Concentrating Solar Power at higher limits: Studies on molten Nitrate Salts at 620°C in a laboratory pilot-scale hot tank

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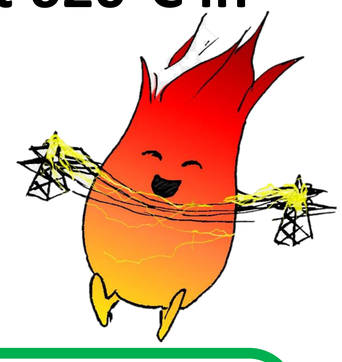
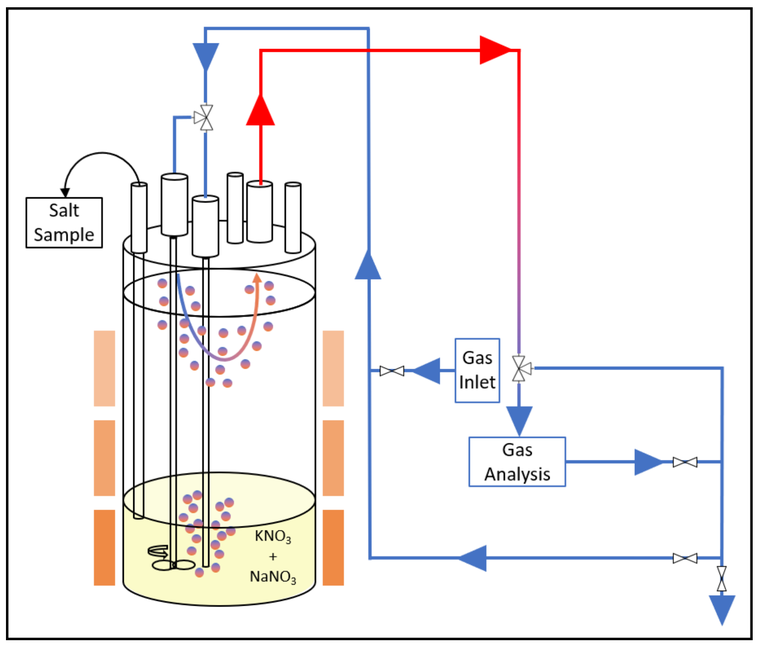
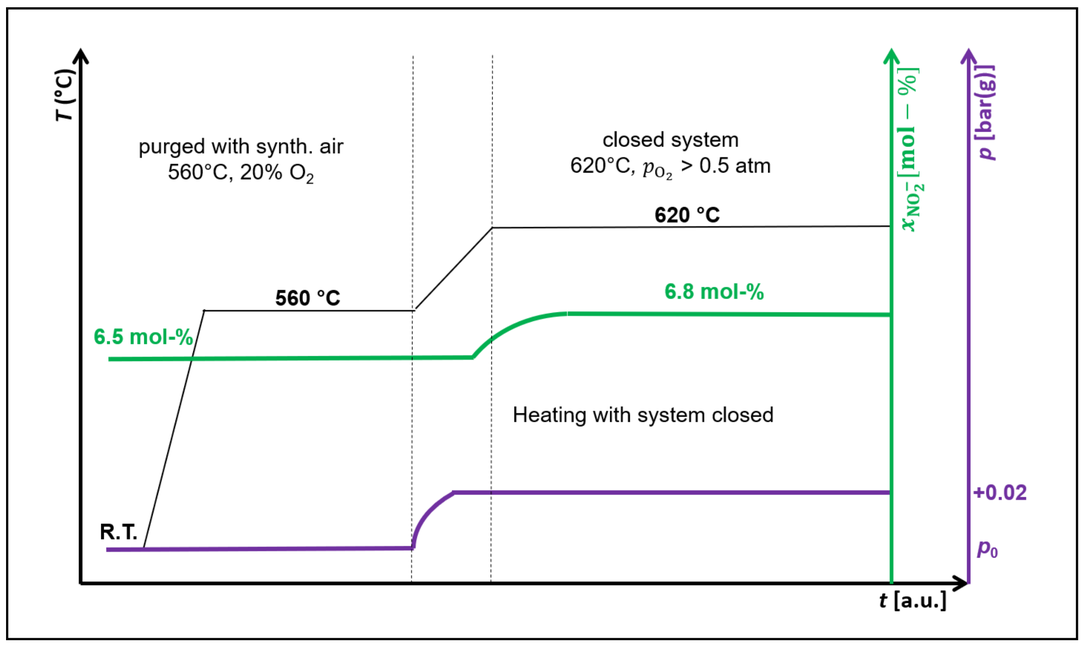


