State of the art

Sensible heat storage in molten nitrate salts
in the temperature range ~280 to ~560 ° C

Physical-chemical investigation
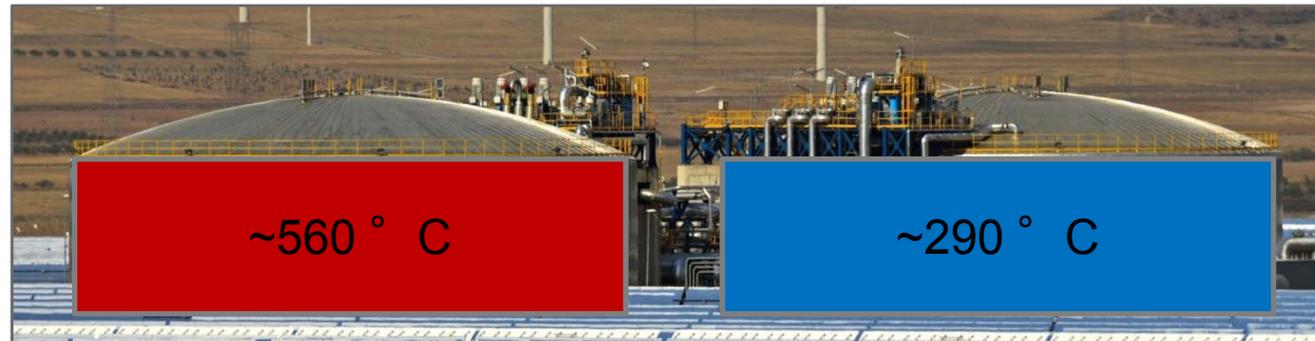# and modeling of nitrate salt melts

Veronika Sötz

Presentation at SOLLAB doctoral colloquium
15. to 17.05.2017

Wissen für Morgen

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Physical-chemical investigation and modeling of nitrate salt melts

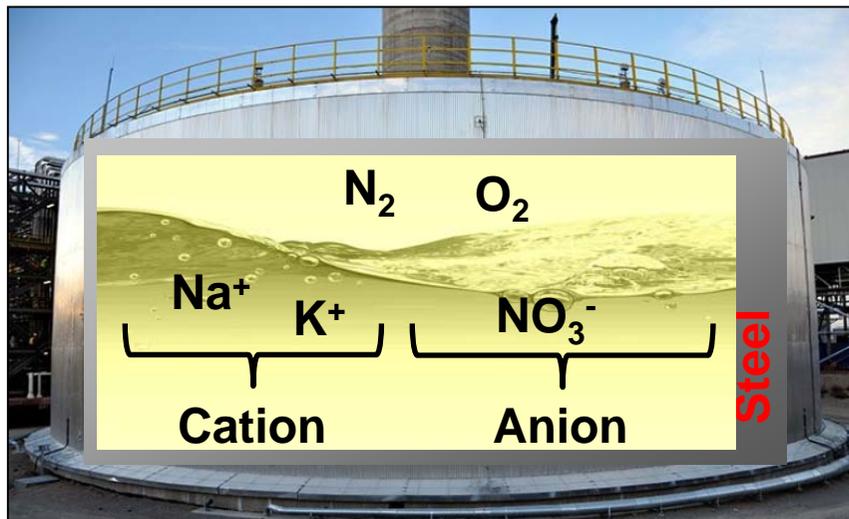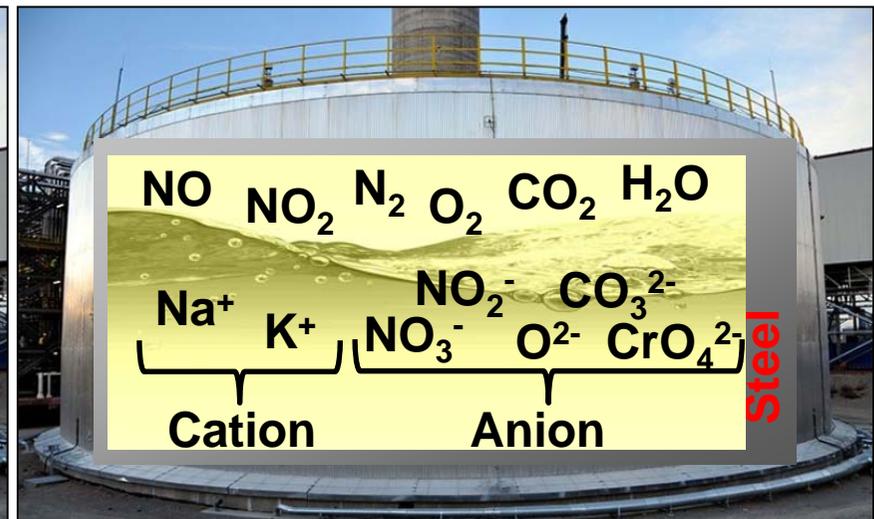|	
State of the art	~560 °C ~290 °C
Goals and Motivation	• Higher storage capacity $\Delta Q \sim \Delta T$ • More efficient conversion of heat to power • Simulation tool

Physical-chemical investigation and modeling of nitrate salt melts

Challenges

'ideal'

N_2 O_2

Na^+ K^+ NO_3^-

Cation   Anion

Steel

'real'

