Institute of
Engineering Thermodynamics

Dehydration and Thermal Stability of a Ternary Nitrate Salt Mixture in Upscaling Experiments

Veronika A. Sötz, Alexander Bonk and Thomas Bauer.

German Aerospace Center (DLR), Linder Höhe, 51147 Köln, Germany.
Contact: +49 2203 601 3606, Veronika.Soetz@dlr.de.

Motivation

Advantages of *YaraMOST*, compared to the current state of the art material Solar Salt[1-3] (Fig. 1)

- Low price of $Ca(NO_3)_2$, Cost reduction
- Lower melting point, Increased specific storage capacity, Reduced risk of freezing

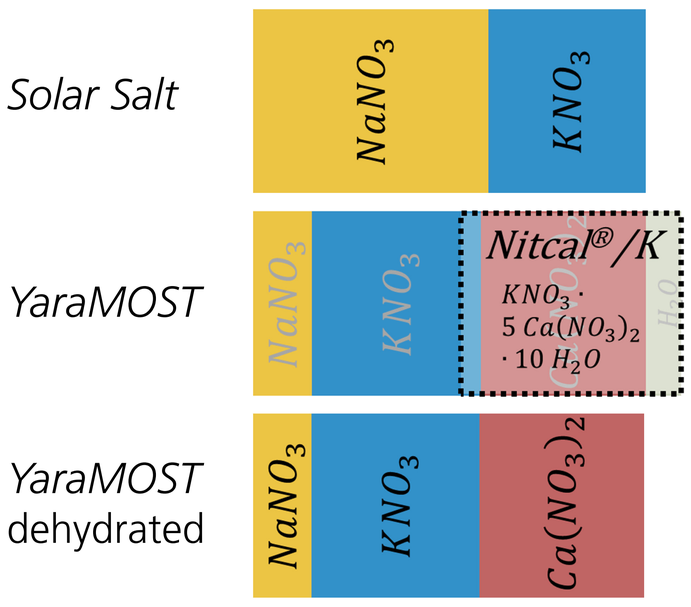

Figure 1. Compositions of Solar Salt and YaraMost by weight fractions.

Scope

- Experimental testing in different experiment scales
- Dehydration characteristics
- Thermal stability and decomposition reactions

Salt Chemistry

- Formation of nitrite and oxygen
$$NO_3^- \rightleftharpoons NO_2^- + 0.5\,O_2$$
- Formation of oxides and nitrous gases, e.g.
$$2\,NO_2^- \rightleftharpoons O^{2-} + NO + NO_2$$
- Chemical equilibrium and reaction kinetics depend on the cation composition

Experimental Set-Ups

- Thermogravimetric Analysis
50 **mg** salt sample,
Recording of mass changes
- Autoclave Test Rig (Fig. 2, left)
200 **g** salt sample,
Recording of condensed water,
Post-analysis of salt samples with ion chromatography and titration
→ Ion composition of the molten salt
- 100 **kg**-Furnace (Fig. 2, right)
Recording of condensed water,
Post-analysis of salt samples with ion chromatography and titration → Ion composition of the molten salt,
Gas analysis → Monitoring of decomposition gases

All experiments are executed under synthetic air purge flow.

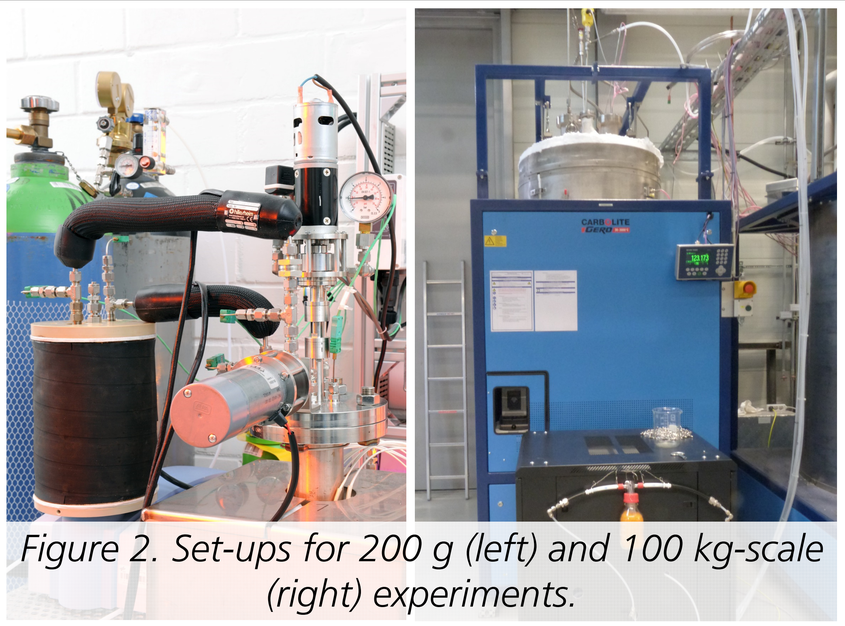

Figure 2. Set-ups for 200 g (left) and 100 kg-scale (right) experiments.

