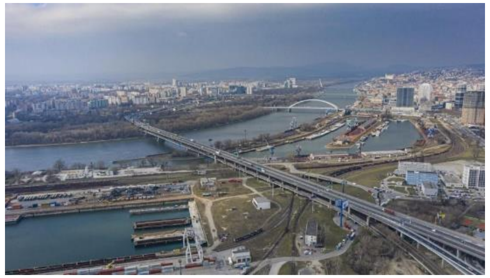
IIS SAS, Bratislava city, Slovakia

Institute of Inorganic Chemistry
Slovak Academy of Sciences




Head of the institute: Miroslav Boča

Speaker for this presentation: Viliam Pavlik

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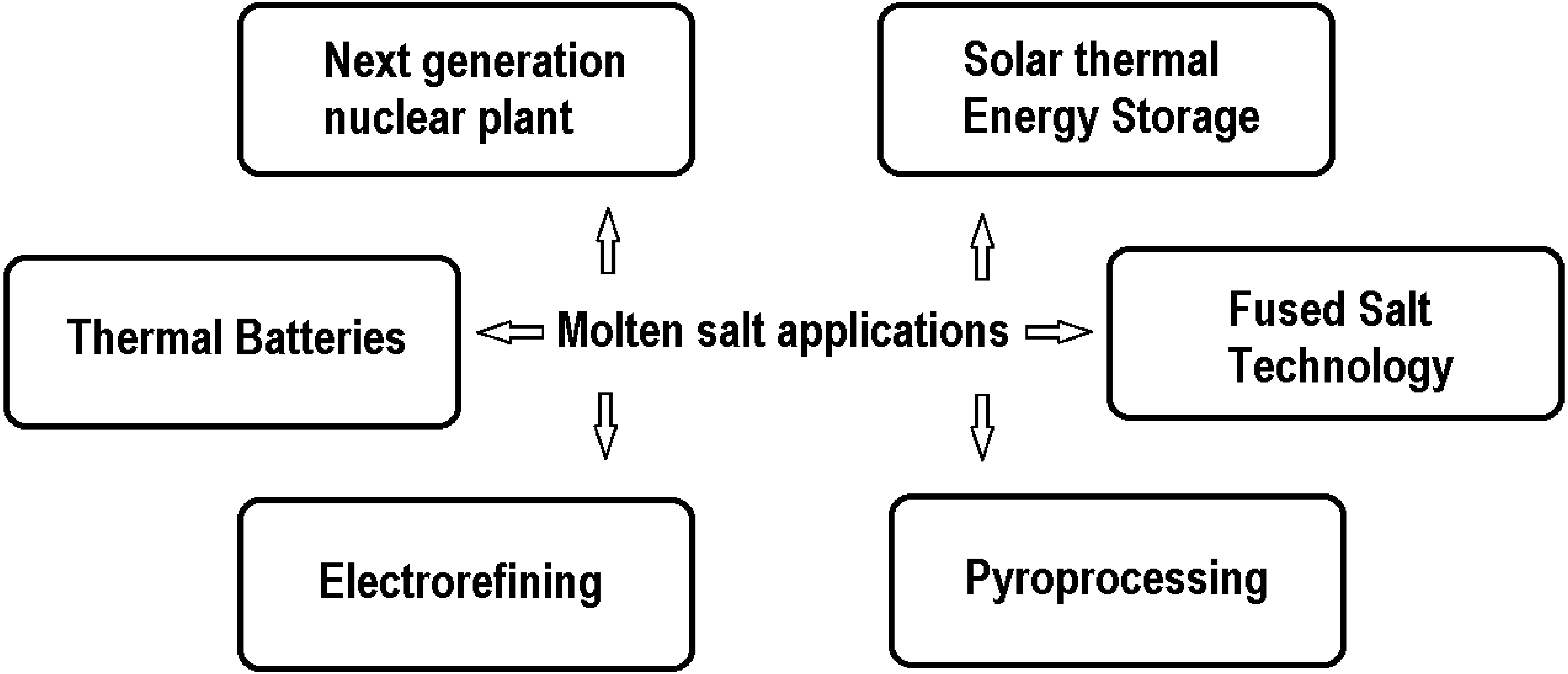
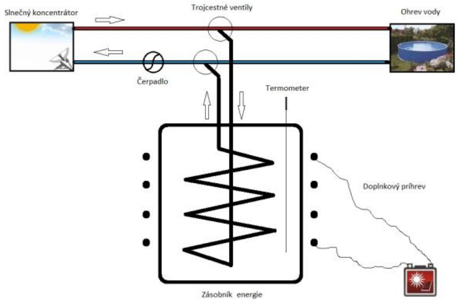
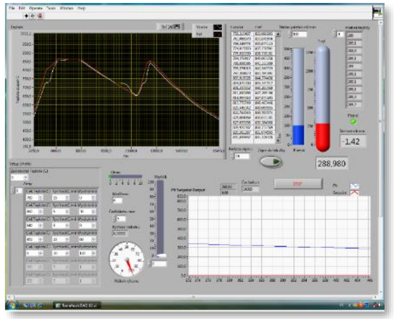
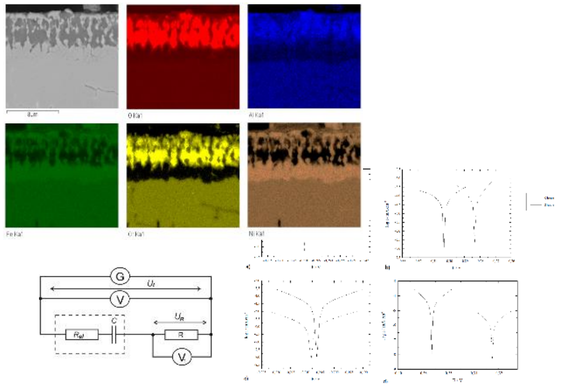

Next generation nuclear plant
Solar thermal Energy Storage
Thermal Batteries
Molten salt applications
Fused Salt Technology
Electrorefining
Pyroprocessing