NO NO_2 N_2 O_2 CO_2 H_2O

Na^+ K^+ NO_2^- CO_3^{2-}

NO_3^- O^{2-} CrO_4^{2-}

Cation   Anion

Steel

Aims of the PhD

- Scientific comprehension of decomposition reactions, thermodynamic and kinetic description
- Development and verification of a model

State of knowledge
Nitrate-nitrite-reaction

- <u>Predominant reaction</u>
  between ~300 and ~550 °C:
  $$NO_3^- \rightleftarrows NO_2^- + 0.5\, O_2$$

- Reversible reaction, kinetics and
  thermodynamics are temperature
  and oxygen pressure dependent
  [Freeman 1956, Freeman 1957, Nissen 1983]
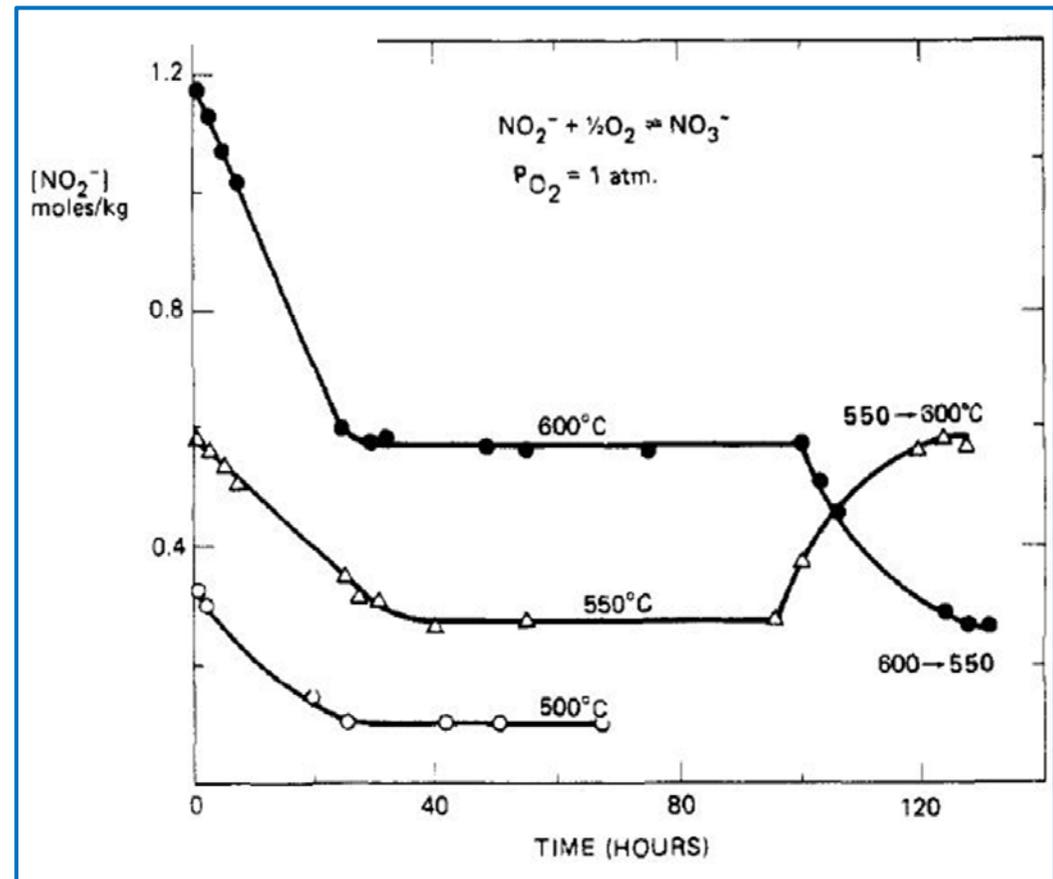
State of knowledge
Nitrate-nitrite-reaction

- <u>Predominant reaction</u> between ~300 and ~500 °C:

$$NO_3^- \rightleftarrows NO_2^- + 0.5\,O_2$$

- Reversible reaction, kinetics and thermodynamics are temperature and oxygen pressure dependent

[Freeman 1956, Freeman 1957, Nissen 1983]

- <u>Thermodynamics:</u>

Known equilibrium constant $K = \dfrac{x_{NO_2^-} \cdot p_{O_2}{}^{0.5}}{x_{NO_3^-}}$

[Carling 1981, Nissen 1983]

- <u>Kinetics:</u>

Known kinetic parameters (rate constants, activation energy)

[Freeman 1956, Freeman 1957, Bond 1966, Paniccia 1973, Nissen 1983]

State of knowledge
Further reaction

- <u>Nitrous gases</u> NO_x

  from thermal decomposition of nitrate and nitrite ions

  [Wei 2014]

- <u>Carbonate</u> CO_3^{2-}

  from dissolution of atmospheric CO_2 and subsequent reaction with oxide ions

  [Bonk 2016]

- <u>Metal impurities</u>

  from steels in corrosion experiments,

  e.g. chromate CrO_4^{2-}

Thank you!

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Literature

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Figures

o Slide 1-3, 6:   http://www.solarreserve.com/en/global-projects/csp/crescent-dunes, 20.01.20107

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                        /pdf/Solana_factsheet_09092013.pdf, 20.01.2017

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