Uranium Carbide, a Potential Nuclear Fuel

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- Purpose:
  - Establish a knowledge base for the behavior some Gen-IV fuel candidates in aqueous systems
  - Understand the release of radionuclides upon accidents and in geological repositories for used nuclear fuel

- The fuel types of main interest :uranium carbides and uranium nitrides:
  Compared to standard UO_2 based fuels Uranium Carbide UC has :

  - better thermal conductivity
  - higher fissile material density

Aim

- Elucidate the mechanisms and kinetics of dissolution of the fuel matrixes (UC and UN) in water :
  - dissolution under oxic and anoxic conditions
  - radiation-induced dissolution
  - impact of fission products and solutes in the water

    ➔To understand the stability of new fuels in aqueous systems

Starting point:

- synthesis of uranium carbides and uranium nitrides
- manufacturing of pellets
- doping pellets with non-radioactive isotopes of fission products as models for irradiated nuclear fuel

Synthesis of UC

Mixing precursors UO_2:C

Pressing mixed powder into green pellets

Carbo-thermal reduction at 1500C under 5%H_2 in N_2

Characterization of the crushed pellet with X-Ray Powder diffraction (XRD)

Preparing dense pellets by Spark Plasma Sintering

Stability of UC

- Dissolution of UC pellets should be studied experimentally under:
  - H_2O_2 exposure
  - GAMMA irradiation

Model Carbides

- Preliminary studies are based on other carbides such as Titanium Carbide(TiC) to get insights on
  - the manufacturing of these carbides
  - understand the behavior of carbides under oxidative dissolution conditions
- Reactivity of Tungsten carbide is also studied for comparison

Synthesis of TiC

Mixing precursors TiO2:C (1:3,3)

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Drying at 80C

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Pressing mixed powder into green pellets

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Carbo-thermal reduction for 16h at 1500C under 5% H_2 in N_2

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Characterization of the crushed pellet with X-Ray Powder diffraction (XRD)