Results and Conclusion

- Dehydration
95% dehydration is reached at ~230 °C in all experiments,
Dehydration time increases with molten salt thickness (Fig. 3)
- Thermal stability (Fig. 4)
High nitrite concentration compared to *Solar Salt* (2.7 mol% at 500 °C, 4.6 mol% at 525 °C[4]),
Nitrite level stabilizes when chemical equilibrium is approached,
Formation rates of nitrite are decelerated in the 100 kg experiment

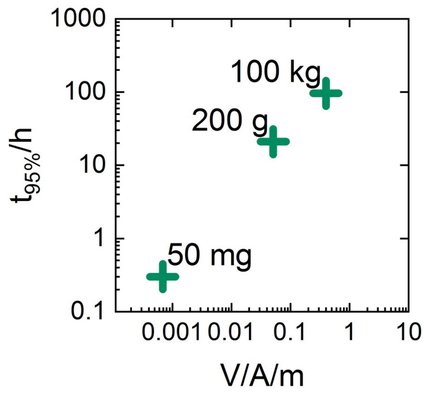

Figure 3. Dehydration times versus volume-to-surface ratio.

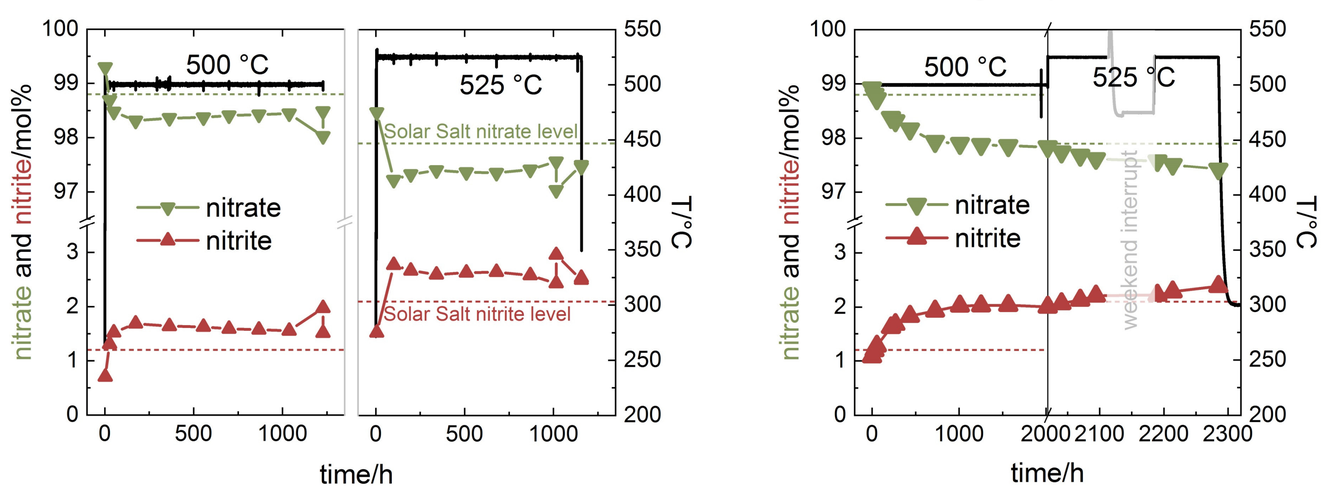

Figure 4. Ion composition with regard to nitrate and nitrite ions at 500 and 525 °C in the 200 g (left) and 100 kg-scale (right) experiments.

Chemical reaction towards oxide ions and nitrous gases:
Oxide deposits at contact area of salt surface and container walls (525 °C),
NO_x production, depending on temperature and purge gas flow rate

→ YaraMOST is a promising candidate for sensible heat storage.
It requires careful handling with regard to oxide and NO_x formation (>500 °C).

Acknowledgements

The research leading to these results has received funding from the European Union H2020-NMBP-2016-2017 Program under grant agreement n° 720985 (NewSol). We greatly appreciate our project partners from Yara and University of Évora.

References

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