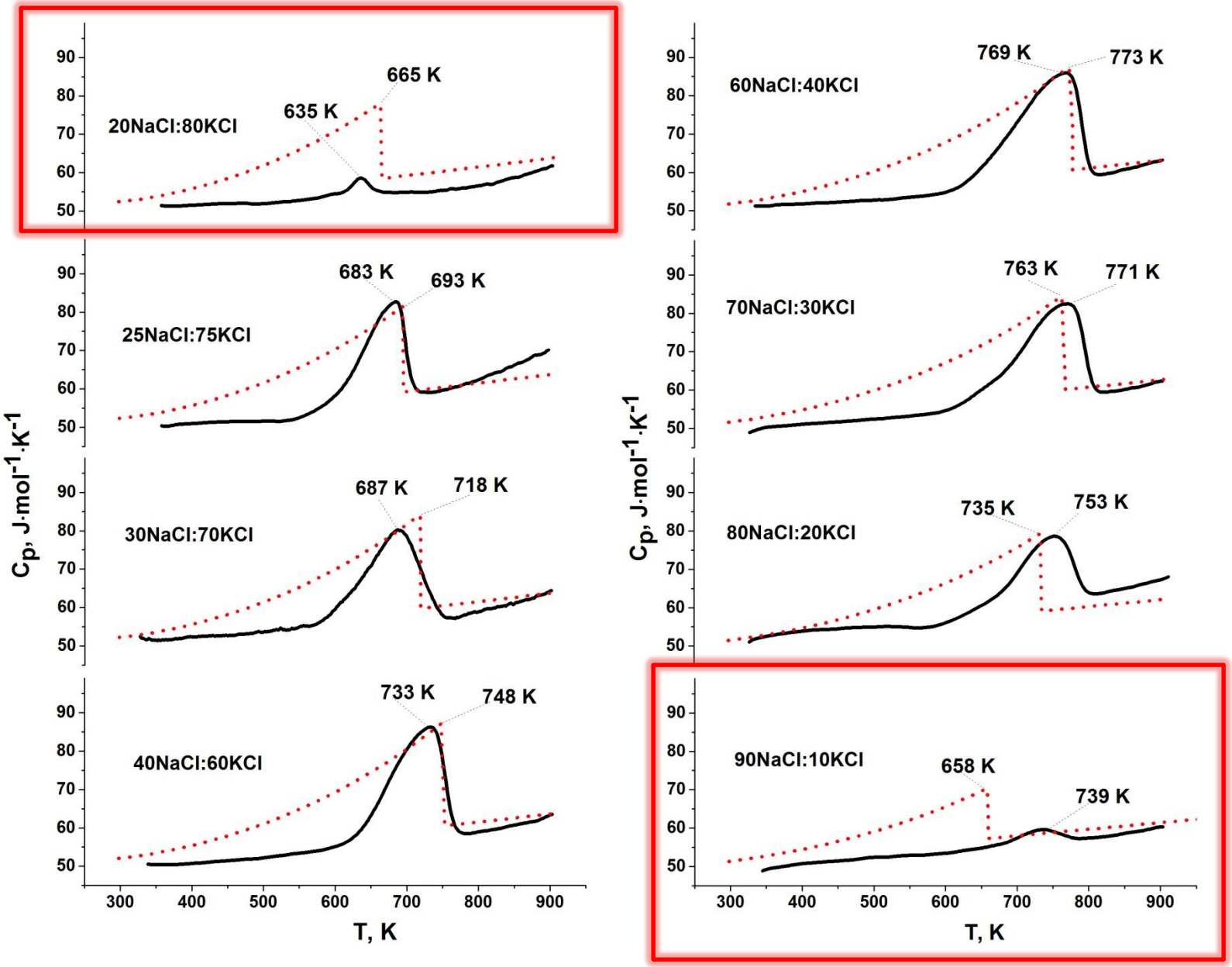
Heat capacity of the 50NaCl-50KCl



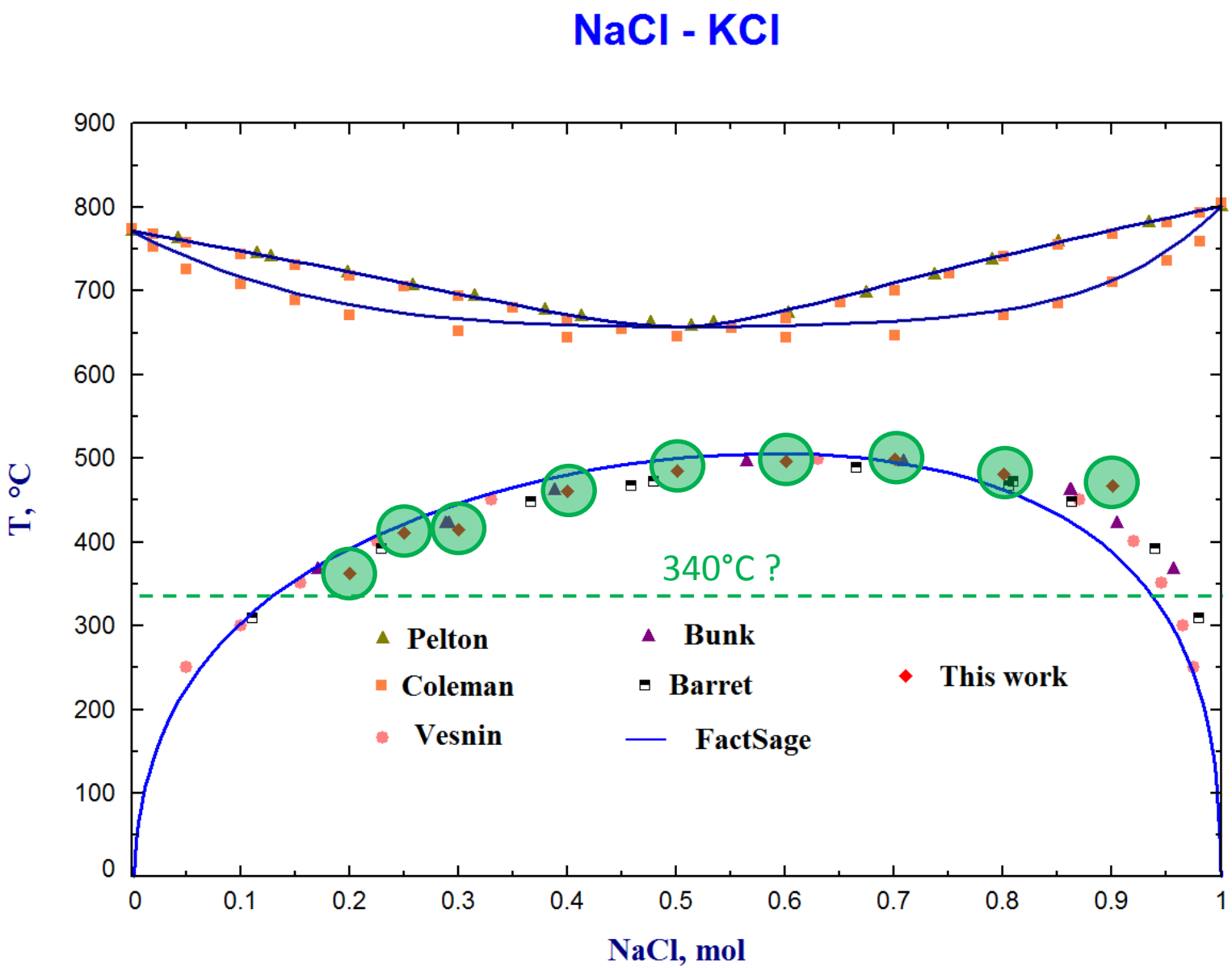


What does the initial temperature 340°C mean?