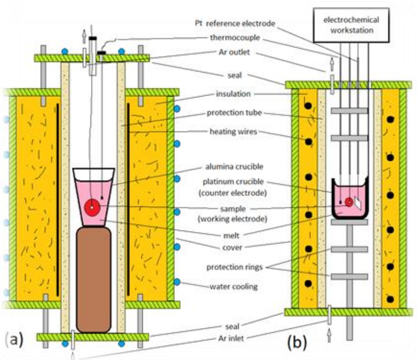
Motivations

- **Energy sector**
- **Automotive industry**
- **Metallurgy**

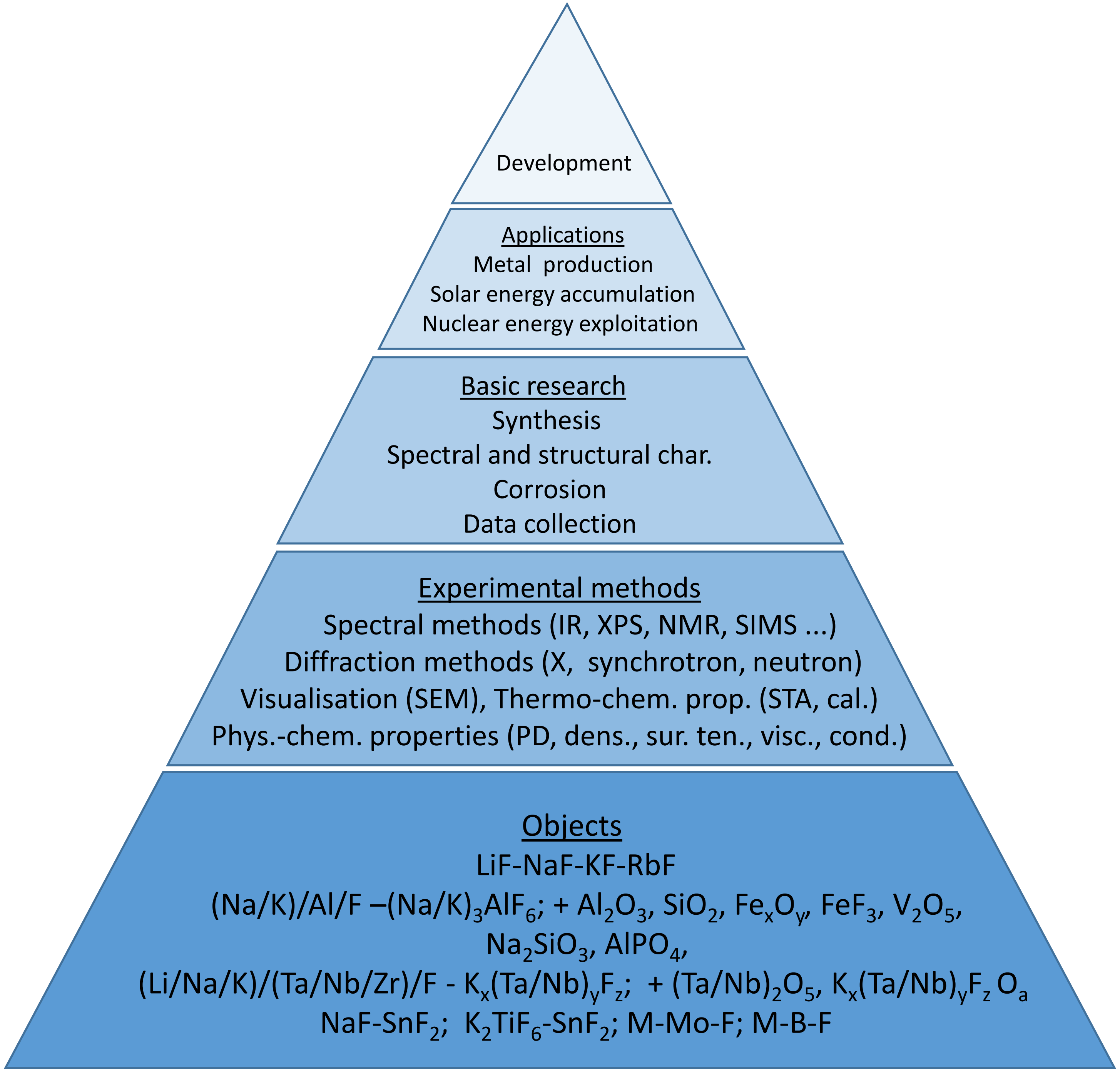






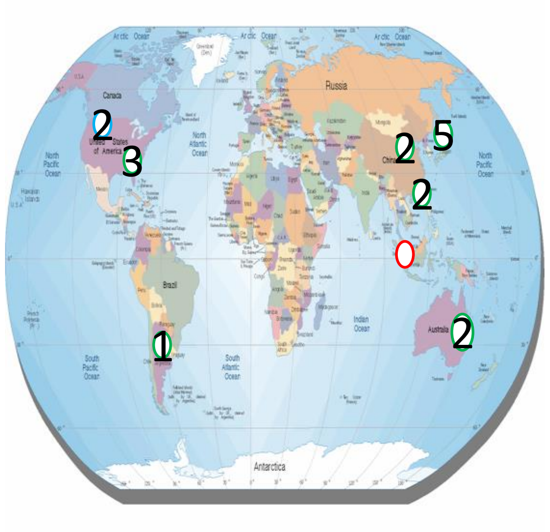


- Solar thermal energy storage
- Enable efficient, long-term high temperature materials/molten salts combinations
- Concentrated solar power system (CSP)
- Electrolytes for fuel cells and molten metal batteries
- Key reactor coolants, media for transfer of high temperature process heat from Gen-IV nuclear reactors
- Heat treatment of industrial components
- Pyroprocessing for extraction and purification of metals
- Catalysis
- Hi-tech applications



Development
Applications
Metal production
Solar energy accumulation
Nuclear energy exploitation
Basic research
Synthesis
Spectral and structural char.
Corrosion
Data collection
Experimental methods
Spectral methods (IR, XPS, NMR, SIMS ...)
Diffraction methods (X, synchrotron, neutron)
Visualisation (SEM), Thermo-chem. prop. (STA, cal.)
Phys.-chem. properties (PD, dens., sur. ten., visc., cond.)
Objects
LiF-NaF-KF-RbF
(Na/K)/Al/F –$(Na/K)_3AlF_6$; + Al_2O_3, SiO_2, Fe_xO_y, FeF_3, V_2O_5,
Na_2SiO_3, $AlPO_4$,
(Li/Na/K)/(Ta/Nb/Zr)/F - $K_x(Ta/Nb)_yF_z$; + $(Ta/Nb)_2O_5$, $K_x(Ta/Nb)_yF_zO_a$
NaF-SnF_2; K_2TiF_6-SnF_2; M-Mo-F; M-B-F

