



C-12 release during corrosion of unirradiated steels in simulated groundwaters



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Introduction

The objective of this study at VTT is to investigate the release of C-12 during corrosion of inactivated steels in simulated groundwaters. This study is part of a project that addresses the release and speciation of C-14 during corrosion of activated steels in cement-based repository conditions.

Radiocarbon, C-14 is a major radiotoxicity contributor in decommissioning waste and it arises from the neutron activation of N-14 impurities in steel materials. It has long half-life (5,730 y) and it can form both inorganic and organic species, which may exist as aqueous and volatile gaseous species. Especially organic species can be highly mobile in geosphere and they can therefore migrate to the biosphere. The original form of nitrogen and hence carbon in the steel may have significant effect on the speciation of the released C-14 species [1]. However, there is not conclusive information on the form and fate of C-14 in irradiated steel materials [1,2].

Steel materials

Leaching experiments were conducted with Loviisa steel (0.08% C), which is identical with the steel in reactor core components of Loviisa NPP, and Japanese high carbon steel (1.2% C). Optical microscopy, scanning electron microscope and energy dispersive X-ray spectroscopy (SEM/EDS) analysis showed that Loviisa steel has composition similar with AISI 321 steel and austenitic structure in which carbon mainly exists as interstitial atoms. In Japanese high carbon steel carbon is mainly present as iron carbide (Fe₃C).

Leaching experiments

Simulant groundwaters (composition based on Loviisa groundwater sample) were selected as leaching solutions [3]. pH 12.5 was selected to simulate the effect of cement in the repository conditions and pH 8.5 works as reference. The batch experiments were conducted in polypropylene vials in the glove box with Ar atmosphere (O₂<1 ppm and low CO₂). In the Ar glove box, the test vials were kept in a closed steel container to ensure as homogenous gas phase as possible around the test vials between the samplings. The mass of the solid / leaching solution volume (m/V) ratio was varied including the ratios: 50 g/100 mL, 25 g/100 mL and 15 g/200 mL.

Table 1. Experimental conditions of the leaching experiments.

Test code	Solid material	m/V	pH (initial)	pH (final)	E _{sc} (70 days) [mV]
LT-CA125(1)	Loviisa Steel	50 g/100 mL	12.4	12.1	-220
LT-CA125(2)	Loviisa Steel	25 g/100 mL	12.4	12.0	-210
LT-CA85(1)	Loviisa Steel	50 g/100 mL	8.5	9.6	-230
LT-CA85(1)	Loviisa Steel	25 g/100 mL	8.5	9.6	-230
YHT-CA85(1)	High carbon steel	50 g/100 mL	8.5	9.9	-410
YHT-CA85(2)	High carbon steel	15 g/200 mL	8.5	10.7	-480

Figure 1. SEM picture of the austenitic structure of the Loviisa steel.

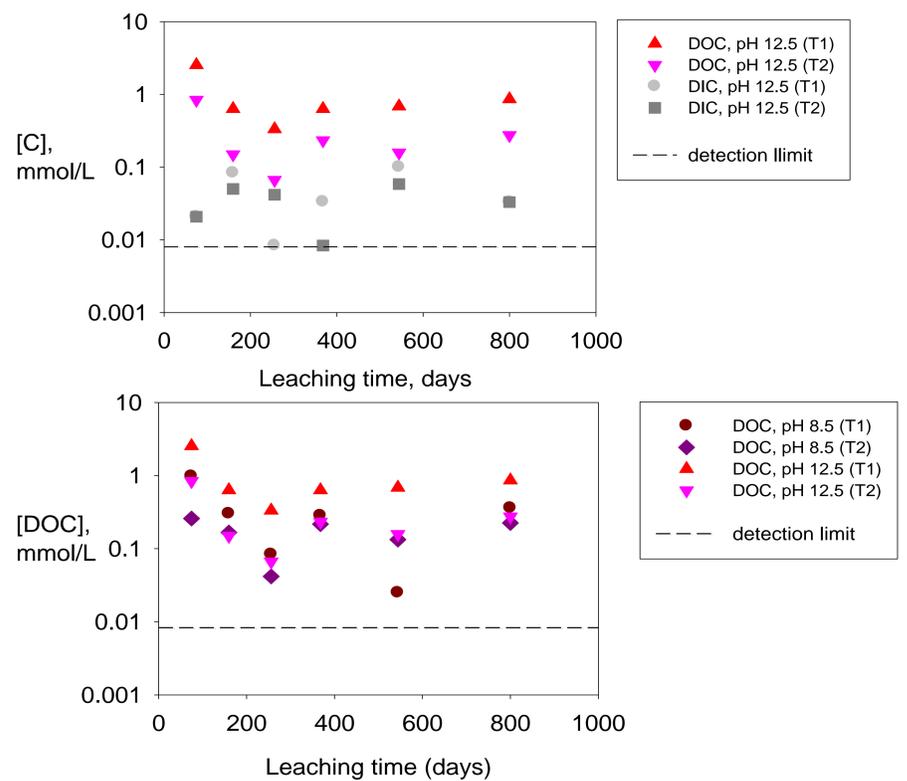


Figure 2. Upper: Dissolved organic (DOC) and inorganic (DIC) carbon contents in the leaching tests of Loviisa steel in simulated groundwater at pH 12.5 as a function of leaching time. T1: m/V = 50 g/100 mL, T2: m/V = 25 g/100 mL. Lower: DOC as a function of pH.

Results

Dissolved inorganic (DIC) and organic carbon (DOC) contents were measured from the filtered samples of the leaching solutions. The amount of DOC was higher compared to DIC in the tests with both steel materials and increased slightly with pH. Relatively high contents for organic carbon, especially in the first sampling, suggest contamination from the grinding process of the solid steel material. The bigger mass of solid steel material in the same volume of leaching solution resulted in the higher amount of dissolved carbon, which is expected.

Conclusions

- Higher DOC compared to DIC in leaching tests with both steel materials; Loviisa stainless steel and Japanese high carbon steel.
- New leaching experiments will be conducted with well-characterised steel powders and Fe(4%C) powder, so that the possible contamination can be excluded.
- Preparation of the new powders was done with gas atomization method and heat treatment at VTT. The initial form of carbon was analysed with XRD (Rietveld refinement).

References

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