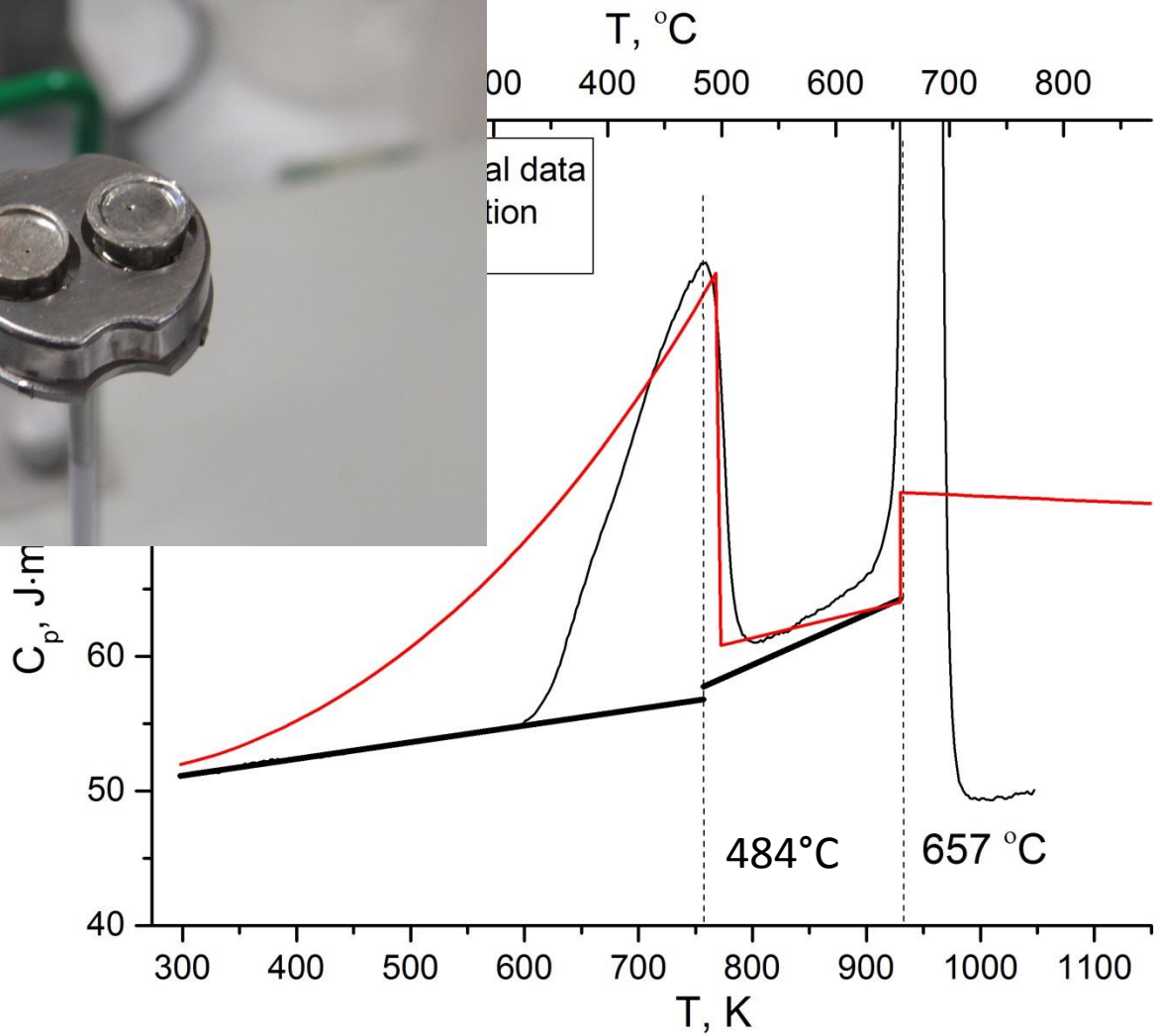
Heat capacity of the NaCl-KCl system



Phase Diagramm

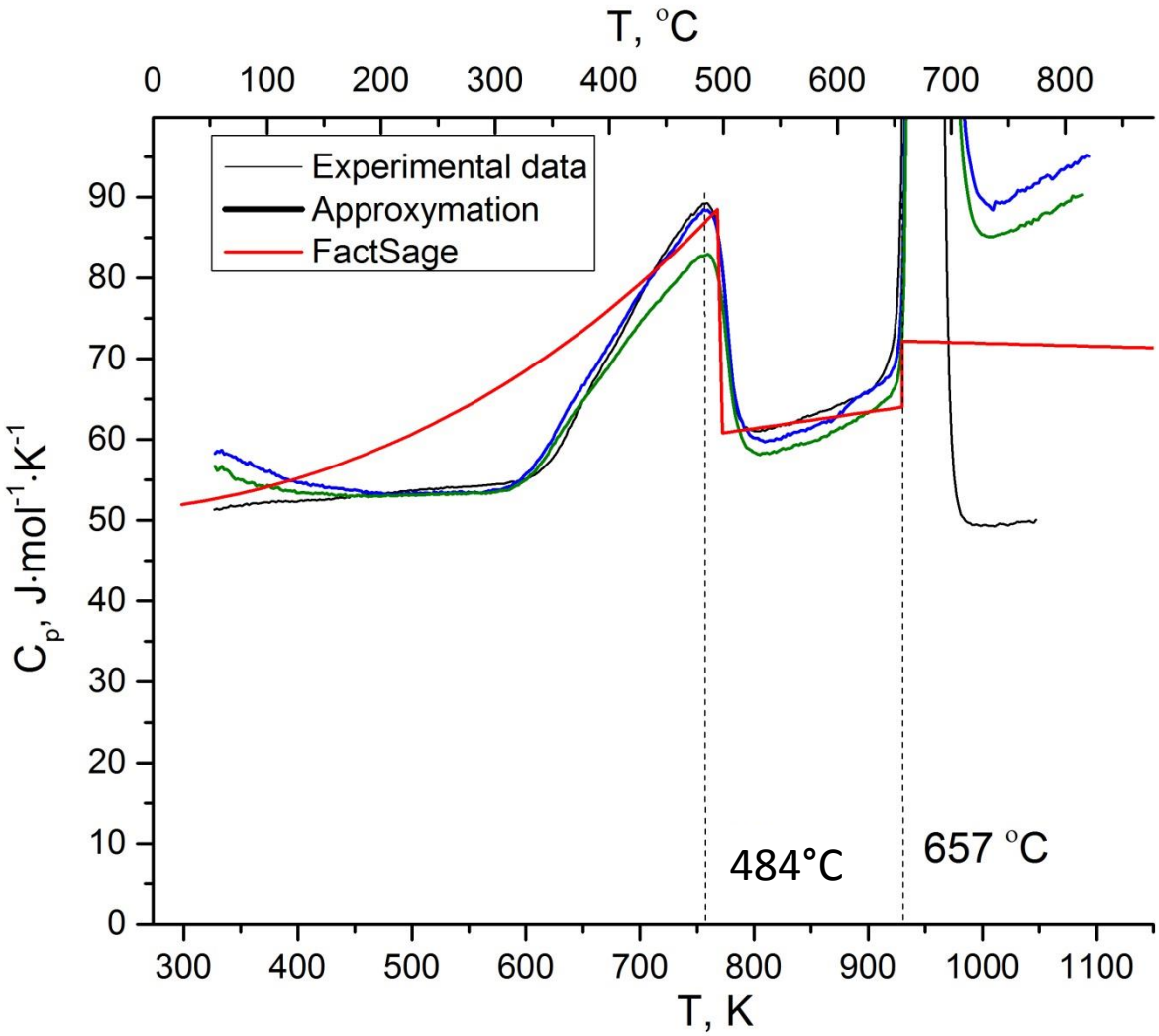


Heat capacity of the 50NaCl-50KCl

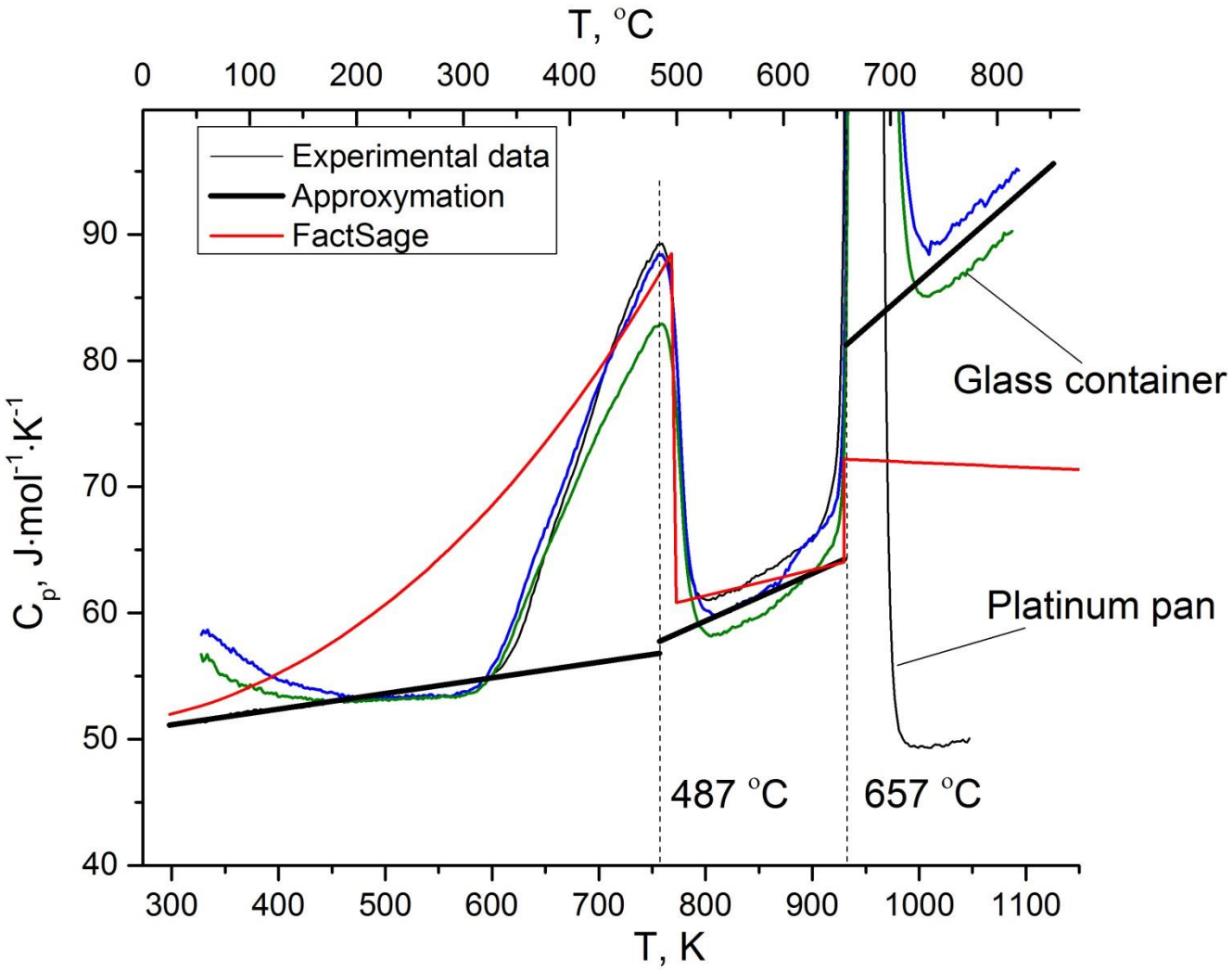


Closed glass container

Heat capacity of the 50NaCl-50KCl

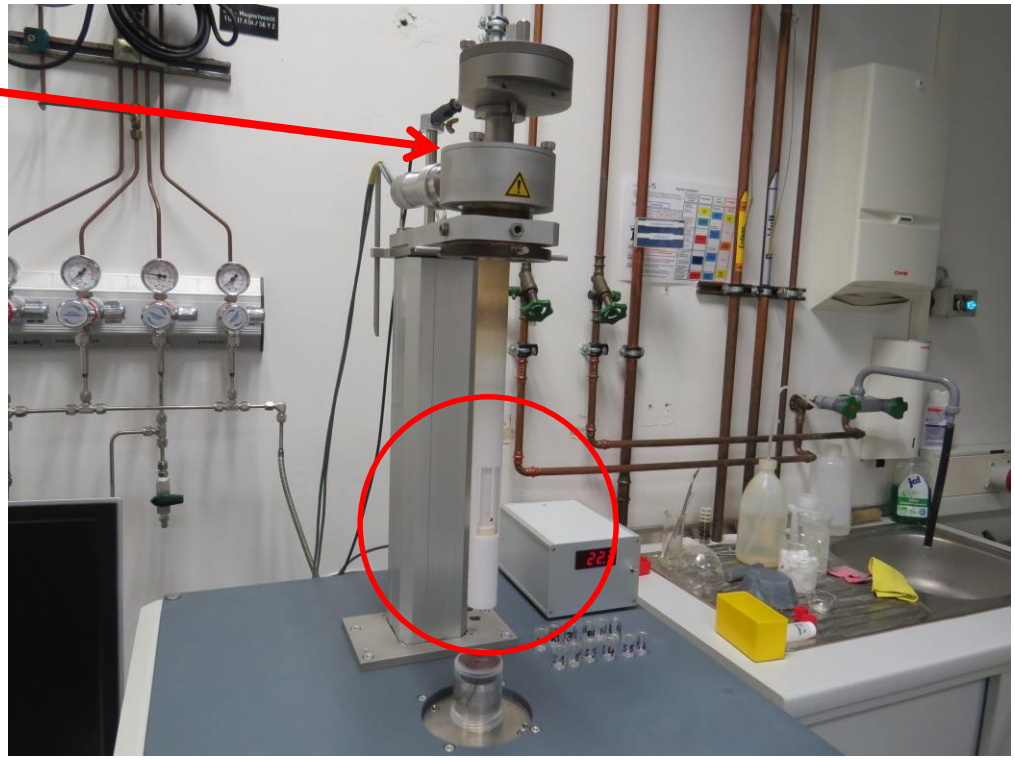


Heat capacity of the 50NaCl-50KCl

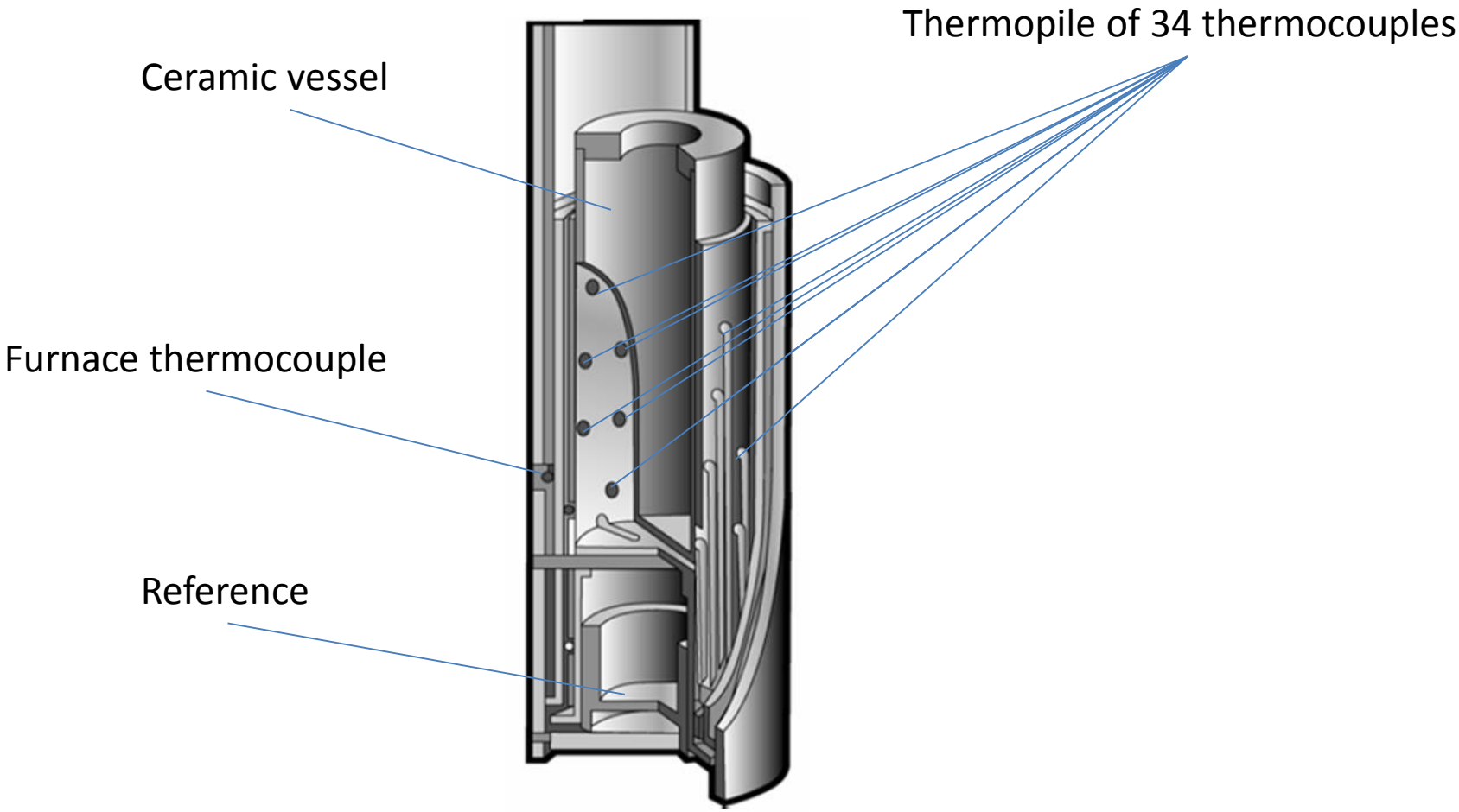


Drop Calorimeter

mHTC 96 Seteram

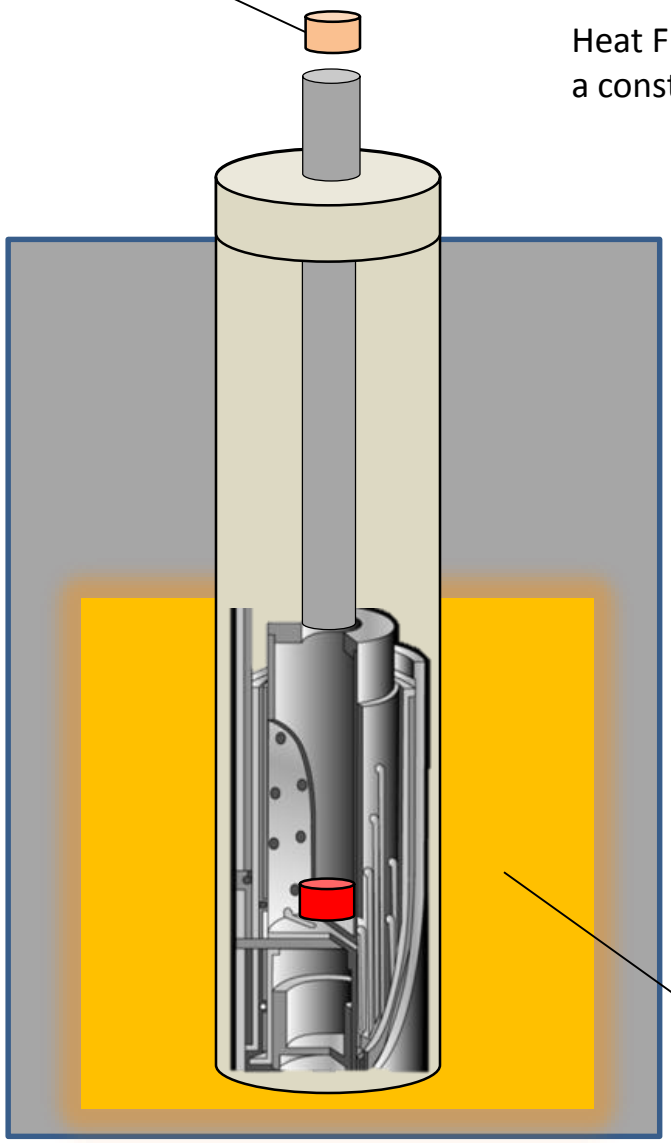


Drop Calorimetric Detector