Cooperation

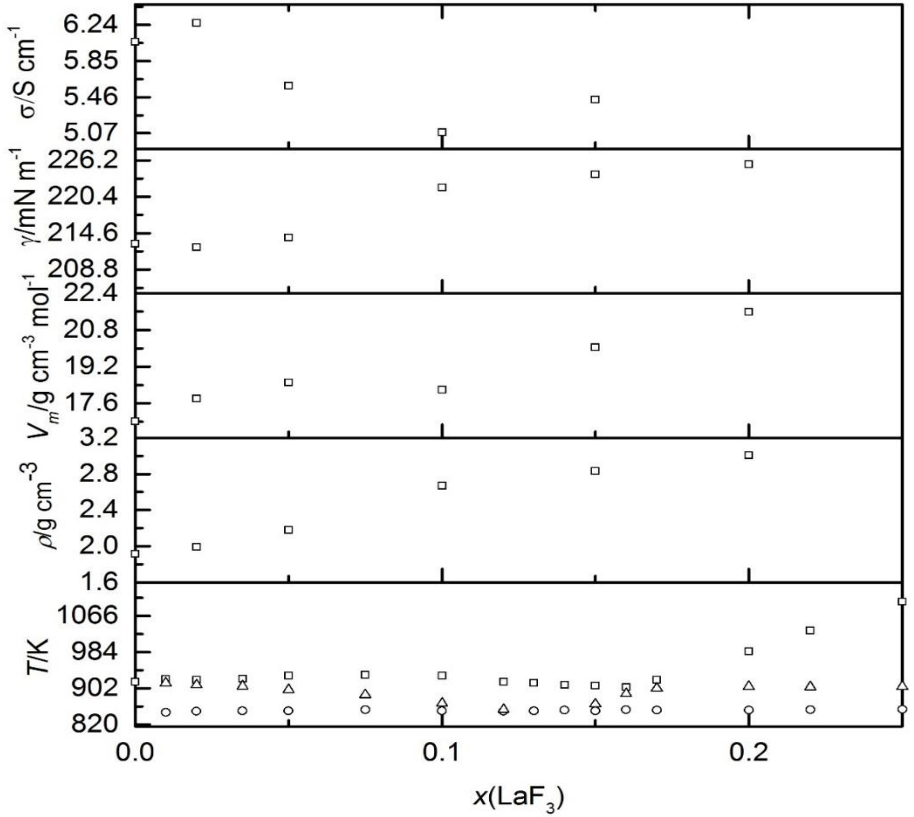


A)
Physico-chemical properties (examples)

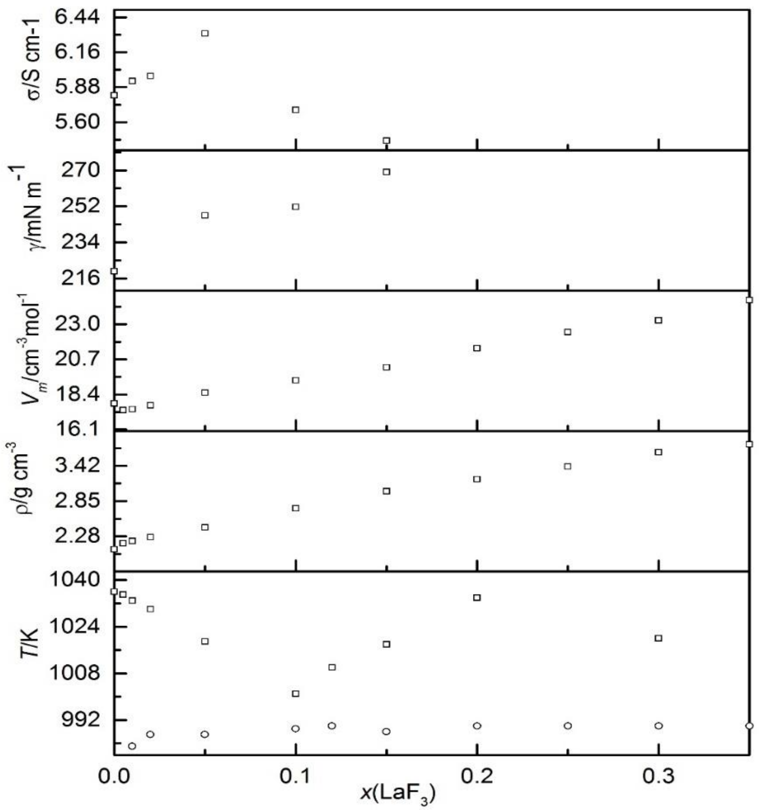
Preparations and characterisation of various molten systems – „multicomponent“ systems*

*examples

$(LiF\text{-}NaF)eut\text{-}LaF_3$ vs. $(LiF\text{-}CaF_2)eut\text{-}LaF_3$



$(LiF\text{-}NaF)_{eut}\text{-}LnF_3$ (Ln= La, Nd, Sm and Gd)

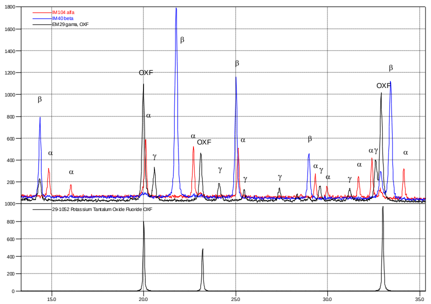


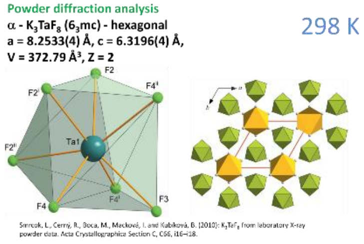
$(LiF\text{-}CaF_2)_{eut}\text{-}LnF_3$ (Ln= La, Nd, Sm and Gd)

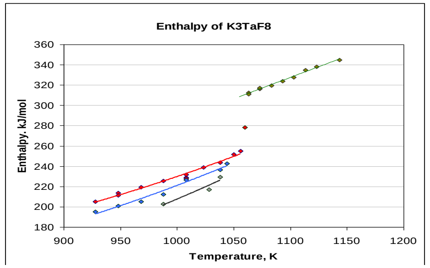
$(LiF\text{-}NaF)_{eut}\text{-}LnF_3$ (Ln= La, Nd, Sm and Gd)

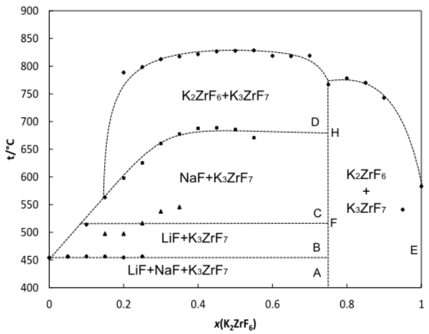
Preparations and characterisation of various molten systems – „single“ systems