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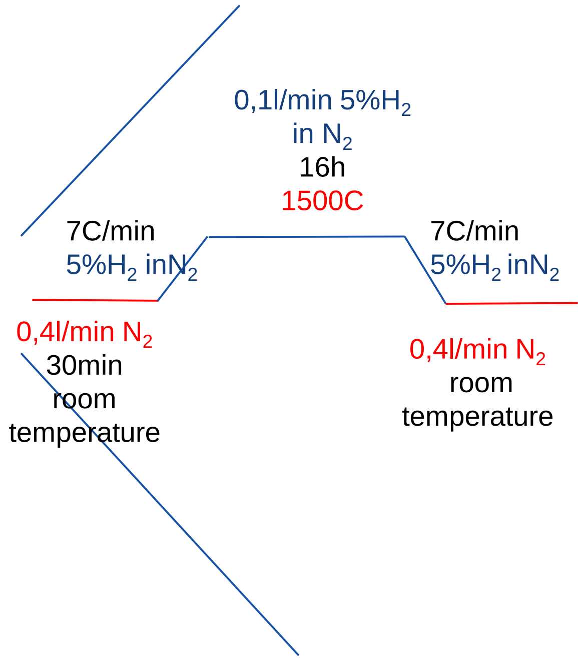
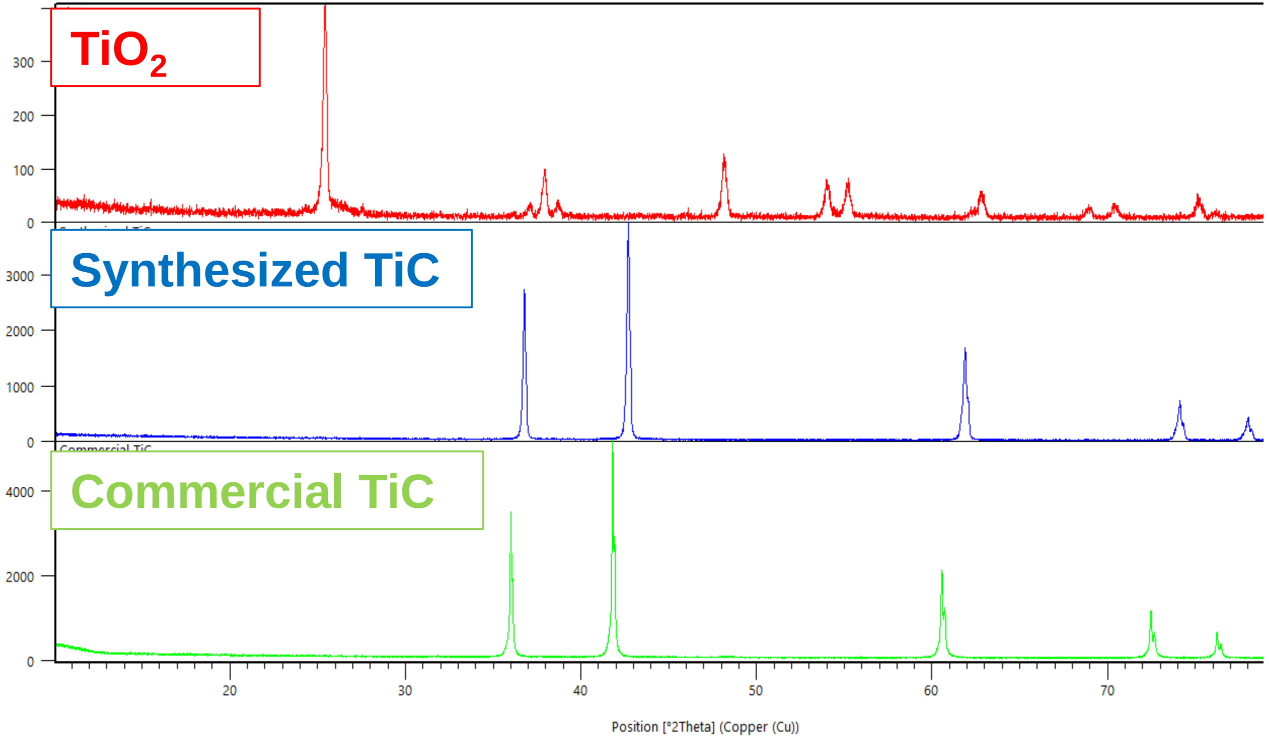
Preparing dense pellets by Spark Plasma Sintering



XRD-Diffractogram



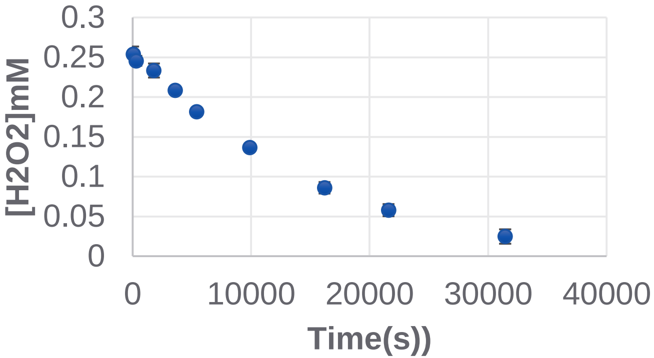
Reactivity of TiC in the presence of H_2O_2

- The Ghormley triiodide method :measure H_2O_2concentration.
  - The absorbance of I_3^- is subsequently measured spectrophotometrically at 350 nm.
  - A linear correlation between the absorbance and the H_2O_2 concentration was obtained by a calibration curve to calculate $[H_2O_2]$

