Chemistry and transport of fission products (CATFIS)

SAFIR2018 Final seminar 21-22.3.2019

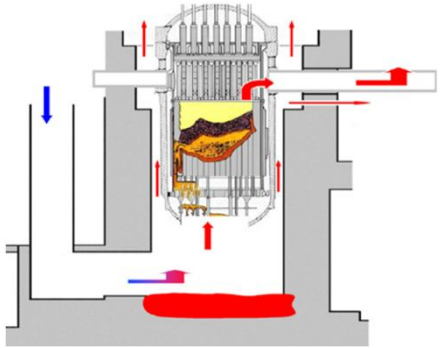
Teemu Kärkelä, Mélany Gouëllo, Jouni Hokkinen
Karri Penttilä, Tommi Kekki, Petri Kotiluoto

Objectives of CATFIS

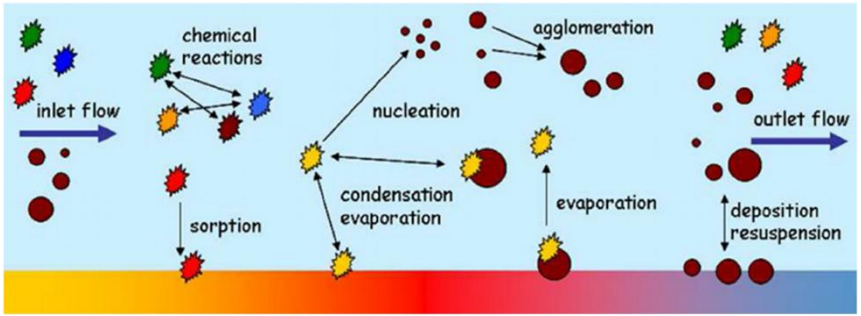
Primary circuit and containment conditions

- The aim is to investigate the transport and chemistry of gaseous and particulate fission products in severe accident conditions.

- The emphasis is on the phenomena, which are poorly-known internationally or not considered in the current severe accident analysis codes due to the lack of information.