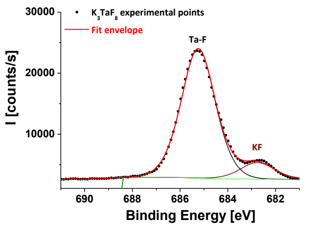
K3TaF8

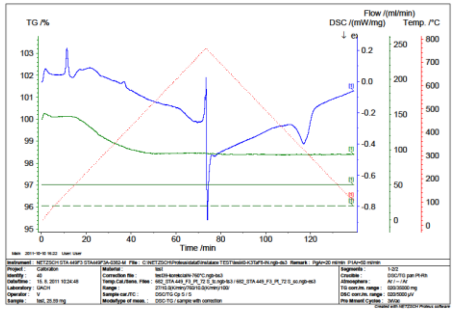




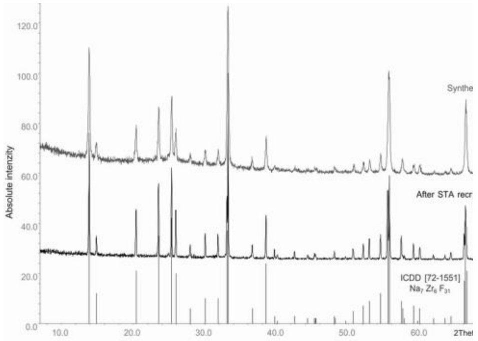


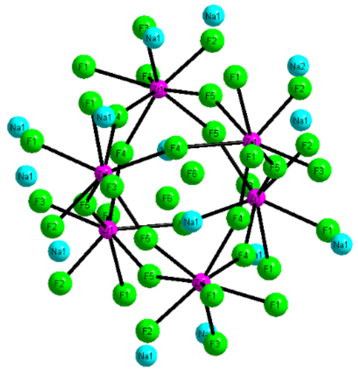


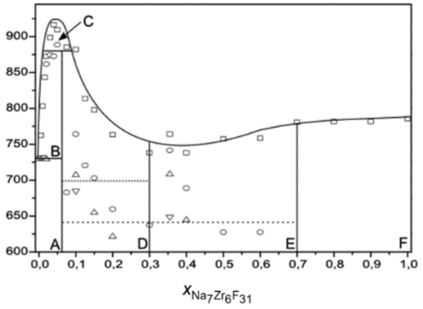


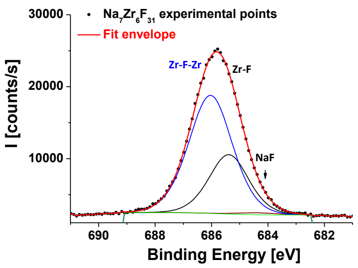


Na7Zr6F31

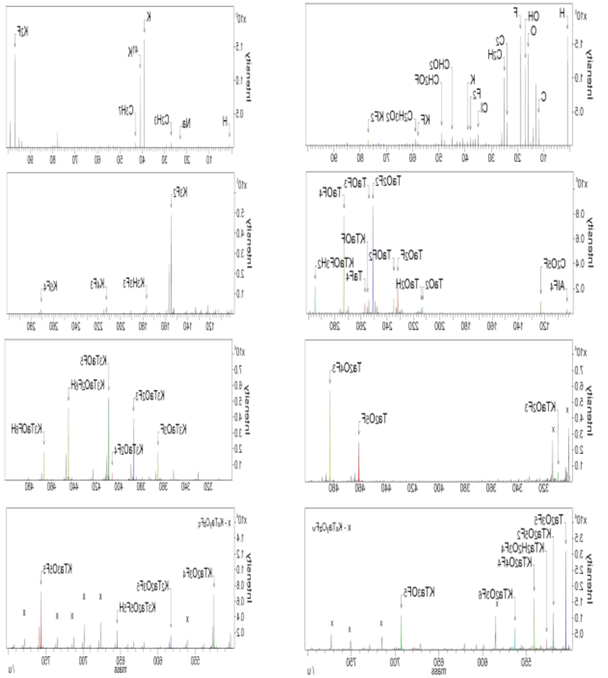




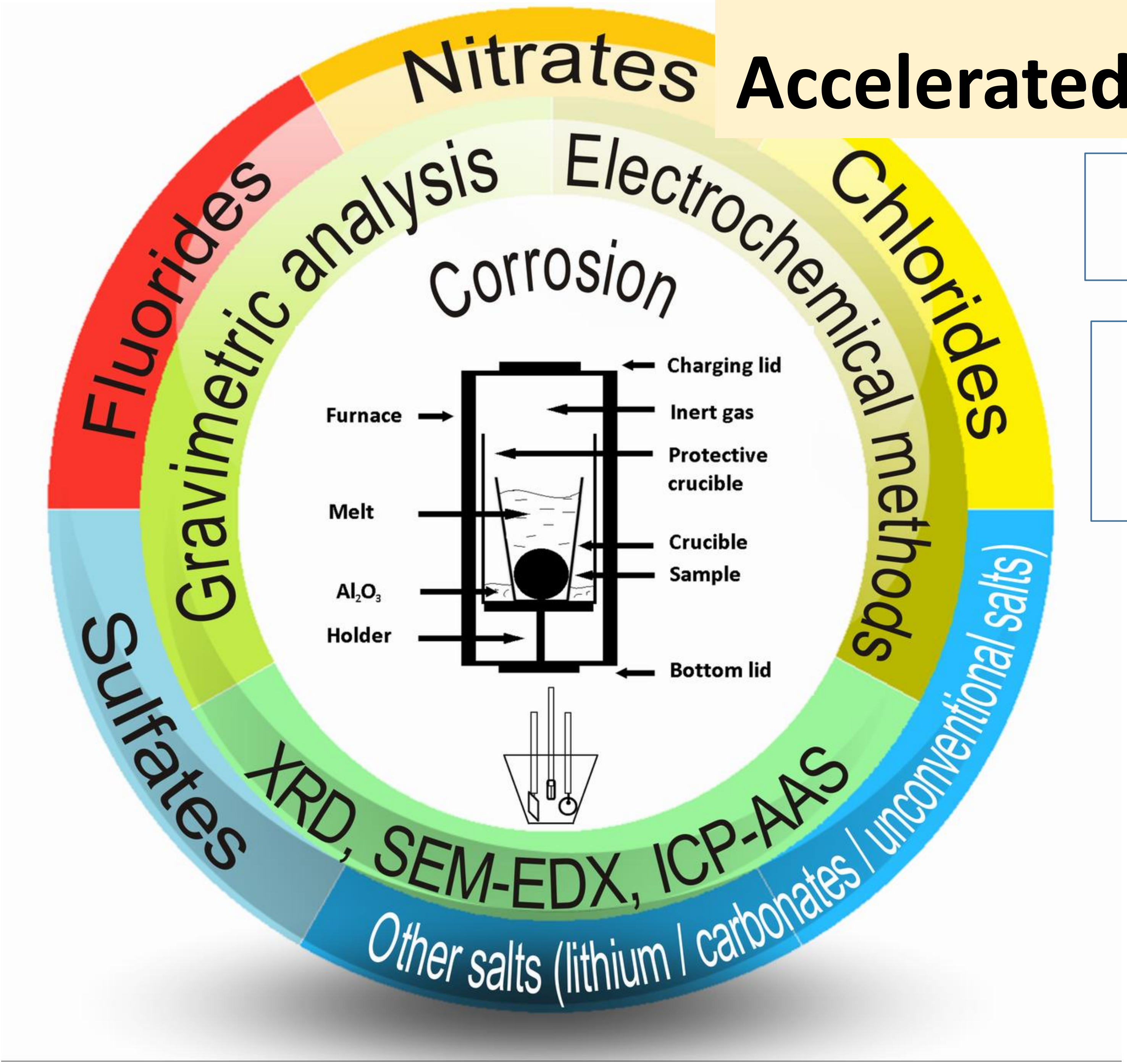




K_3TaOF_6 ←?→ $K_3TaO_2F_4$



Accelerated corrosion testing (ACT)