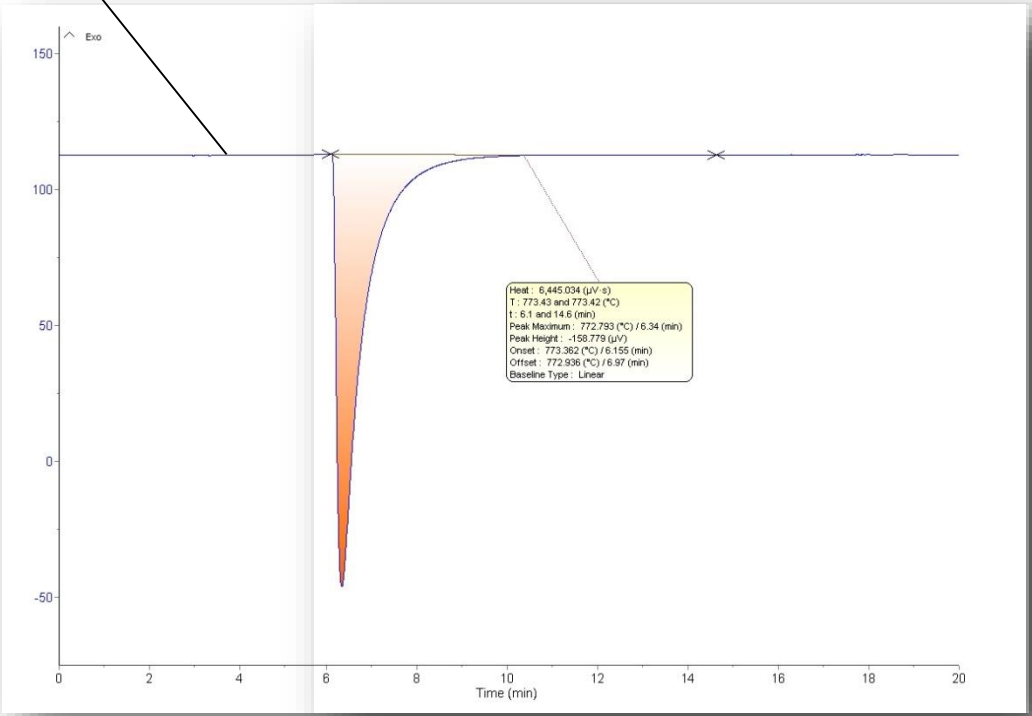
Drop Calorimetry

Sample (10-100mg)
at room temperature



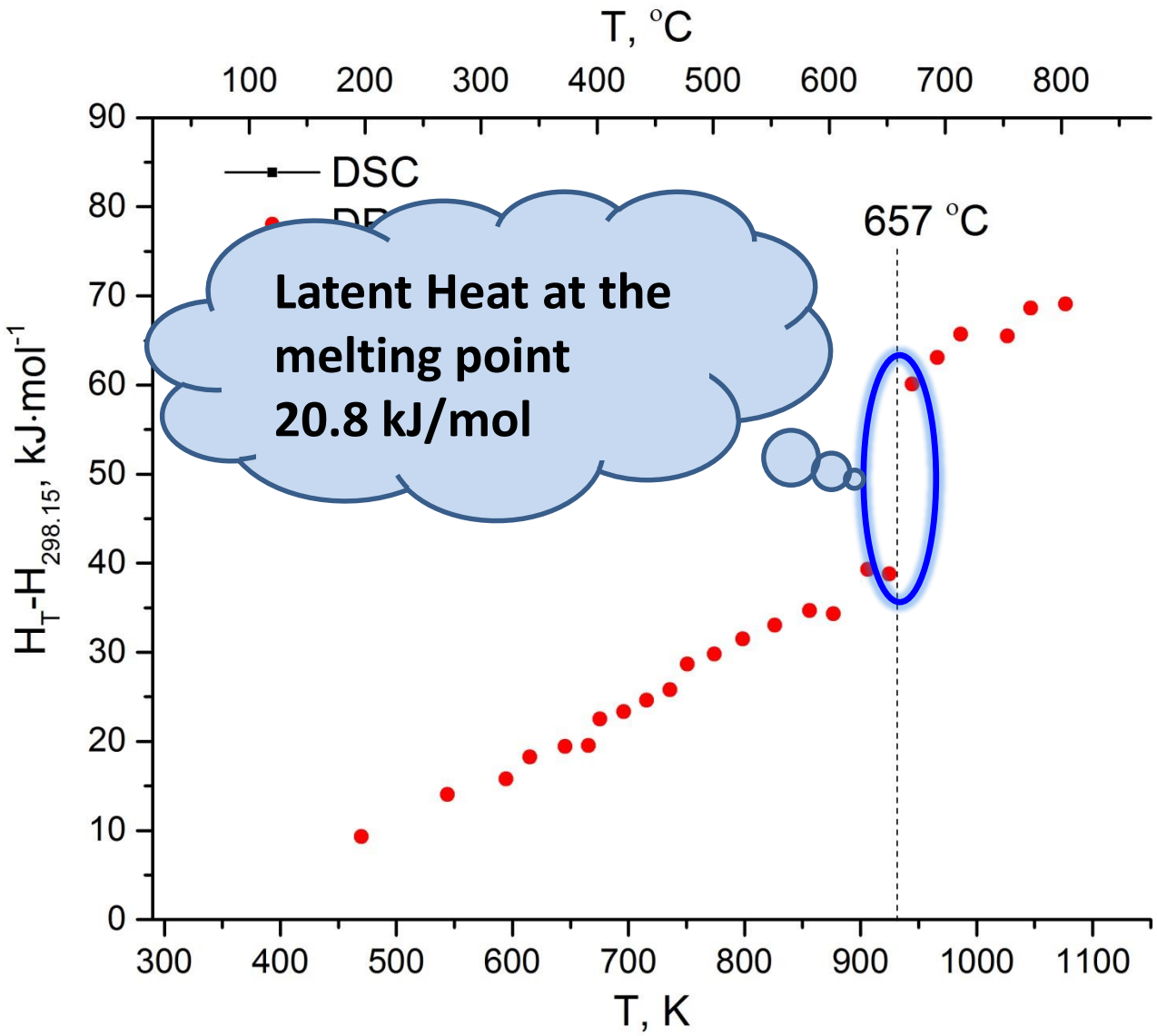
Heat Flow (µV) at
a constant *T*

Experimental data

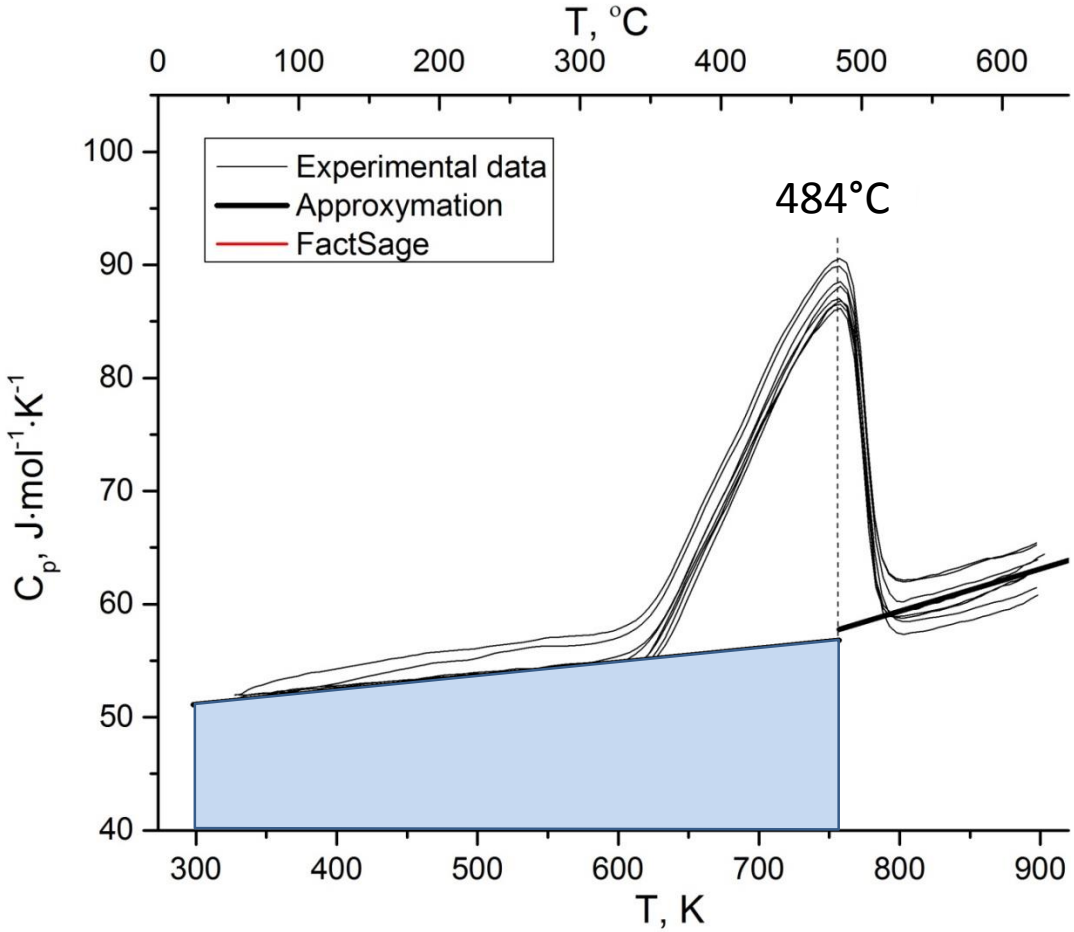


Hot zone,
constant temperature T

Enthalpy increment in the 50NaCl – 50KCl mixture

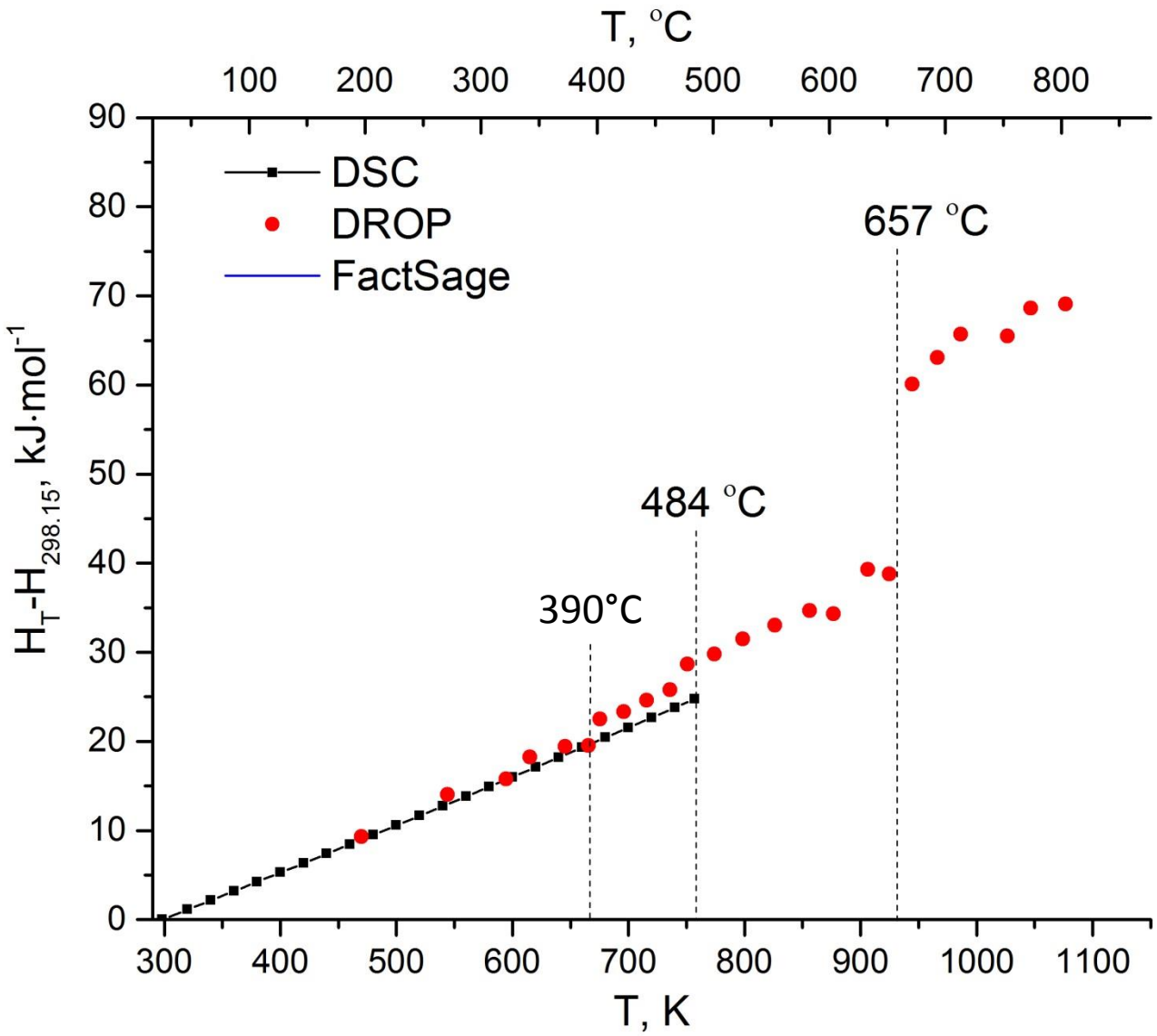


Heat capacity of the 50NaCl-50KCl

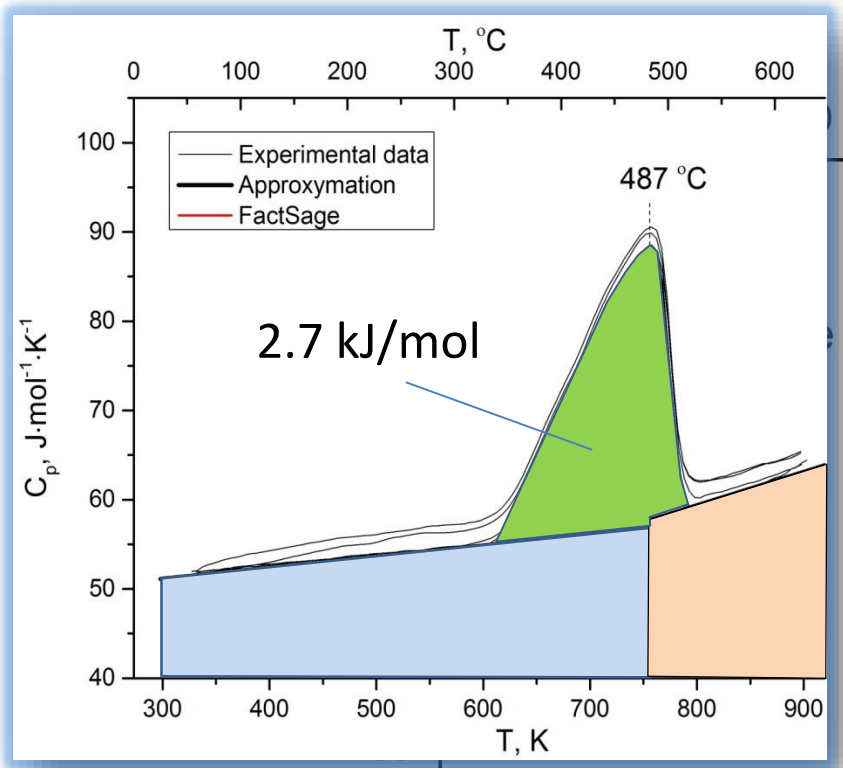


$$H_T^\circ - H_{298.15}^\circ = \int_{298.15}^{T} C_p^\circ(T)dT$$