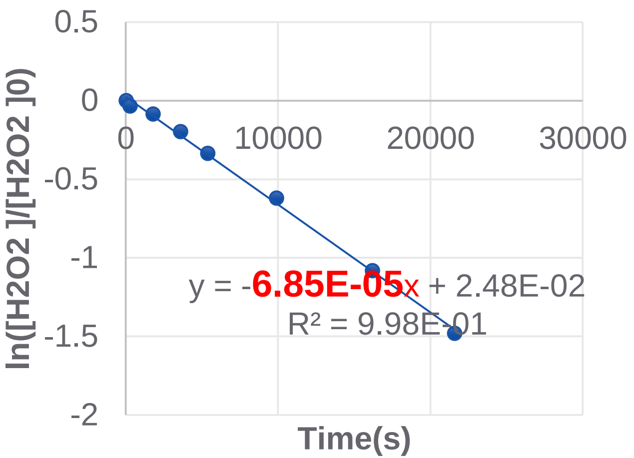
- H_2O_2 decomposition was studied for different amount of of TiC powder (50mg, 0,25g 0,5g and 0,75g) in a 25 ml volume of $H_2O_.$

Reactivity of TiC in the presence of H_2O_2

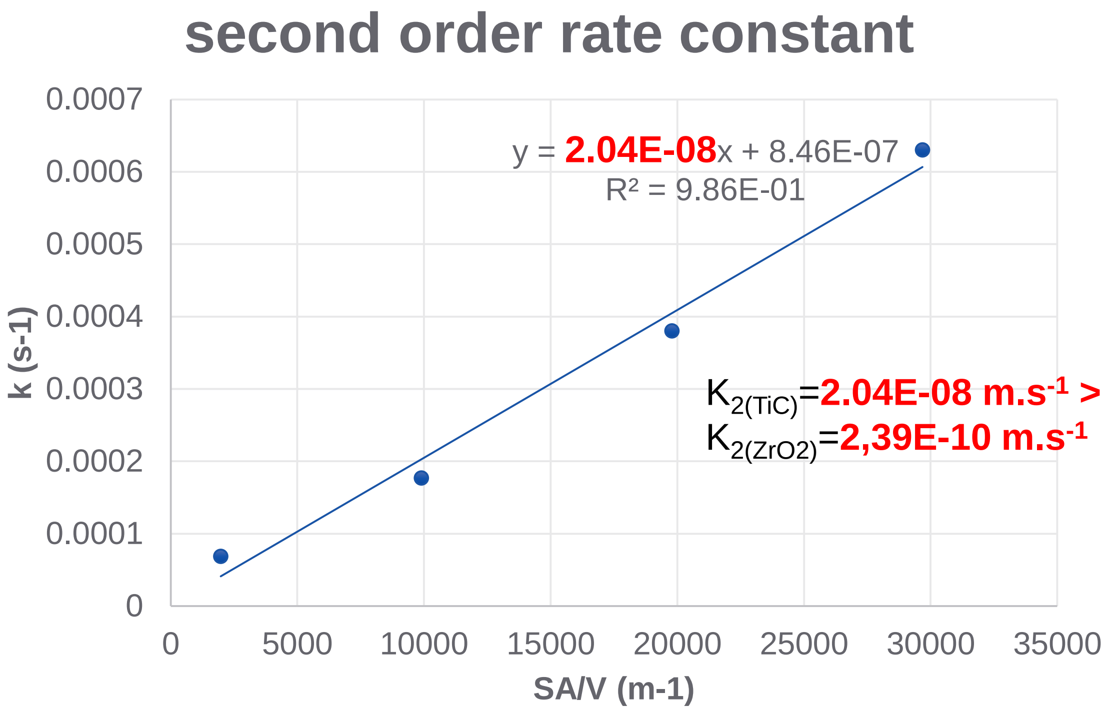
50mg TiC in 25ml H_2O 0,26mM H_2O_2

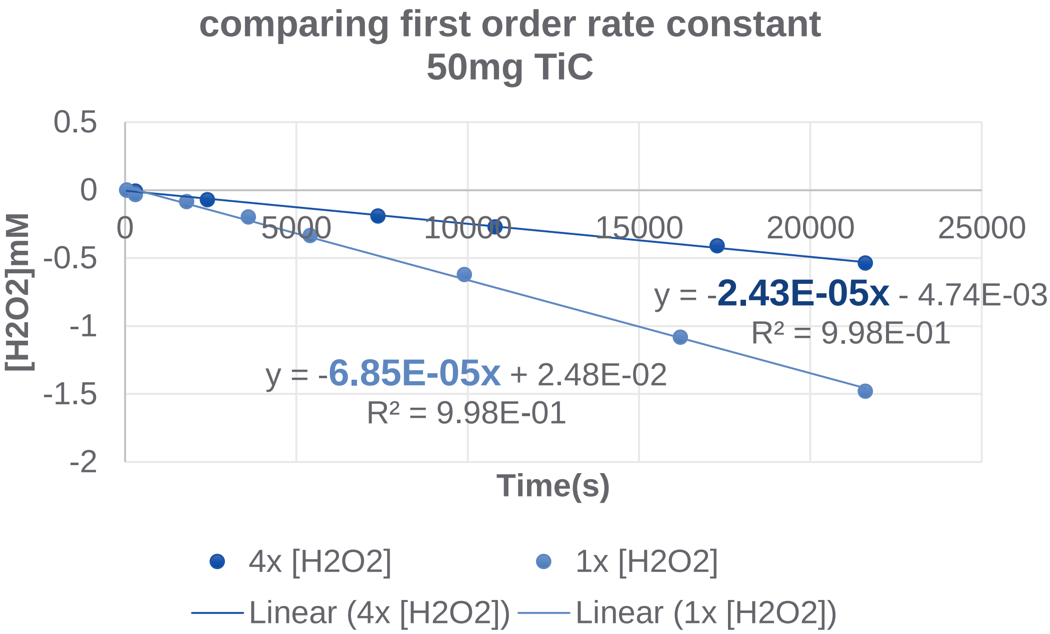


first order rate constant



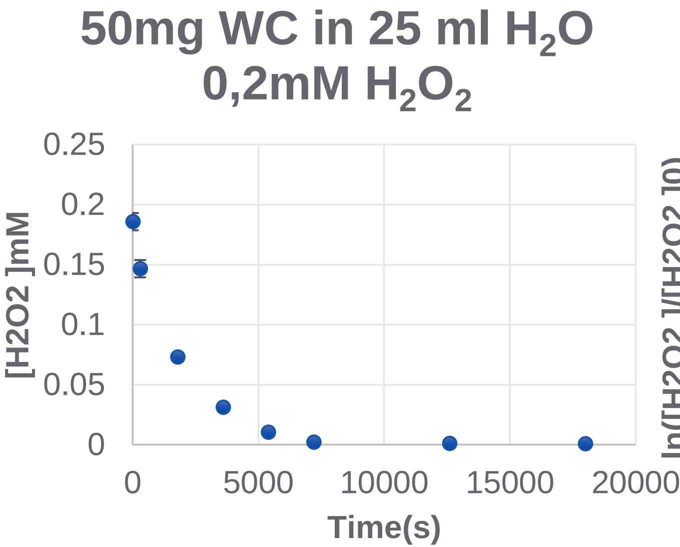
Reactivity of TiC in the presence of H_2O_2