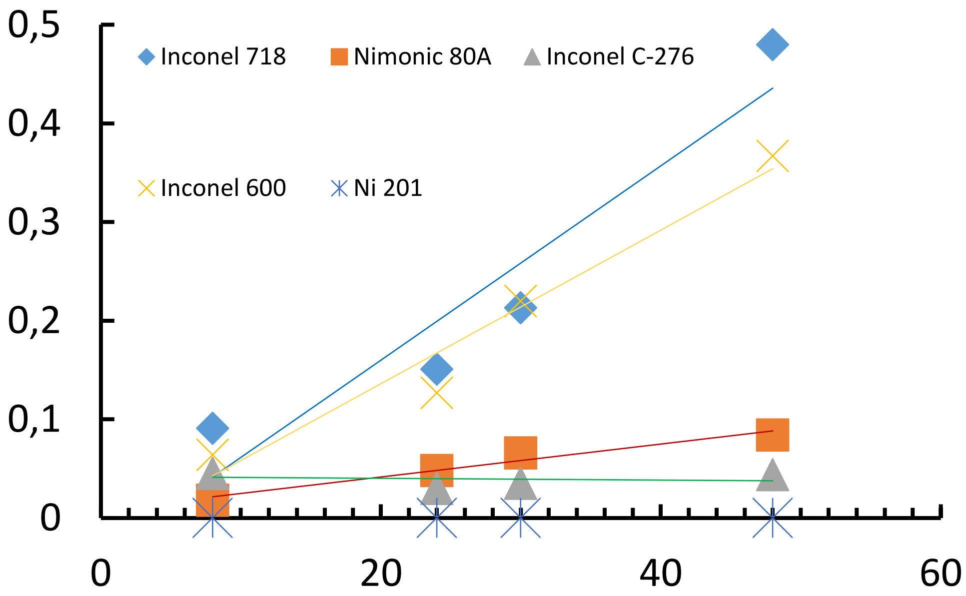
Of course, the compatibility of industrial materials with molten salts must be investigated.

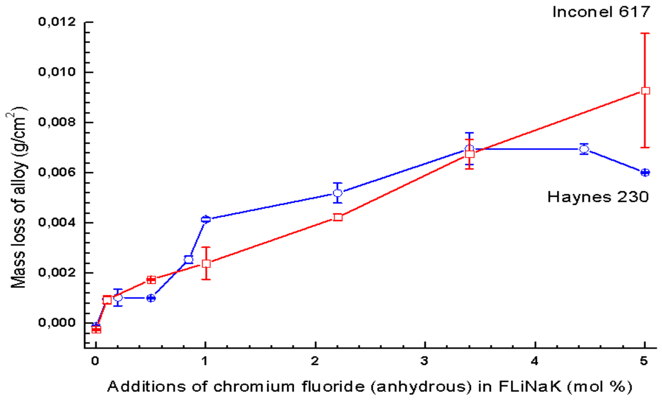
High temperature corrosion behavior of superalloys in molten salts – A review

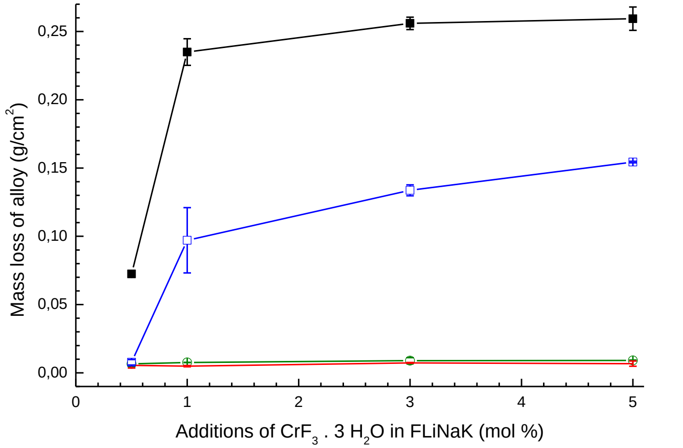
Niketan S. Patel, Viliam Pavlík, Miroslav Boča

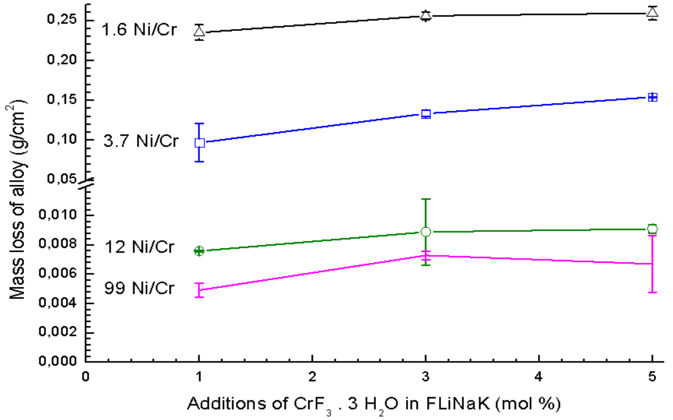
In: Critical Reviews in Solid State and Materials Sciences

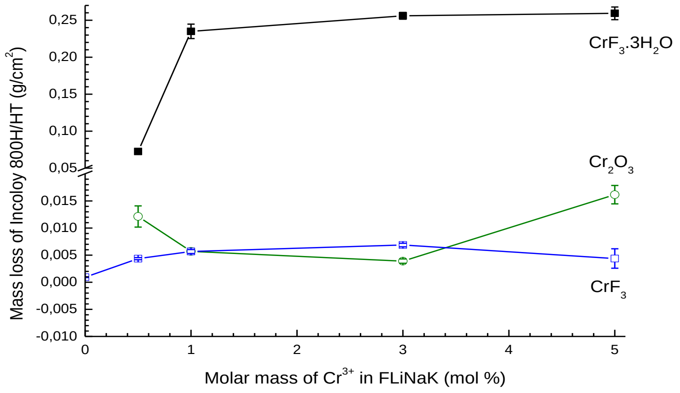
Corrosions looses of choosen alloys after 8h, 24h, 30h a 48h in FLiNaK (pure or with additives)