Enthalpy increment in the 50NaCl – 50KCl mixture

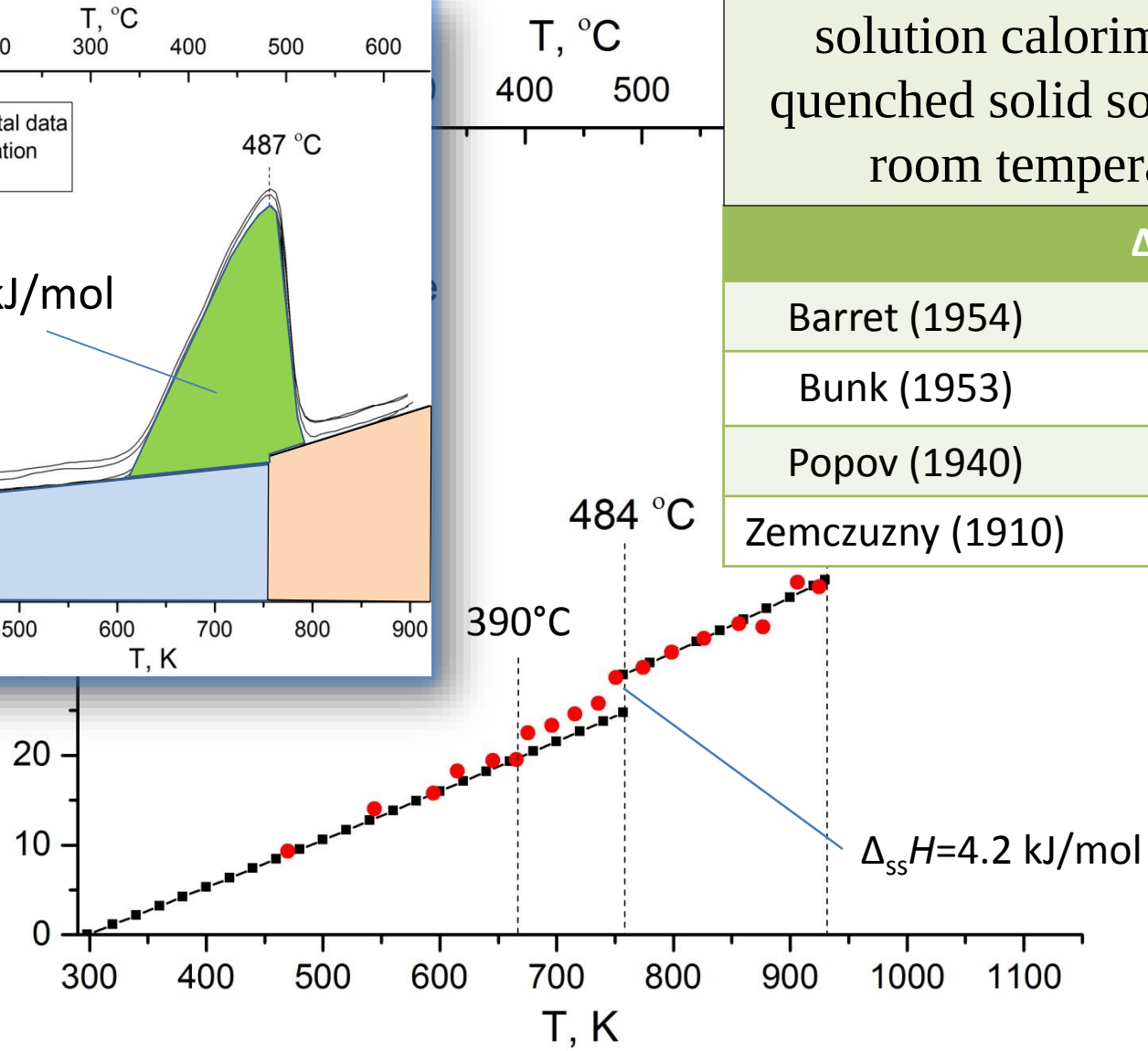


Enthalpy increment in the 50NaCl – 50KCl mixture



Literature data obtained by solution calorimetry of quenched solid solutions at room temperature

	$\Delta_{ss}H$, kJ/mol
Barret (1954)	4.4
Bunk (1953)	4.5
Popov (1940)	4.4
Zemczuzny (1910)	4.4



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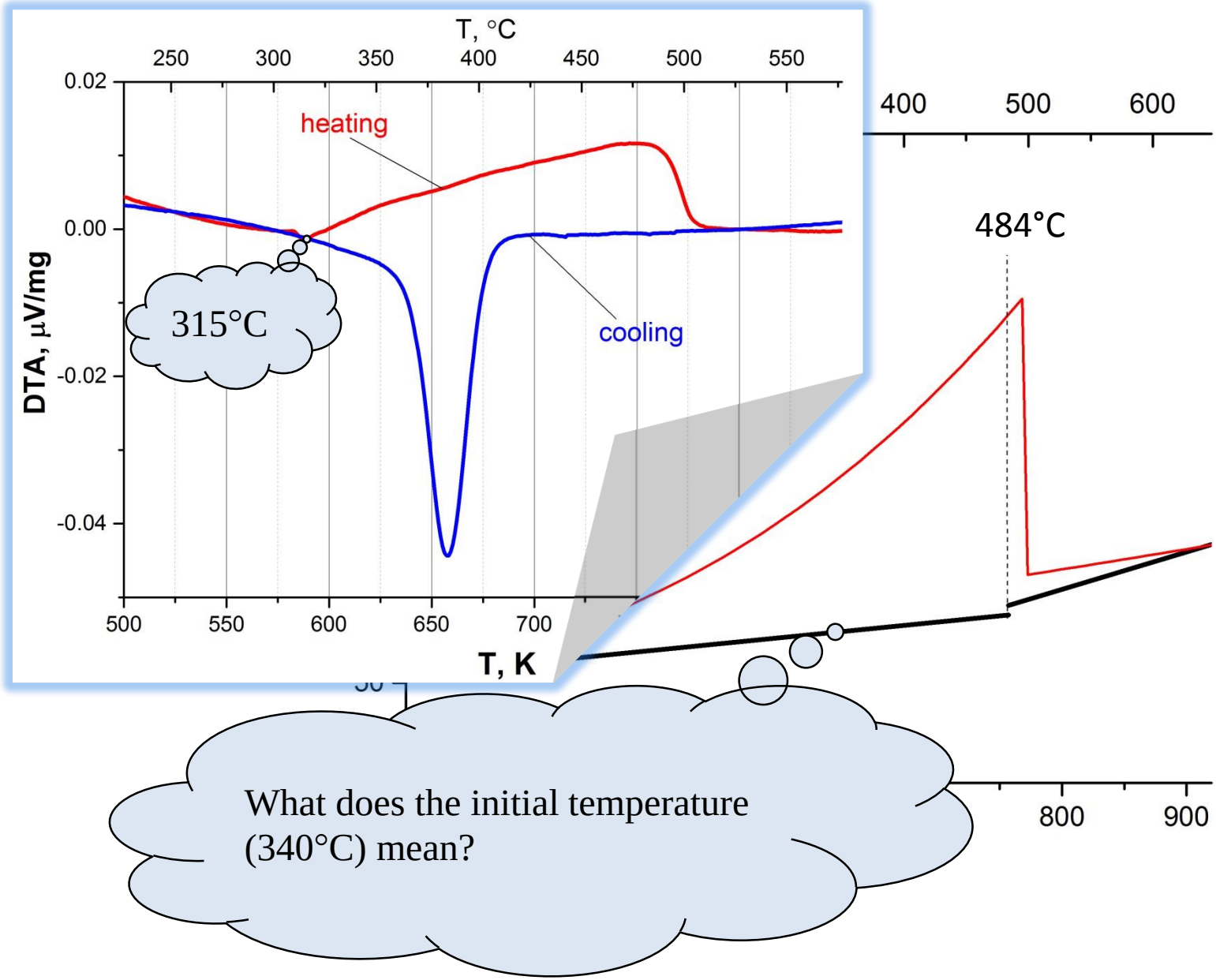
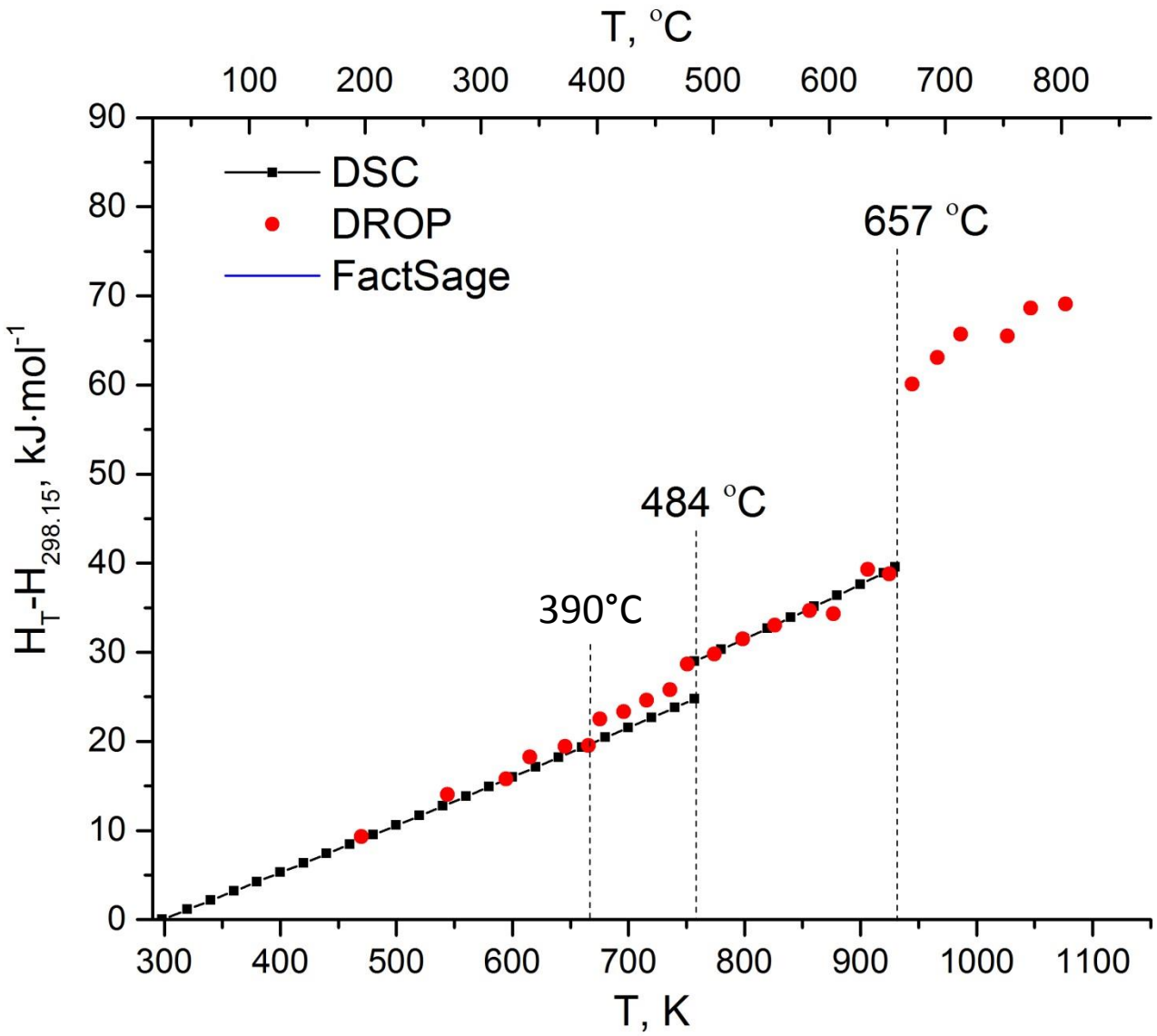
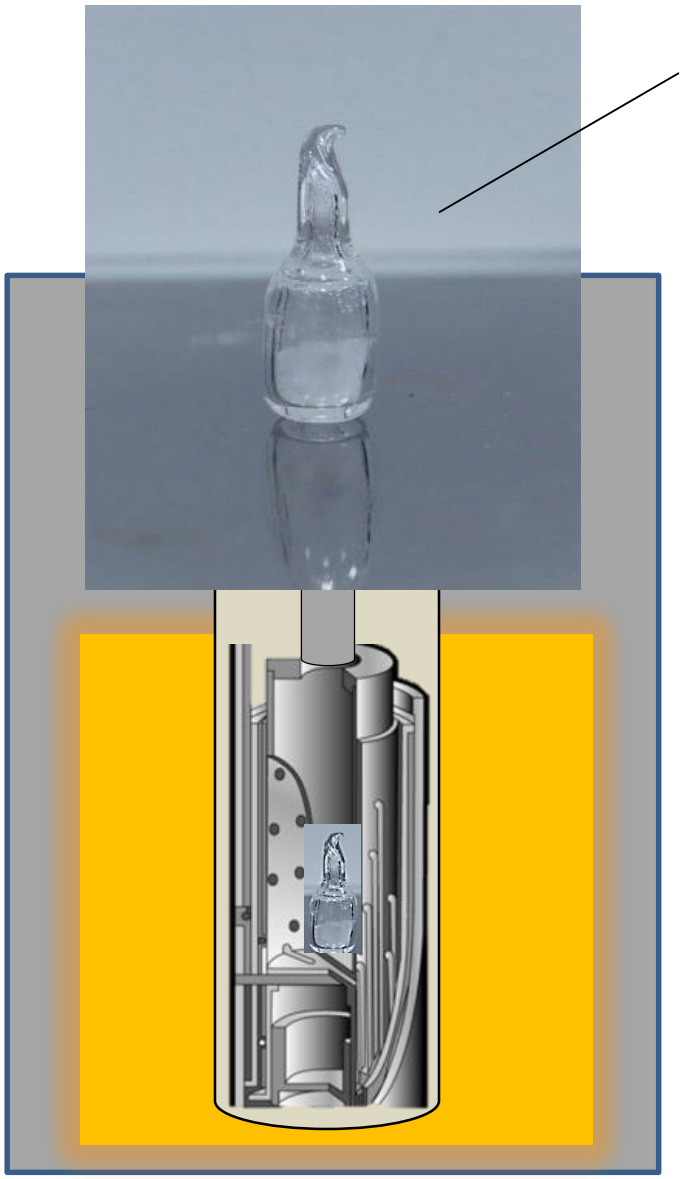