Motivation

- Molten Solar Salt (60 wt-% $NaNO_3$, 40 wt-% KNO_3) is the state-of-the-art media in modern concentrated solar power plants (CSP) at up to 565 °C[1]
- Volumetric storage capacity, heat-to-electric conversion efficiencies mostly rely on the applied hot tank temperature[2,3]
- Thermal stability in terms of decomposition of the nitrate ions limits the maximum operating temperature
- Stability maintained up to 600 °C in a lab-scale by sealing the storage system[4]
- No experiments on Solar Salt with temperatures beyond 565 °C in a larger scale (> 100 kg) known

Experimental Set-Up

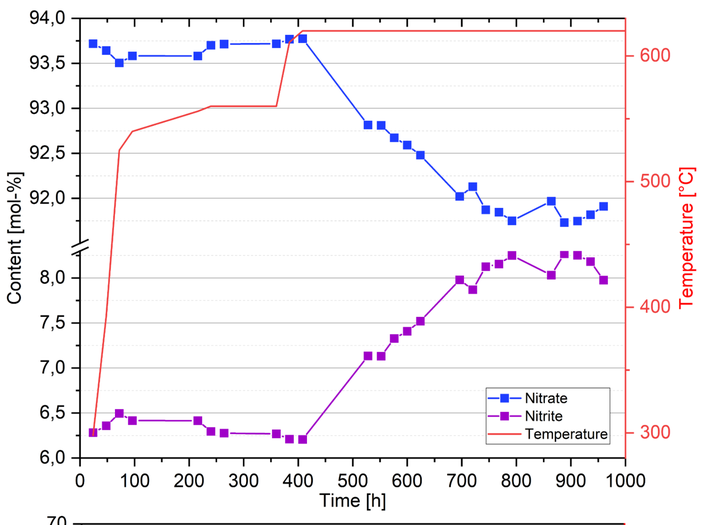


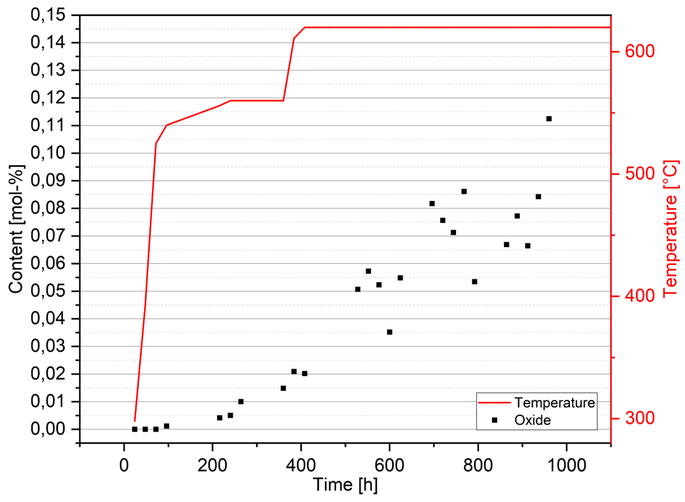


- 100 kg technical-scale hot tank with in situ gas analysis, temperature and pressure control
- T_{max} = 620 °C, p_{max} = 0.02 bar(g), t ≈ 2000 h
- Starting salt composition: Solar Salt (60 wt-% $NaNO_3$, 40 wt-% KNO_3), 6.5 mol-% $NaNO_2$
- Post-analysis of salt samples with ion chromatography (IC) and titration → Ion composition of the molten salt
- Continuous gas analysis measurement → Monitoring of decomposition gases (NO, NO_2, O_2)