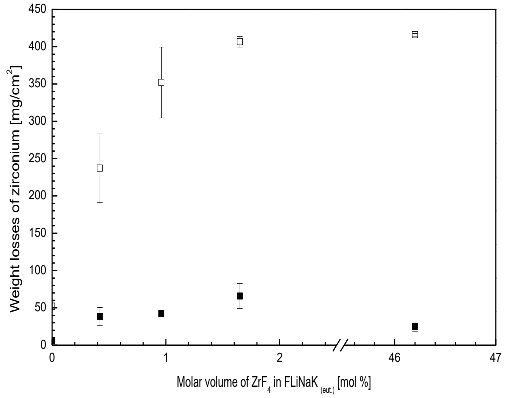


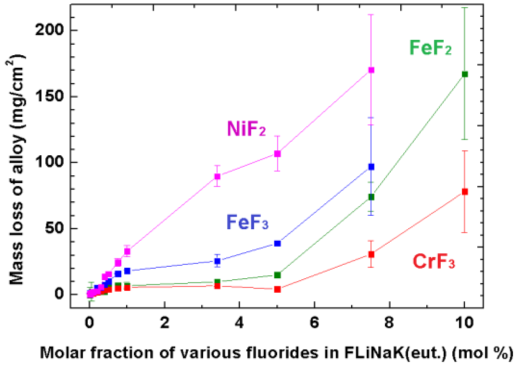




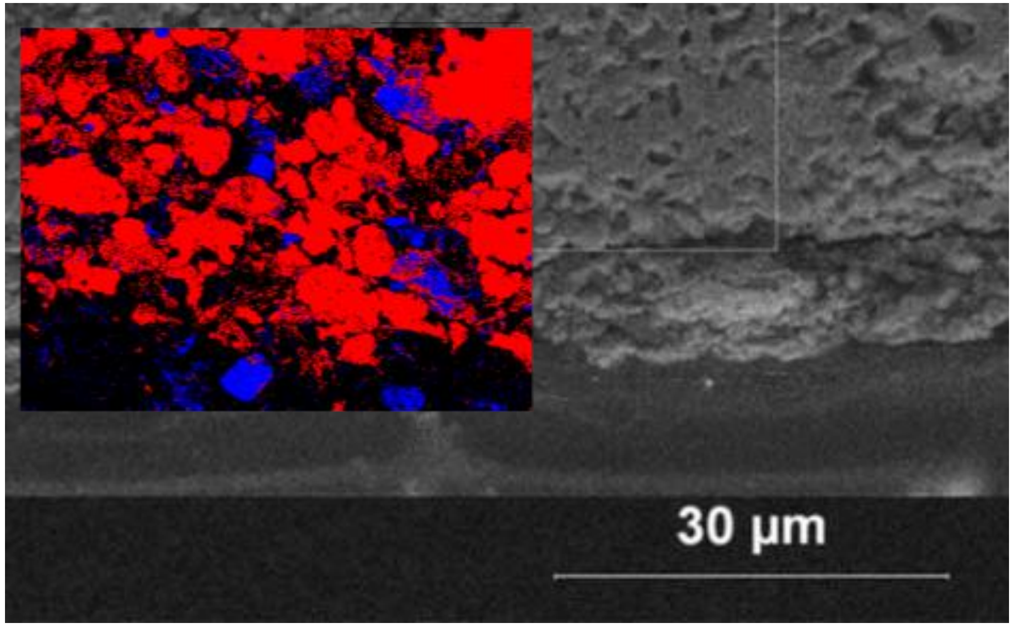


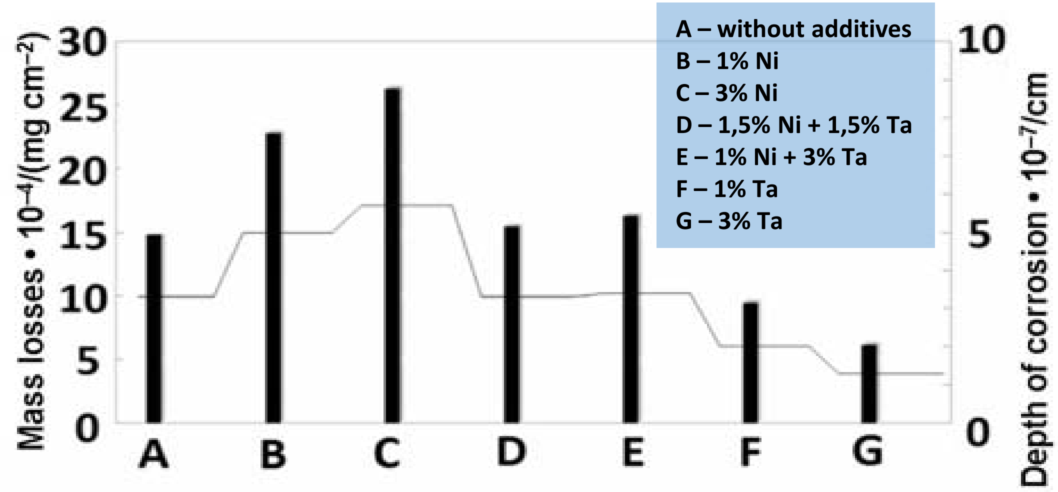




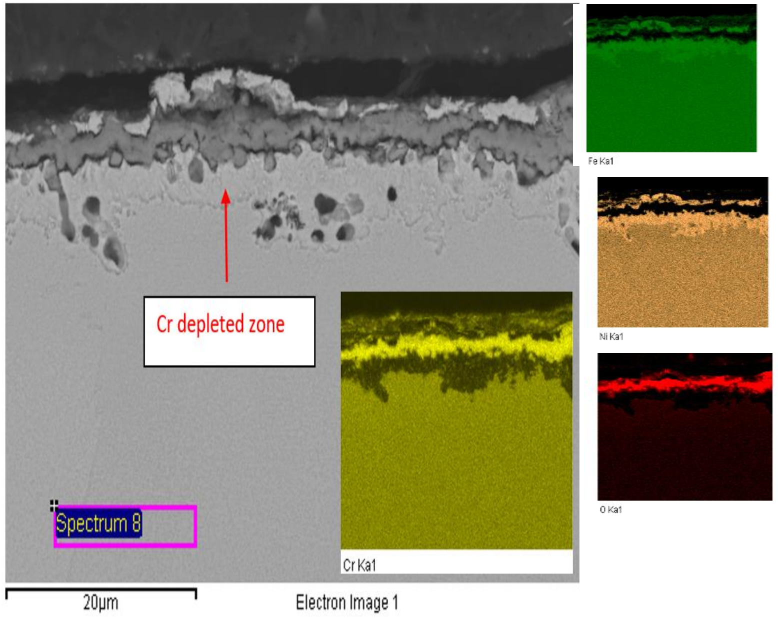


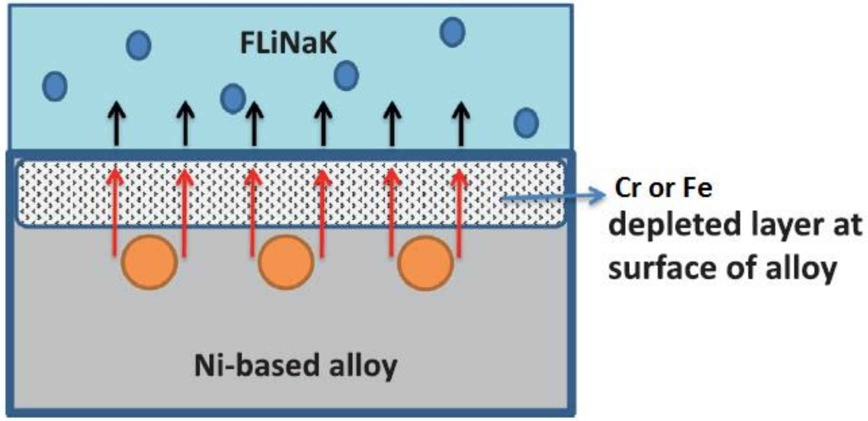
Titanium diboride with various sintering additives after 8h corrosion at 600 °C





Incoloy 800H superalloy in molten FLiNaK at 680 °C – corrosion mechanism proposal





(b) Alloy elements diffuse outward to surface first, and then dissolve into FLiNaK to form metal fluoride

B)

Solar energy and „solar salt“

Starting with the EU project „ENERGOZ“ in 2012:
„Effective management and energy consumption for renevable resources“

2.