Enthalpy increment in the 50NaCl – 50KCl mixture

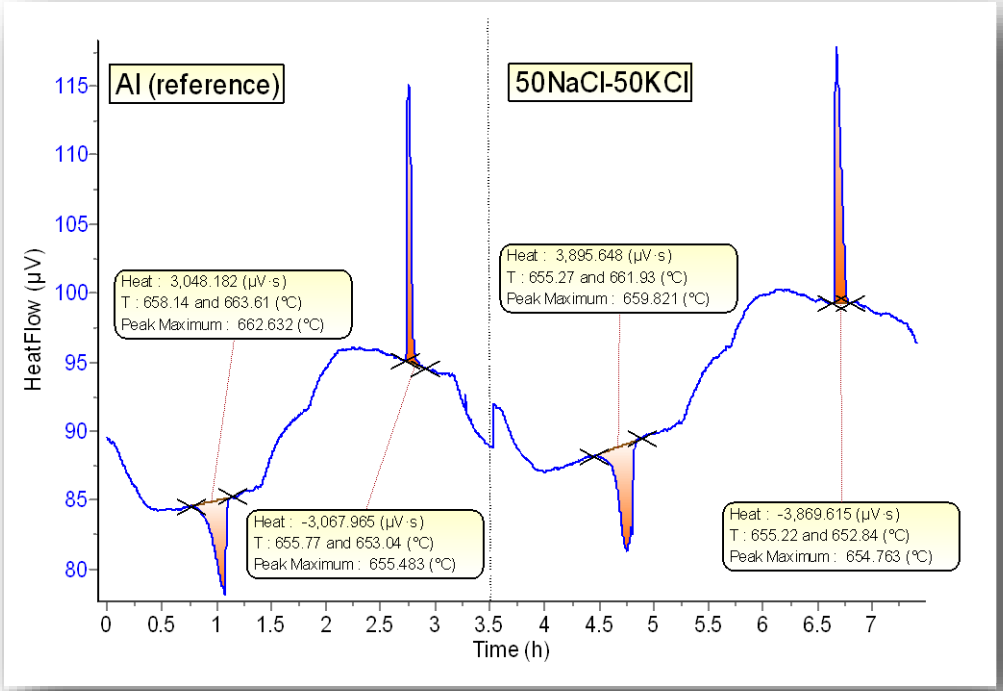


~~Drop~~ Calorimetry

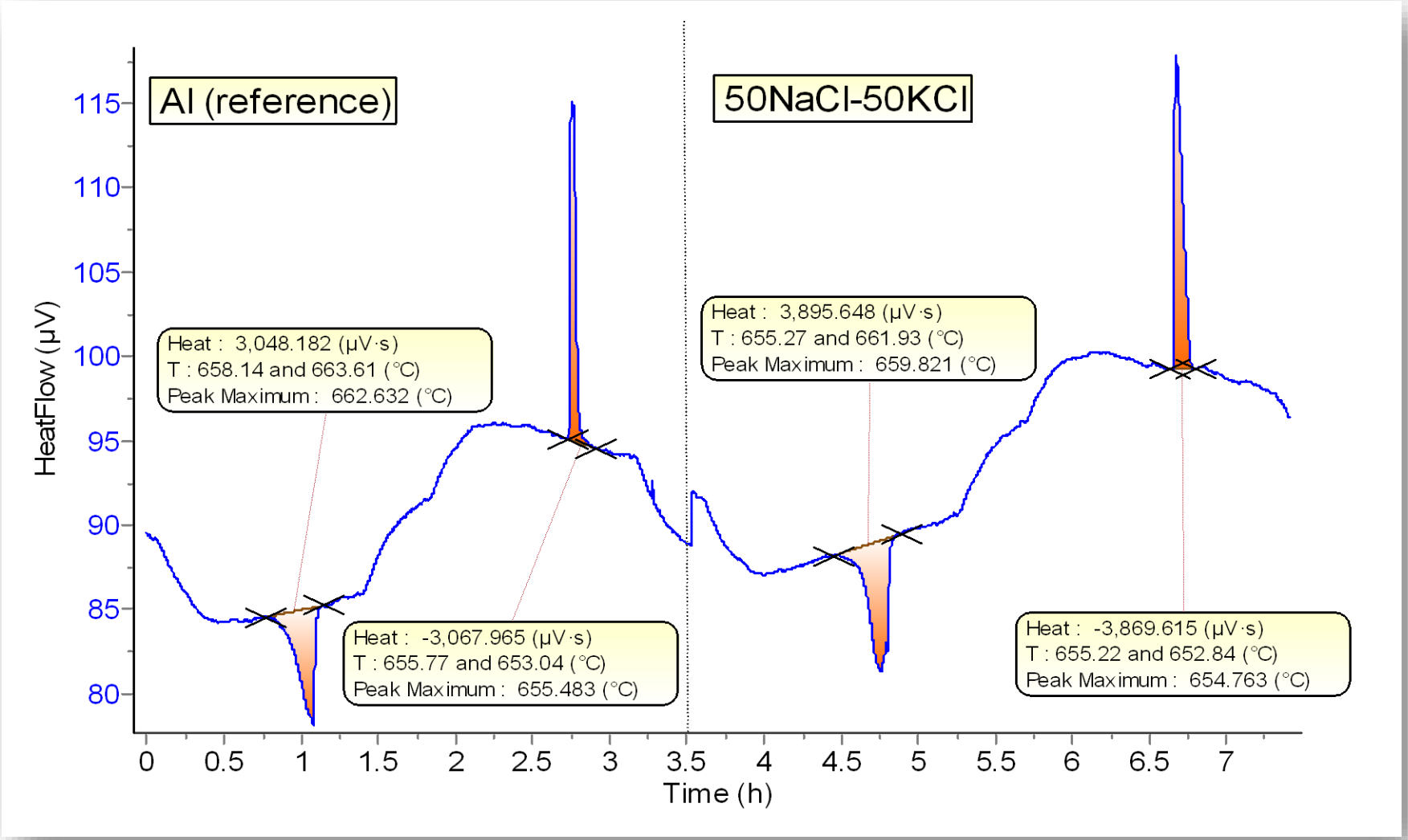


Sample like as in the DSC measurements

Heat rate 0.25 K/min



~~Drop~~ Calorimetry



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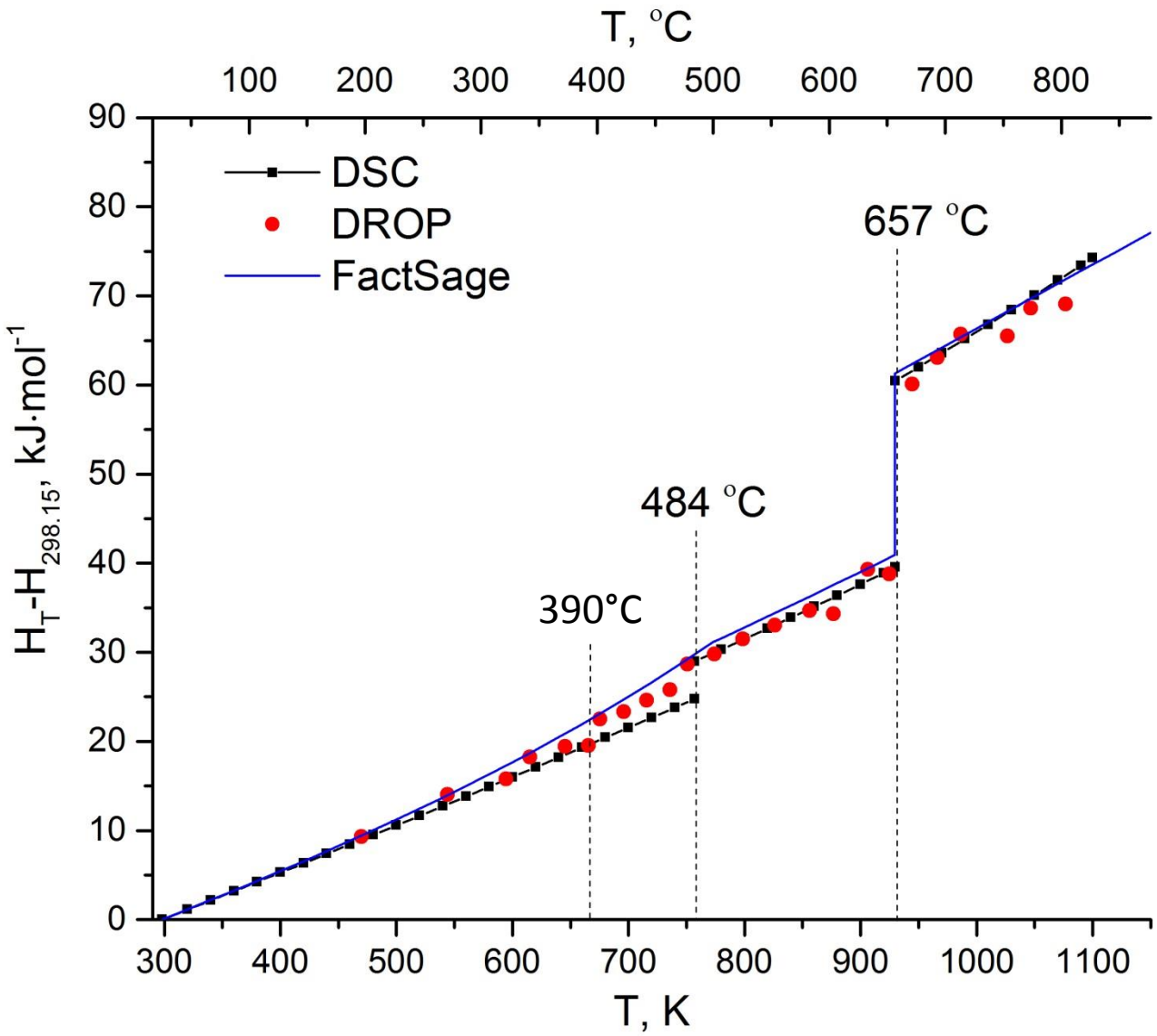
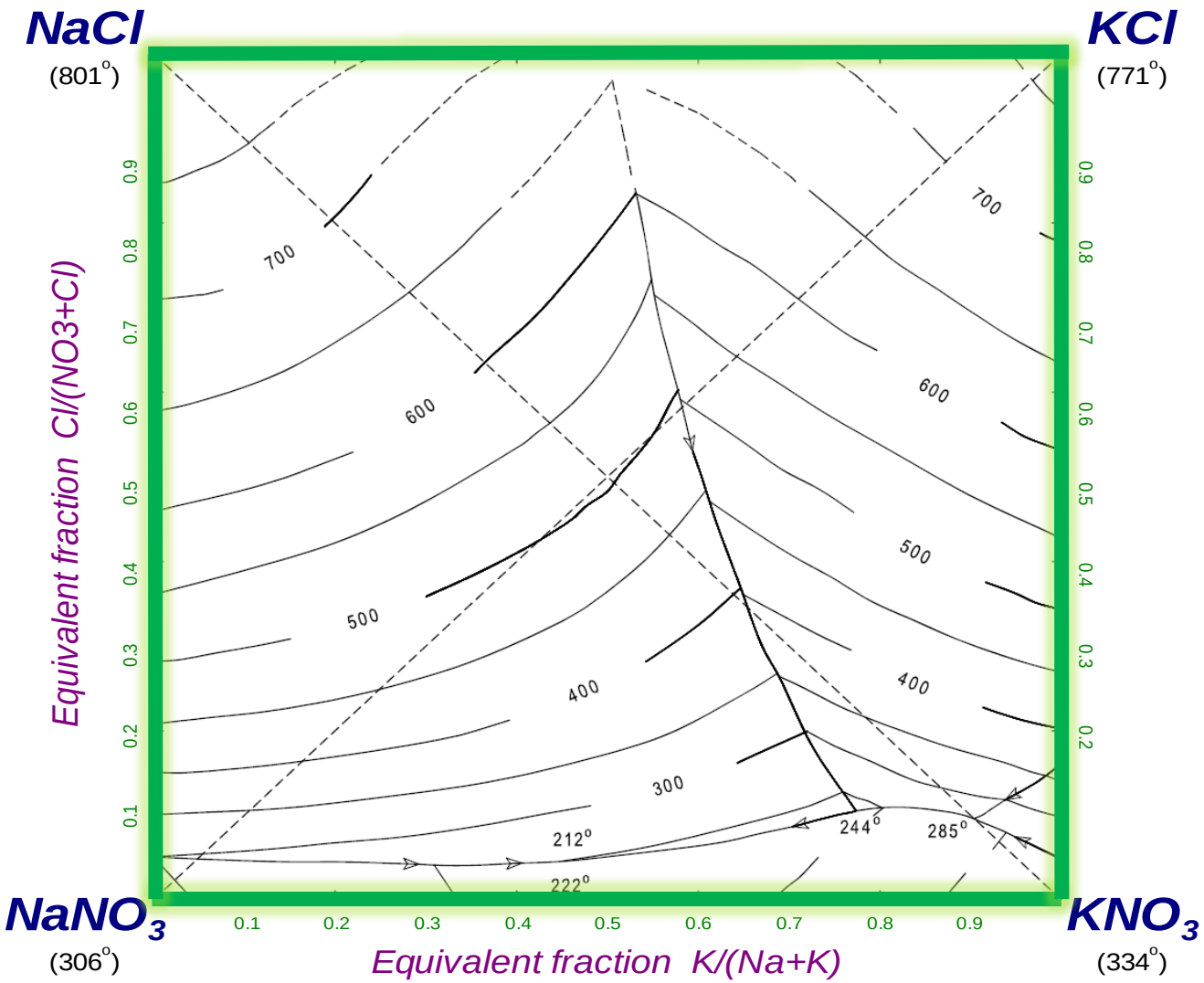
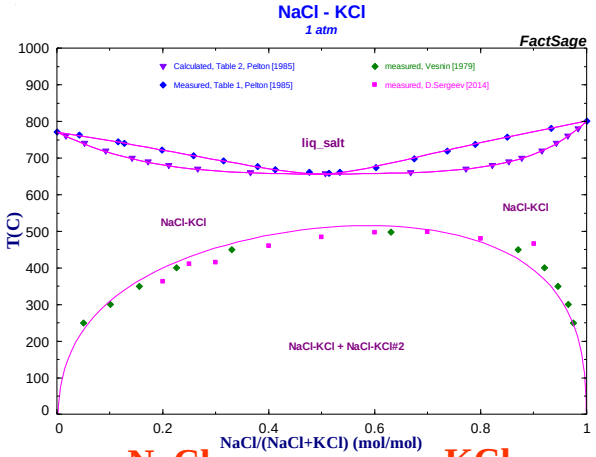