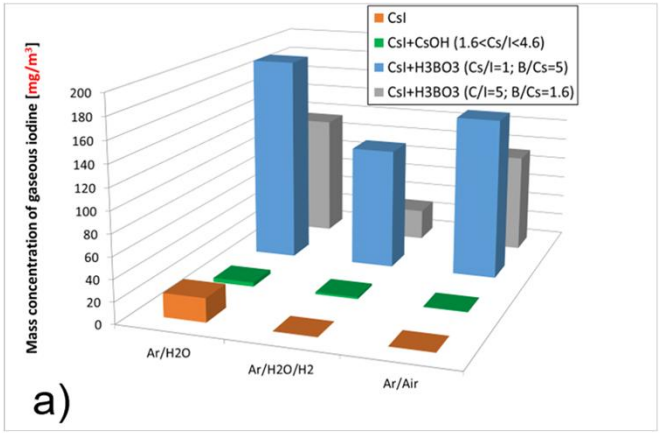
T. Haste et al. NED 2009

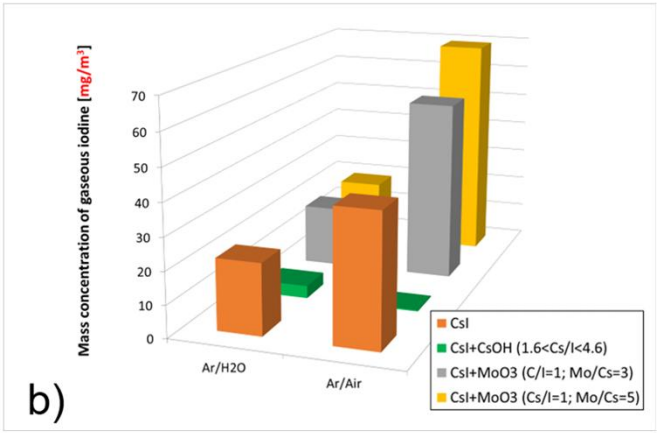


L. Cantrel et al. NED 2014

Primary circuit chemistry of iodine

Formation of gaseous iodine from surface deposits of FPs



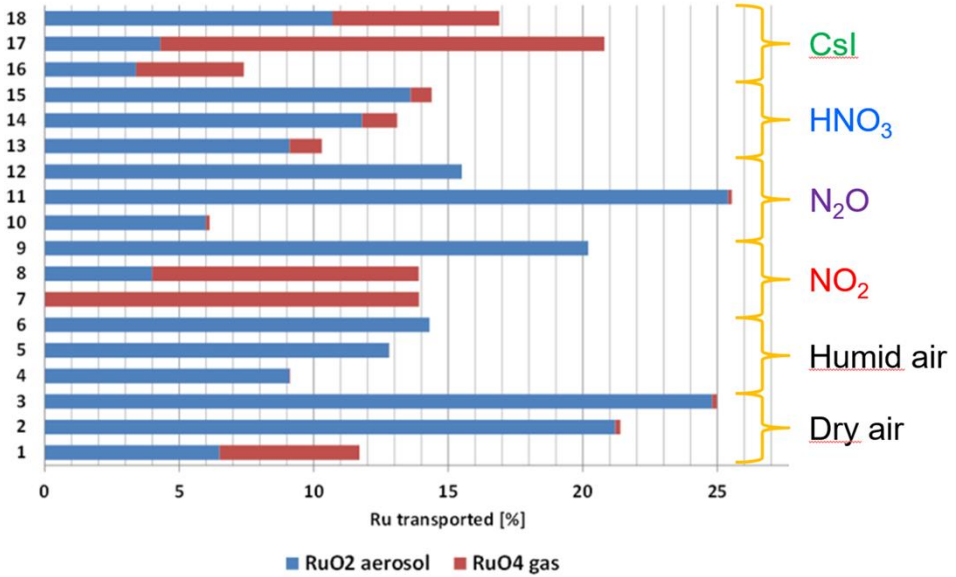


- a) Boron and b) molybdenum reacted with CsI forming solid caesium-borate and caesium-molybdate, respectively. It resulted in a high formation of gaseous iodine. Oxygen in the atmosphere seemed to enhance the formation of gaseous iodine.
- The surface deposits could be an important source of gaseous iodine in a long term.

Primary circuit chemistry of ruthenium

Formation and transport of Ru compounds

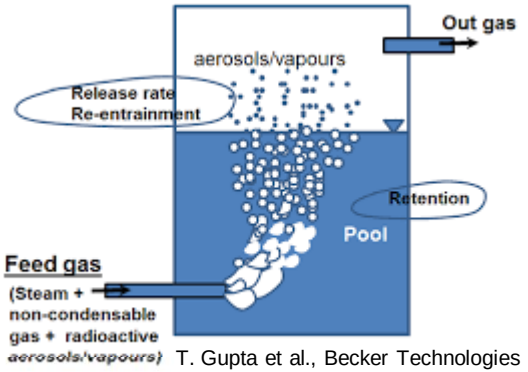
- Transport of ruthenium as gaseous and aerosol compounds.
- Air radiolysis products may significantly increase the transport of (low volatile) ruthenium as a gaseous compound into the containment building (air ingress conditions).
  - NO_2 was efficient in forming gaseous RuO_4.
- The highest transport of ruthenium as a gaseous compound was observed when CsI reacted with ruthenium oxides.
  - Further studies to explain the observation are needed.



Pool scrubbing

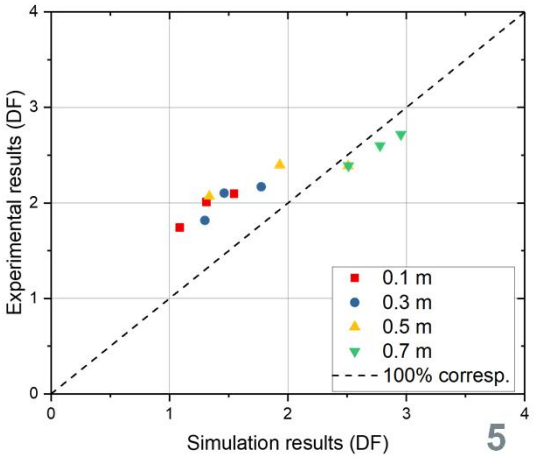
Retention of gaseous and aerosol FPs in containment pools

- Aerosol retention in supression pool conditions at 20 to 100 °C was investigated with experiments (CATFIS project) and subsequent simulations (CASA project) of experiments with ASTEC and MELCOR severe accident analysis codes.



T. Gupta et al., Becker Technologies

- Preliminary decontamination factor (DF) results:
  - Experiments were performed with CsI aerosol at 20 °C varying the pool depth from 0.1 to 0.7 m and non-condensable N_2 flow rate through the pool from 8, 14 to 27 l/min.
  - ASTEC V2.1.1.4 code calculations seemed to be in a good agreement with the experiments.
    - However, experimental and analytical methods will be further improved to assure reliable results.
- The research work has been started recently and it will be continued in SAFIR2022 MANTRA.



References

- Gouëllo, M., Hokkinen, J., Kärkelä, T., Auvinen, A., A study of chemical behaviour of caesium iodide in presence of boron in condensed phase (650 °C and 400 °C) under primary circuit conditions, Nuclear Technology, 203(1), 66-84 (2018).
- Gouëllo, M., Hokkinen, J., Experimental study on the behaviour of CsI on primary circuit surfaces of a nuclear power plant: Effects of molybdenum on iodine transport: part II, VTT-R-04457-18 (2018).
- Kajan, I., Kärkelä, T., Auvinen, A., Ekberg, C., Effect of nitrogen compounds on transport of ruthenium through the RCS, Journal of Radioanalytical and Nuclear Chemistry 311(3), 2097-2109 (2017).
- Kärkelä, T., Kajan, I., Tapper, U., Auvinen, A., Ekberg, C., Ruthenium transport in a RCS with airborne CsI, Progress in Nuclear Energy 99, 38-48 (2017).
- Kärkelä, T., Korpinen, A., et al., Retention of fission products in a containment pool - Parts A and B, Research report VTT-R-00152-19 (2019).