Solar salt (220 °C)

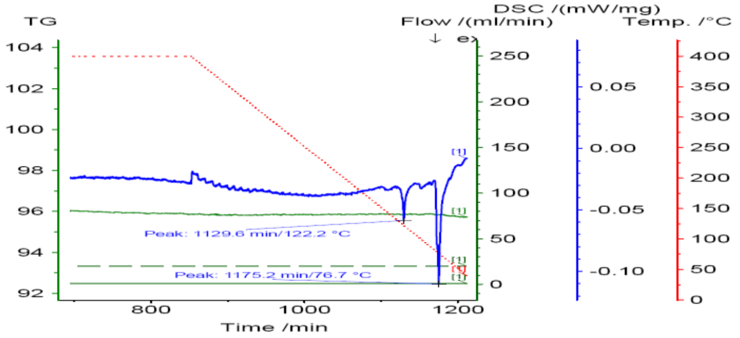
$NaNO_3$ (40%)+KNO_3 (60%)

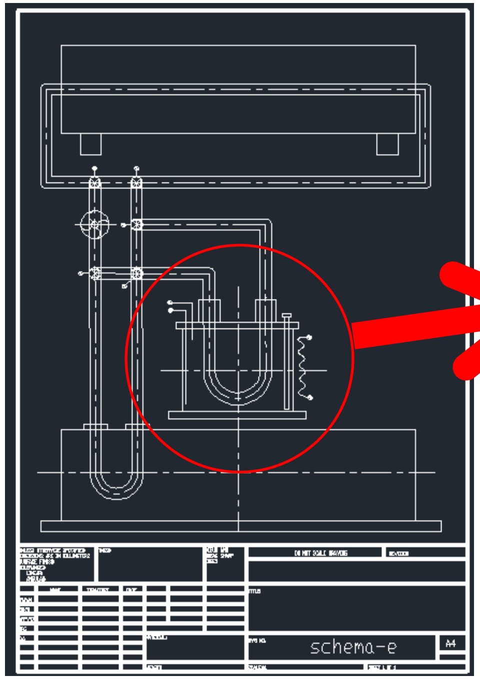
HITEC® (142 °C)

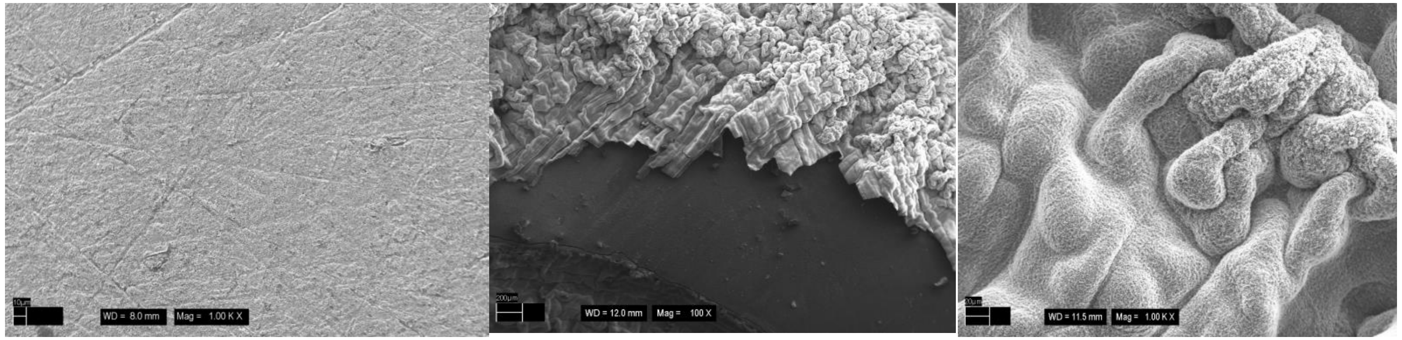
$NaNO_3$(7%)+KNO_3(53%)+$NaNO_2$(40%)

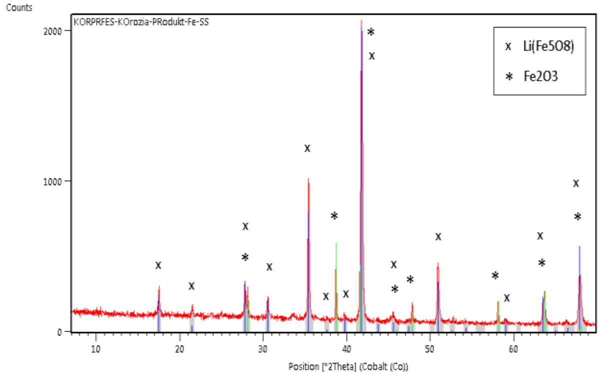
OTS soľ pre „Energoz“ (77 °C, 122 °C)

$LiNO_3$ (27,5%) – $NaNO_3$ (22%) – KNO_3 (43,5%) – $NaNO_2$ (6%) – $Ca(NO_3)_2$ (1%)



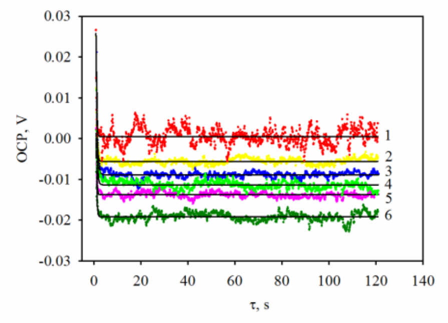




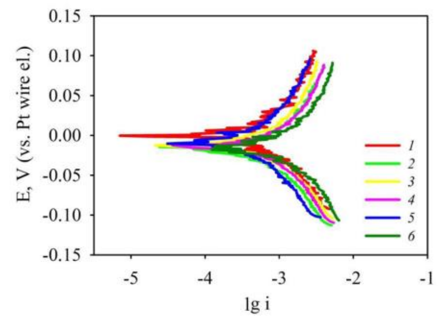


and currently continues in bachelor and master theses:

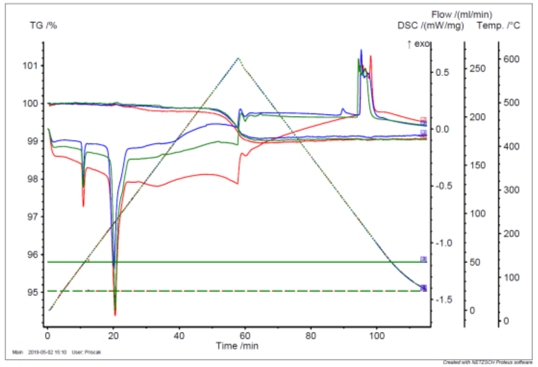
* NaNO3 + KNO3, (60 wt.% and 40 wt.%) NaCl = impurity 2 wt.% or 5 wt.%



Dependences of OCP on time at different sodium chloride content in the solar salt at 550 °C: (1), (2) and (3) – AISI 304; (4), (5) and (6) – AISI 316; (1) and (4) – 0 wt.% NaCl; (2) and (5) – 2 wt.% NaCl; (3) and (6) – 5 wt.% NaCl