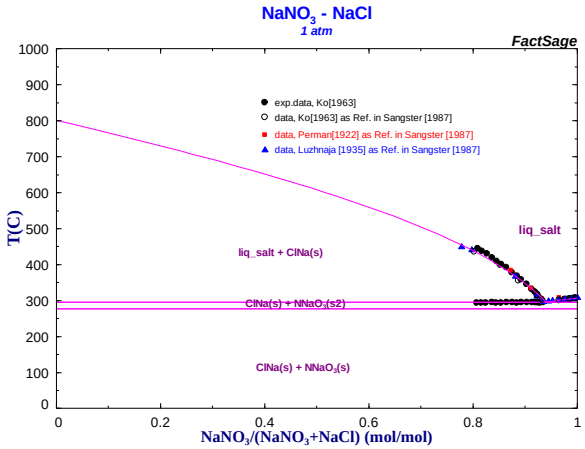
Reciprocal NaCl-KCl-$NaNO_3$-KNO_3 system

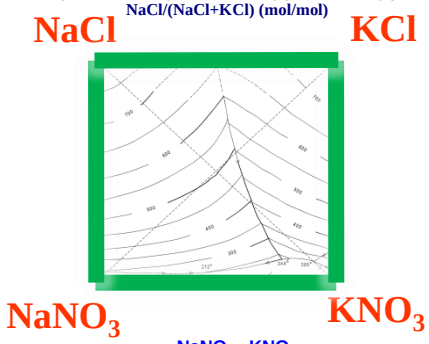


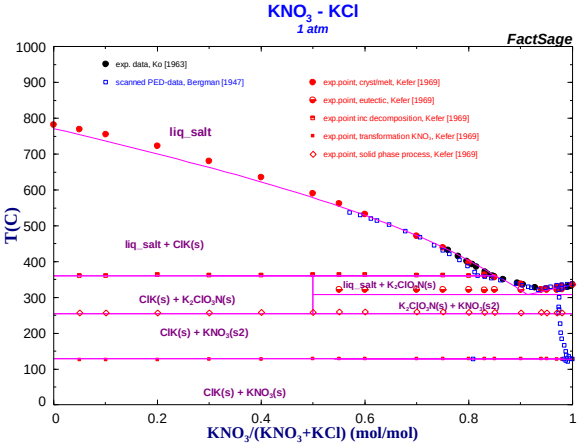
R.N. Nyankovskaya, *Izv. Sekt. Fiz.-Khim. Anal.*, 21 (1952) 259-270.

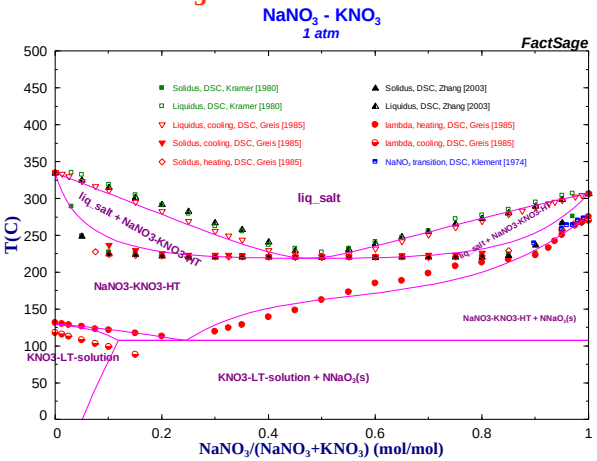
Modelling results of the binary salt systems



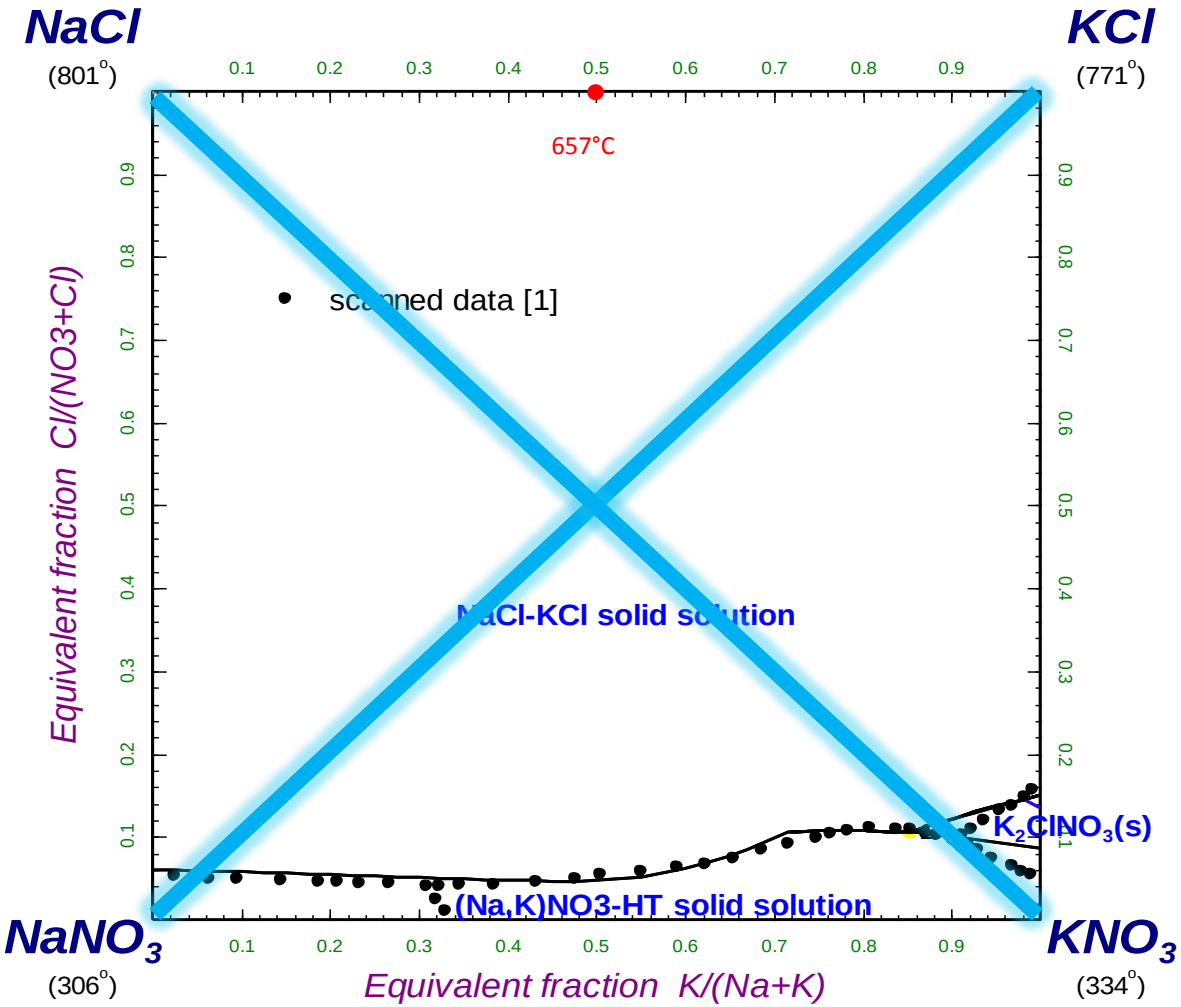








Univariant line of the NaCl-KCl-$NaNO_3$-KNO_3 system



[1] R.N. Nyankovskaya, *Izv. Sekt. Fiz.-Khim. Anal.*, 21 (1952) 259-270.