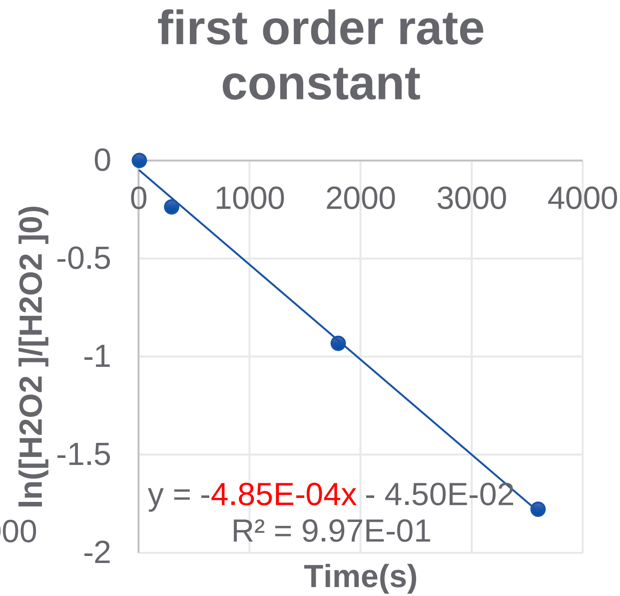




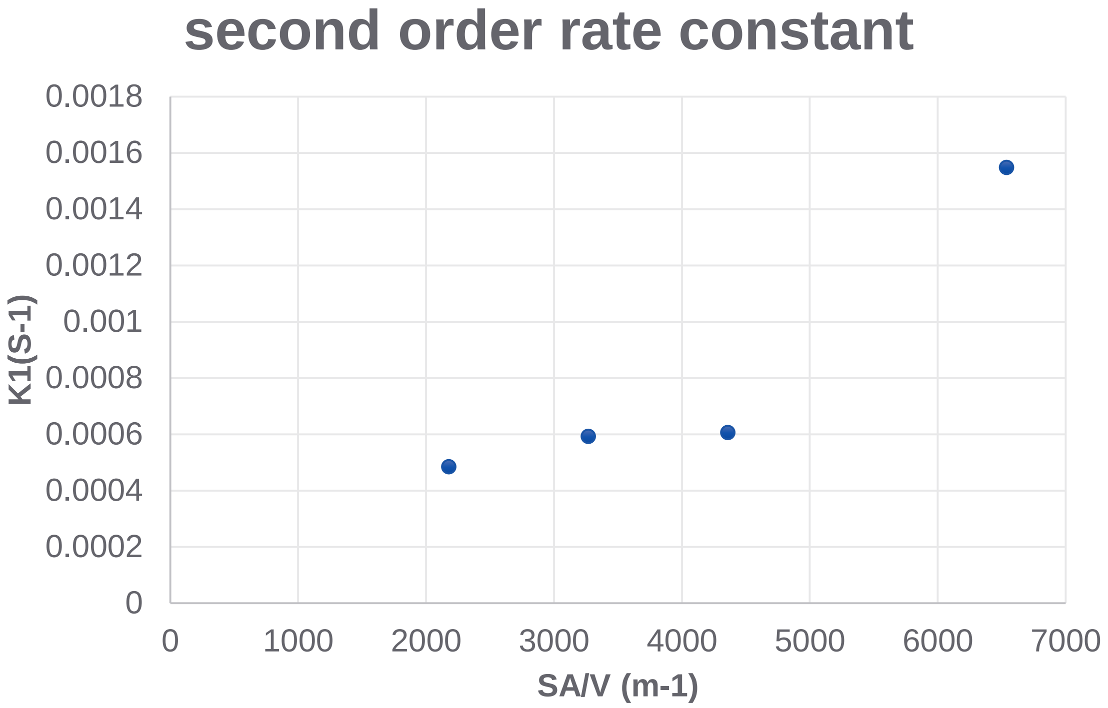
comparing first order rate constant
50mg TiC
0.5
0
-0.5
-1
-1.5
-2
0
5000
10000
15000
20000
25000
[H2O2]mM
Time(s)
y = -2.43E-05x - 4.74E-03
R² = 9.98E-01
y = -6.85E-05x + 2.48E-02
R² = 9.98E-01
4x [H2O2]
1x [H2O2]
Linear (4x [H2O2])
Linear (1x [H2O2])

Reactivity of WC in the presence of H_2O_2





Reactivity of WC in the presence of H_2O_2



Conclusion

- Carbothermal reduction is an effective process in producing carbides
- TiC and WC are reactive once exposed to H_2O_2
- Carbides seems to be more reactive than the oxides

Acknowledgments

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