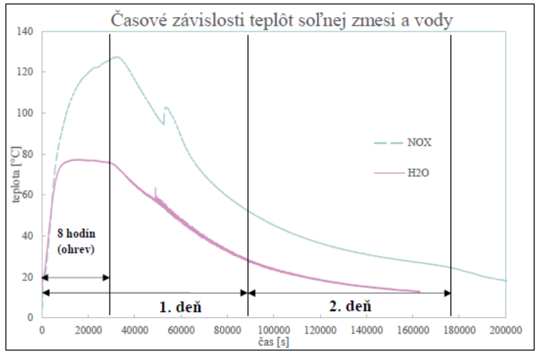


Tafel plots for AISI 304 and AISI 316 samples in the solar salt without and with NaCl admixtures at 550 °C: (1), (2) and (3) – AISI 304; (4), (5) and (6) – AISI 316; (1) and (4) – 0 wt.% NaCl; (2) and (5) – 2 wt.% NaCl; (3) and (6) – 5 wt.% NaCl

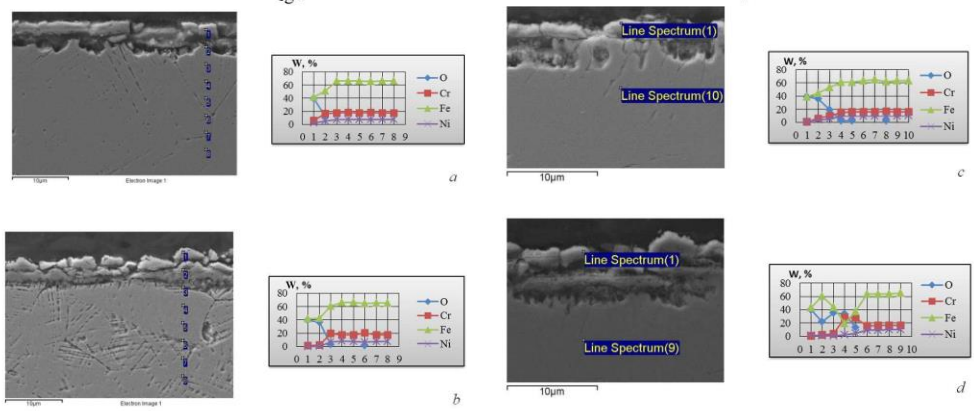


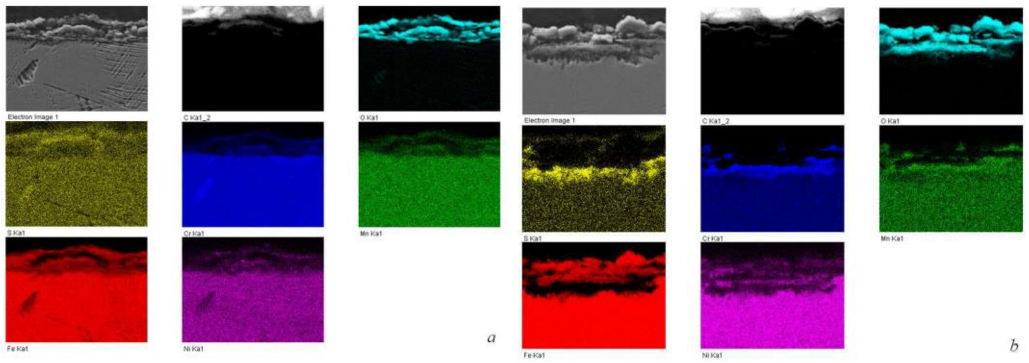
DTA of three solar salts:

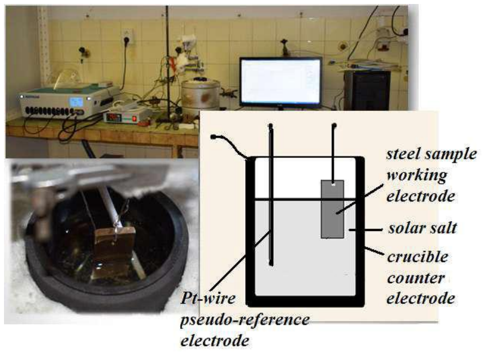
1. Pure mixture NaNO3+KNO3
2. Adds of 2 wt.% NaCl
3. Adds of 5 wt.% NaCl



Time dependence of solar salt and water on the heating temperature of the heat storage tank.







*** Published DOI:** 10.32434/0321-4095-2019-124-3-123-131

C)
Hydrogen and advanced ceramic

Powders*:

- » Preparation of SiCN nanopowders by CVD
- » Cross/linking and pyrolysis of Si-C-N-O organometallic precursors (co-operation with TU Darmstadt)
- » Preparation of carbon nanotubes (CNT´s)

Engineering ceramics*:

- » Si_3N_4/SiC based micro/nanocomposites
- » Polymer derived mixed α/β/o-sialons
- » SiC special ceramics
- » CNT/alumina and CNT/Si_3N_4 based composites
- » Oxinitride matrix materials for refractories

Engineering ceramics with function*:

- » Layered composites (Si_3N_4/Si_3N_4, Si_3N_4/SiC) – materials with selfdetection
- » SiC/(TiNb)C – electricaly conductive ceramics
- » Transparent alumina and YAG based ceramics
- » $MgSiN_2$, $LaSi_3N_5$ – HTC materials
- » Nitride based phosphors
- » Bioceramics for implants and SRBSN ceramics – bio and HTC materials

Production of H_2

- thermo-chemical processes
- electro-chemical processes

*** - not all of mentioned systems are used for direct investigation of hydrogen evolution, but they serve to create a knowledge base for future experiments**

Hydrogen economy in Slovakia

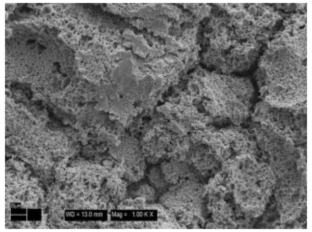
- Use stable and high-porous ceramic components as a working electrodes
- Preparation of high-quality nano- AND micro- surface by galvanostatic method in one step(!)
- Enormous reduction of time in fabrication of the electrodes (crucial component for H-evolution)

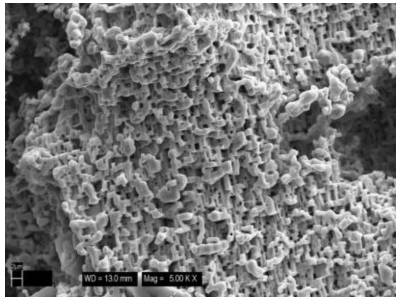
➢Increase of the surface of the working electrode

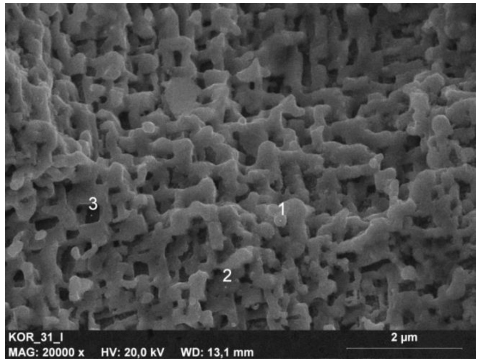
➢Increase of hydrogen evolution

➢Increase of productivity of the electrolyzer

Our preliminary results →







and even more…

Thanks for your attention!