Simultaneous Thermal Analyzer TG+DTA

STA 449C Netzsch

Sample Preparation

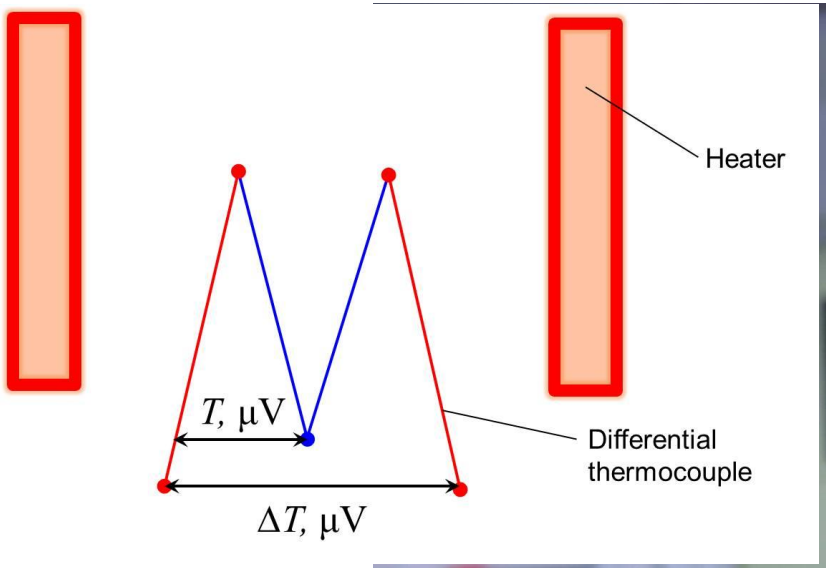
Glove box

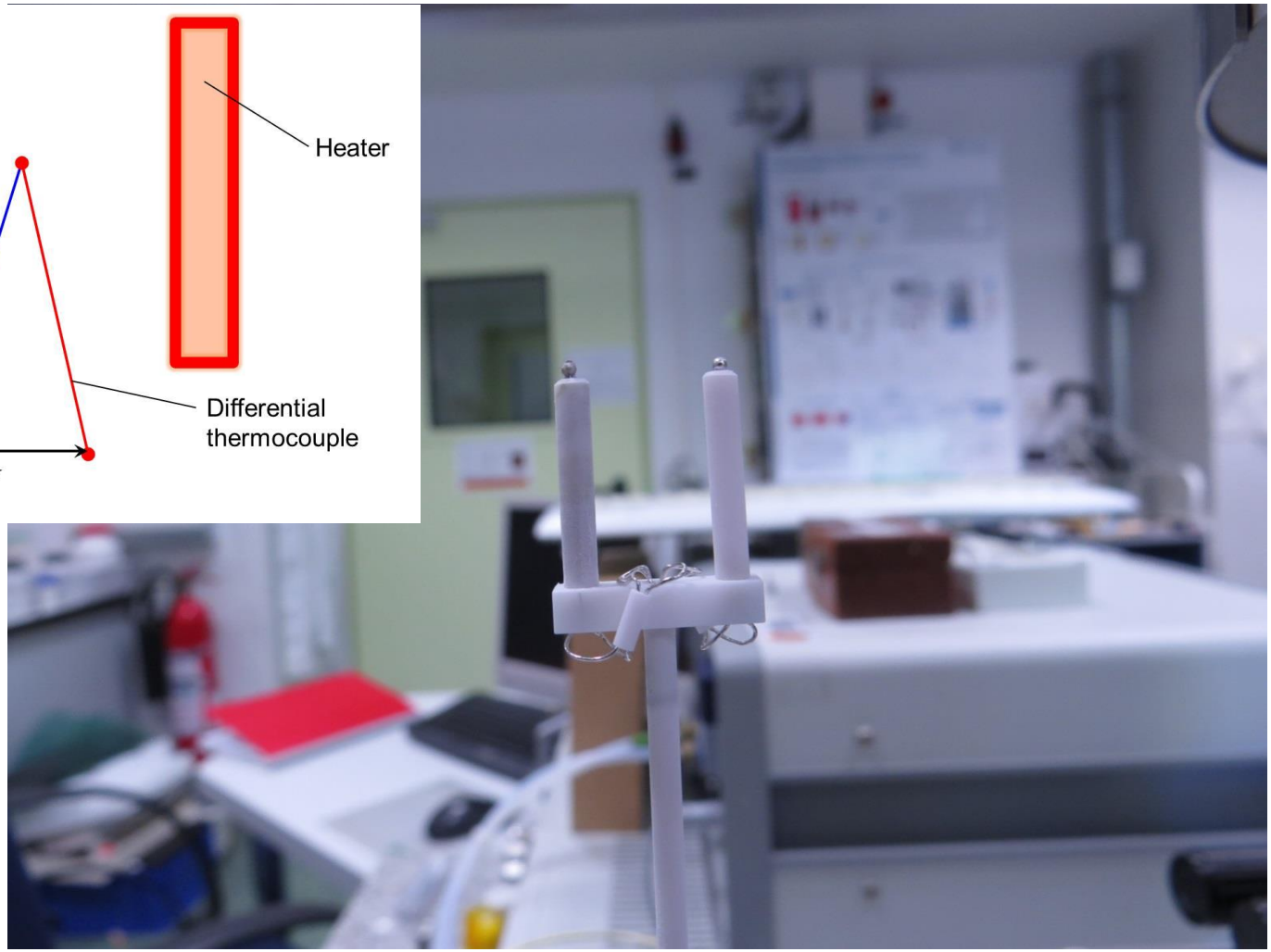
Vacuum seal

Closed glass containers

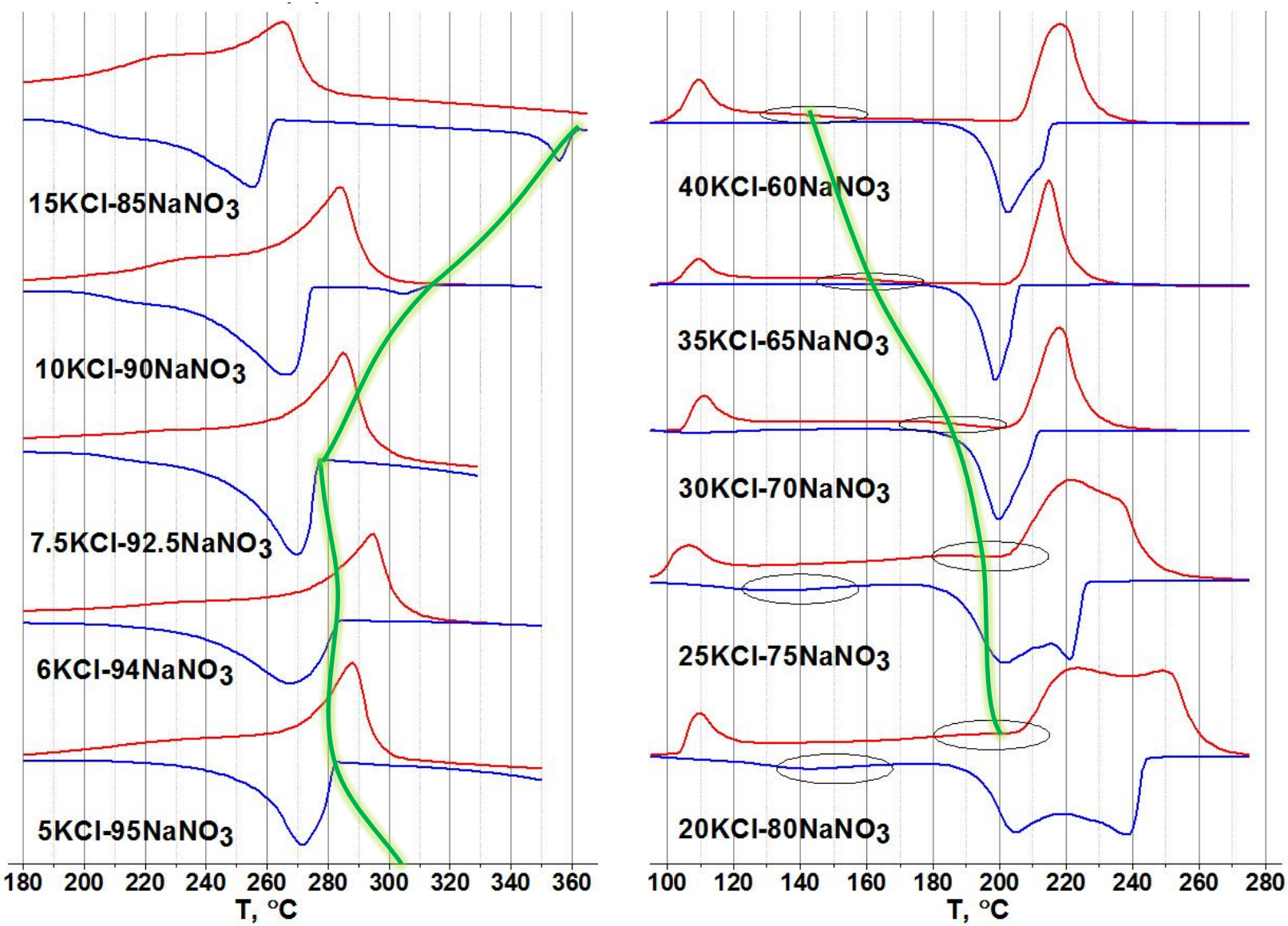
Differential Thermal Analysis (DTA)