Results

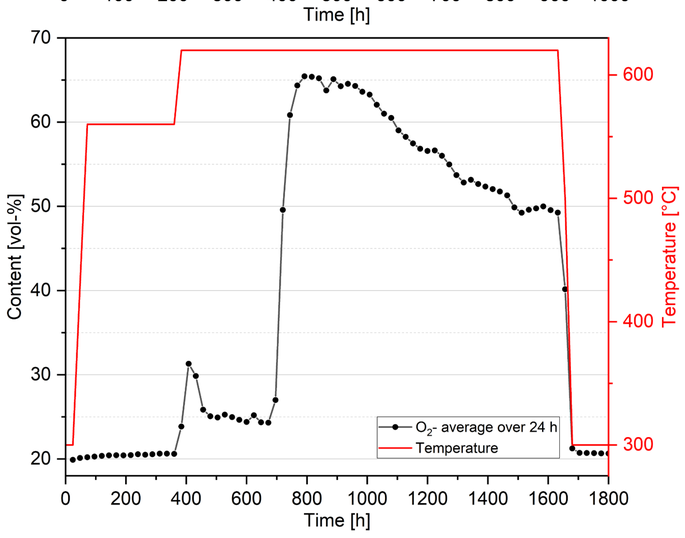
Ion composition with regard to nitrate/nitrite at 300 – 620 °C obtained from IC measurements.

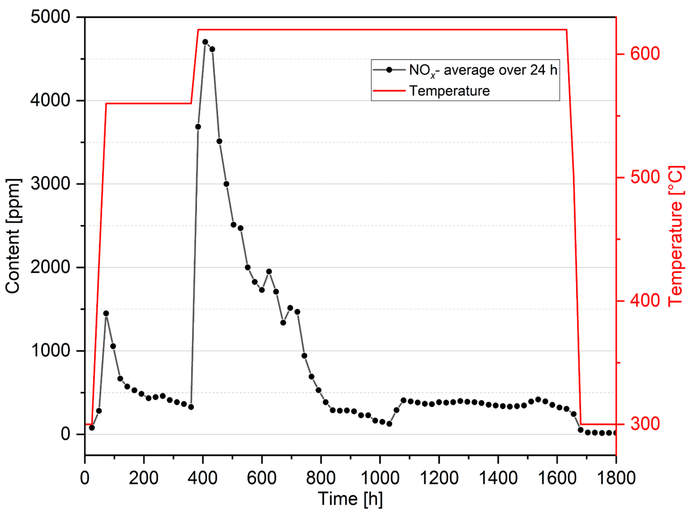




Oide ion content at 300 – 620 °C obtained via titration with $HCl_{(aq)}$ according to Warder.

Oxygen content of the gas phase in the furnace and gas system during the experiment in vol-%.





NO_x content of the gas phase in the furnace and gas system during the experiment in ppm.

Summary & Conclusion

- Operation of 100 kg hot tank VeraHTS A at T_{max} = 620 °C successful
- Stable nitrate / nitrite content (92 mol-% / 8 mol-%) → chemical equilibrium reached after about 800 h
- Lower nitrate / higher nitrite content compared to 200 g lab-scale
- Stable oxide content at around 0.12 ppm

➢ Raising the temperature of molten Solar Salt beyond the state-of-the-art level while maintaining salt stability is possible

References

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[3] A. G. Fernández, J. Gomez-Vidal, E. Oró, A. M. Kruizenga, A. Solé, L. F. Cabeza, *Renewable Energy*, **2019**, *140*, 152–176.
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