Sample holder

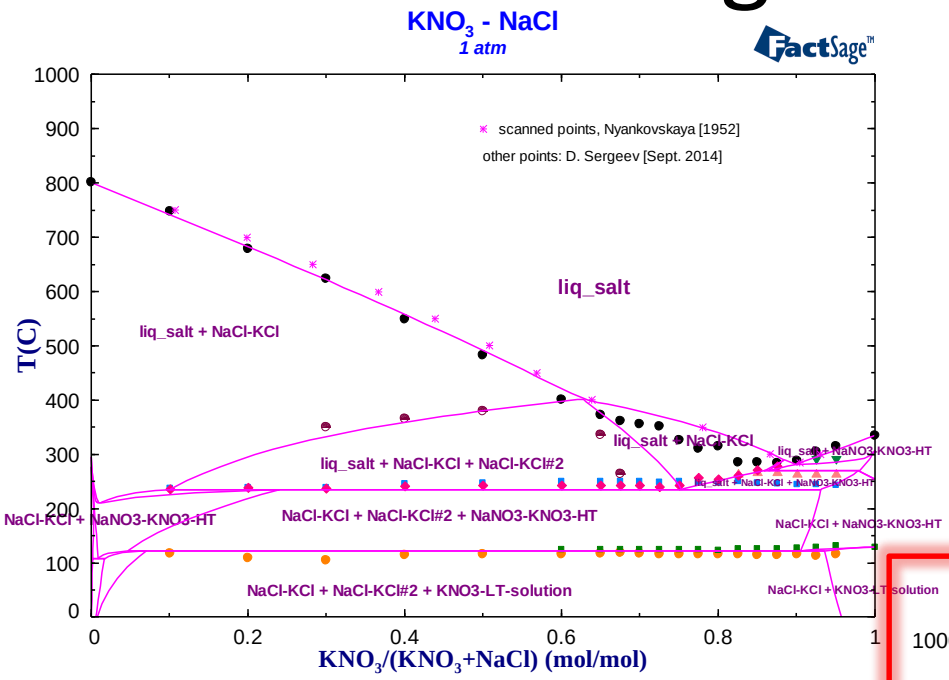


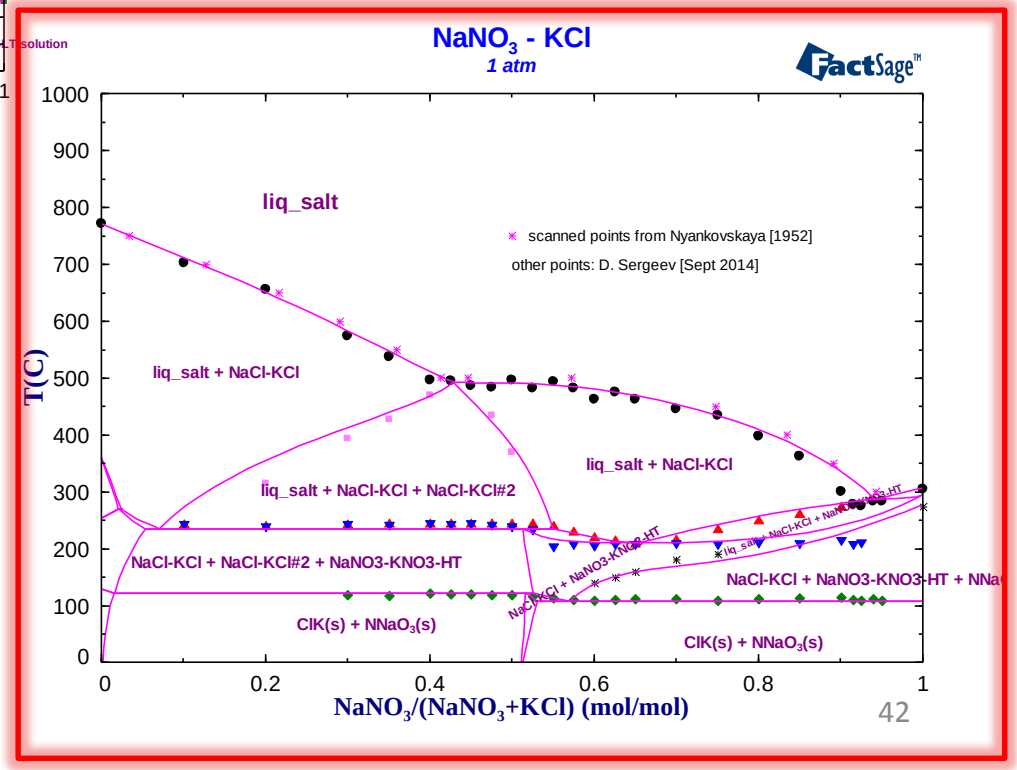


DTA curves of the KCl-$NaNO_3$ system

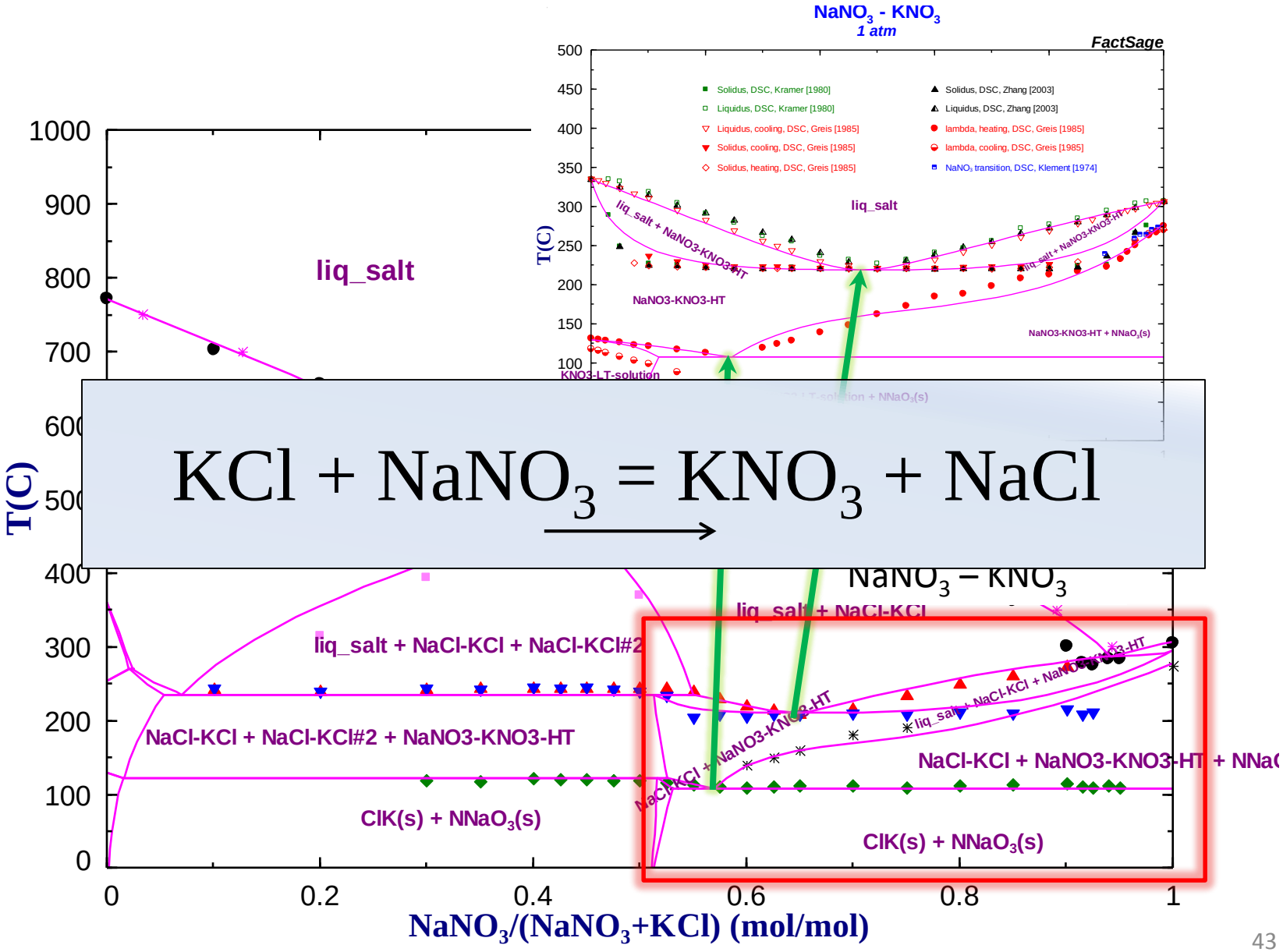


Diagonal Systems



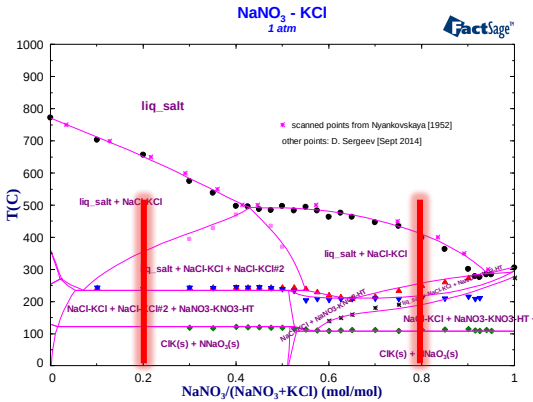


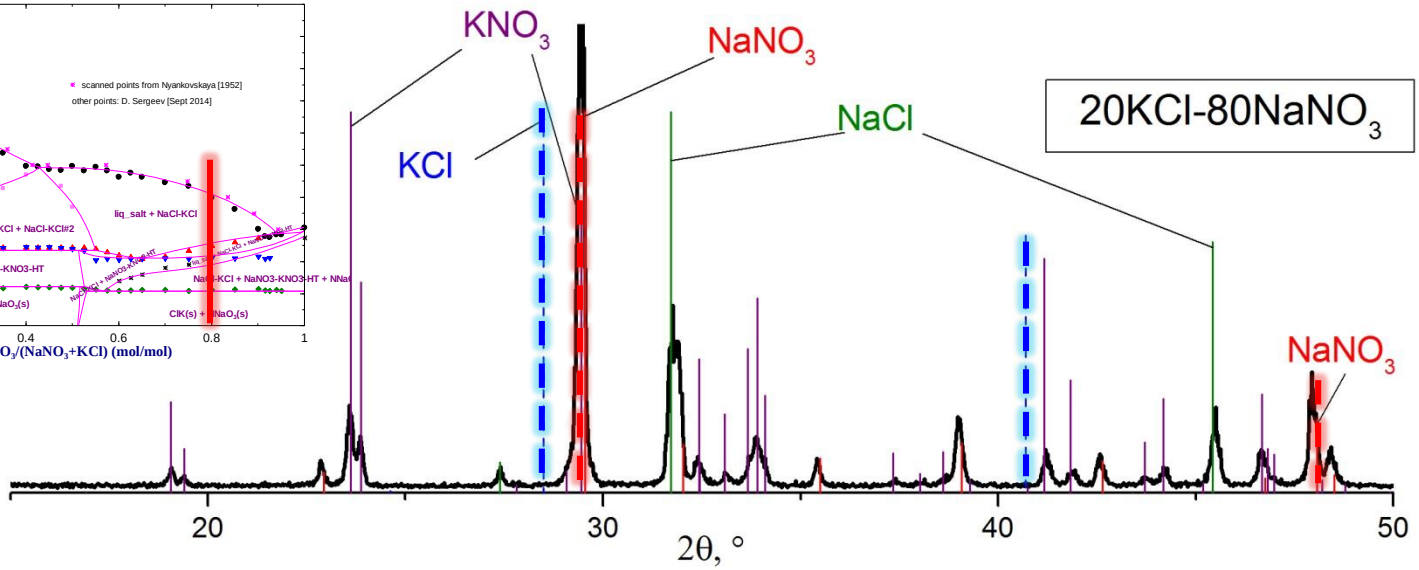
Diagonal System

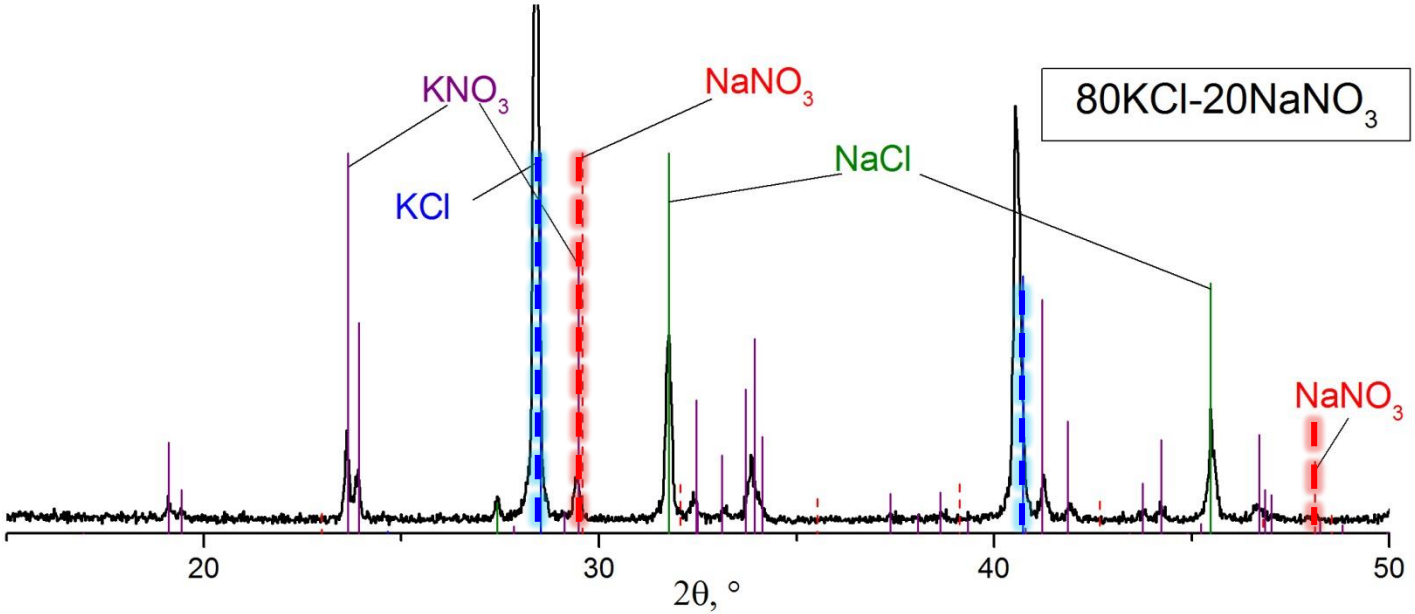


$$KCl + NaNO_3 \rightarrow KNO_3 + NaCl$$

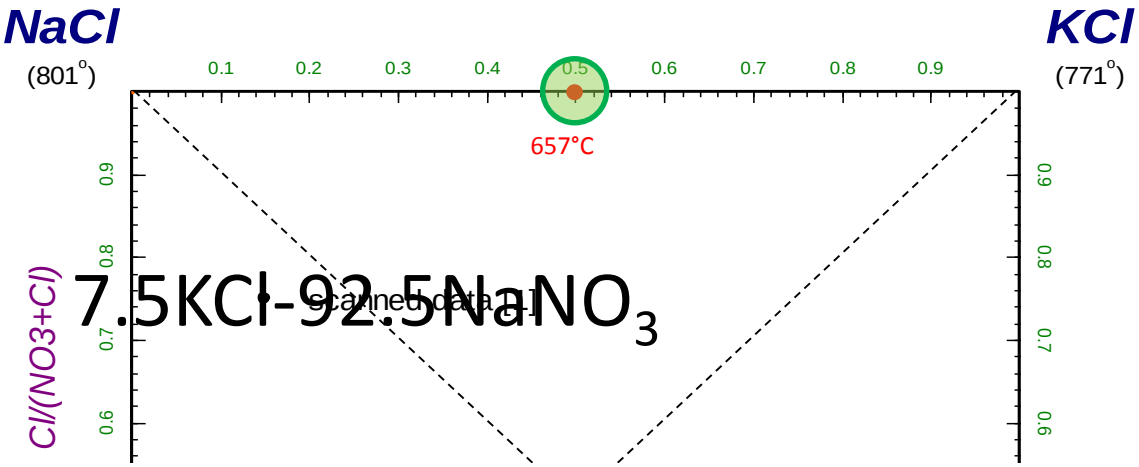
XRD Analysis of KCl-$NaNO_3$ System

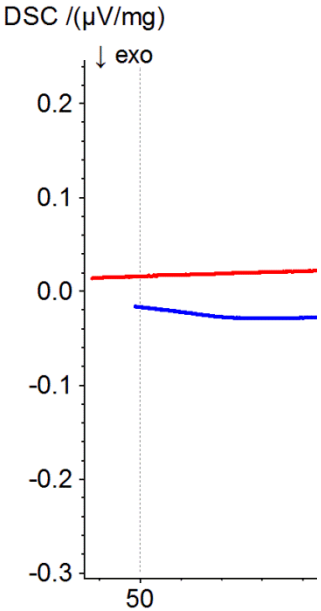


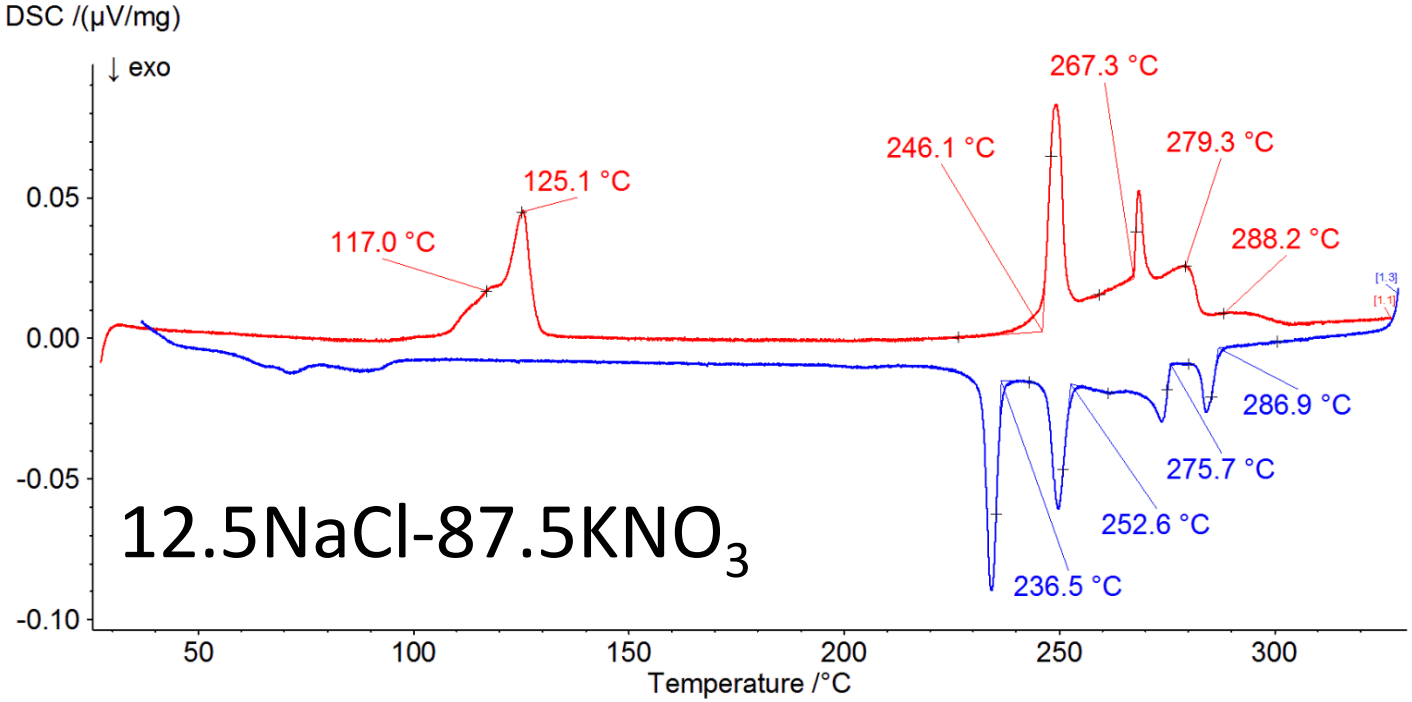




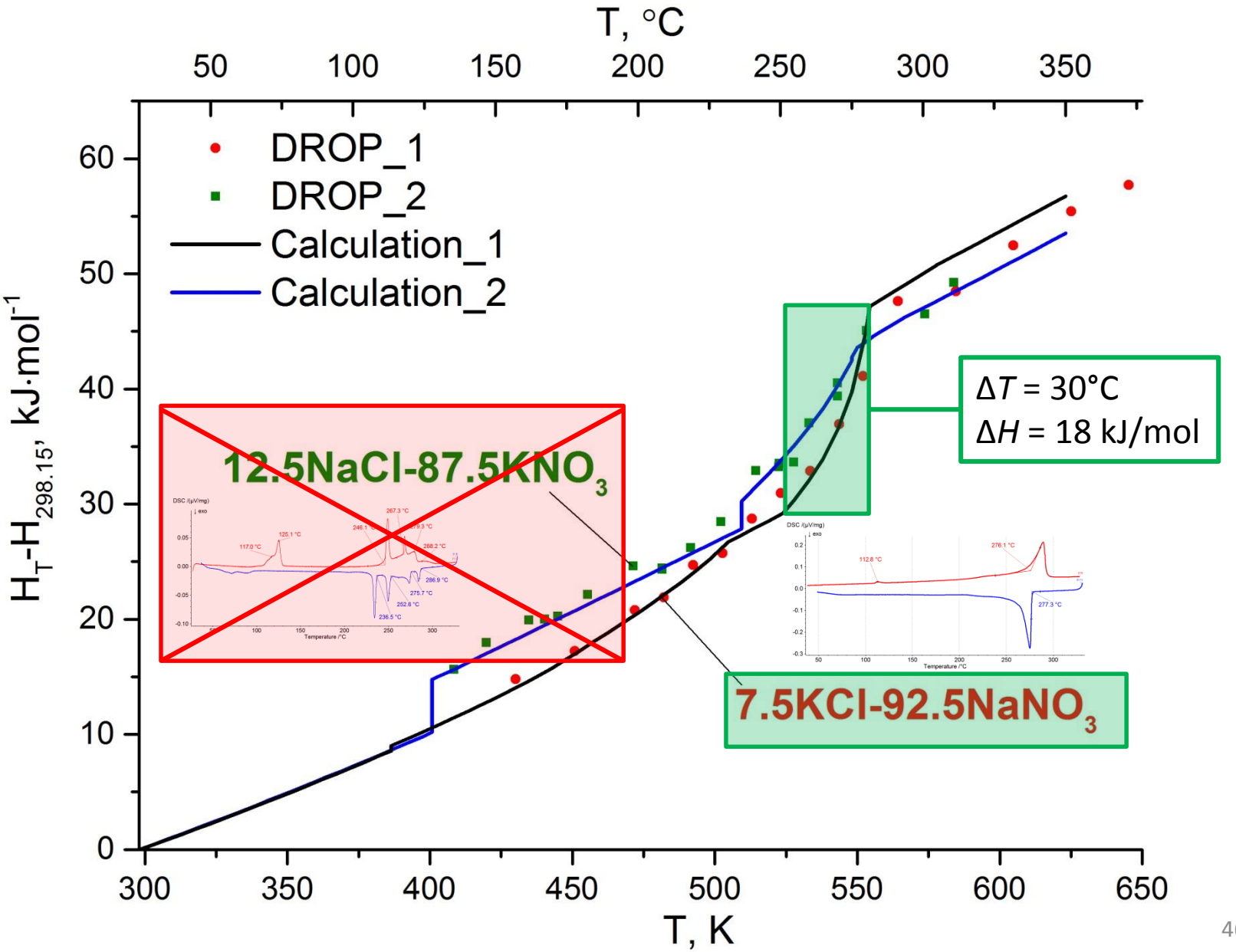
Reciprocal NaCl-KCl-$NaNO_3$-KNO_3 system







Heat Increment



Energy Saving Technologies

Thank you for your kind attention!