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CArbon-14 Source Term

CAST

Summary of scientific progress achieved through CAST (D7.24)

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CAST – Project Overview

The CAST project (CArbon-14 Source Term) aims to develop understanding of the potential release mechanisms of carbon-14 from radioactive waste materials under conditions relevant to waste packaging and disposal to underground geological disposal facilities. The project focuses on the release of carbon-14 as dissolved and gaseous species from irradiated metals (steels, Zircaloys), irradiated graphite and from ion-exchange materials as dissolved and gaseous species.

The CAST consortium brings together 33 partners with a range of skills and competencies in the management of radioactive wastes containing carbon-14, geological disposal research, safety case development and experimental work on gas generation. The consortium consists of national waste management organisations, research institutes, universities and commercial organisations.

The objectives of the CAST project are to gain new scientific understanding of the rate of re-lease of carbon-14 from the corrosion of irradiated steels and Zircaloys and from the leaching of ion-exchange resins and irradiated graphites under geological disposal conditions, its speciation and how these relate to carbon-14 inventory and aqueous conditions. These results will be evaluated in the context of national safety assessments and disseminated to interested stakeholders. The new understanding should be of relevance to national safety assessment stakeholders and will also provide an opportunity for training for early career researchers.

For more information, please visit the CAST website at:
http://www.projectcast.eu

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Summary of scientific progress achieved through CAST

Summary

This 2 page summary intends to describe the scientific progress made through CAST. All references on which the described progress is based are included in the final overview of CAST project report Deliverable 7.23. The CAST project focused on the release of carbon-14 as dissolved and gaseous species from waste.

The measurement of released carbon-14 species for the neutron irradiated materials is challenging due to its low chemical amount in waste and low corrosion rates in cementitious materials. Typical carbon-14 activity concentrations in neutron irradiated steel from the core of a nuclear plant are in the order of 10^5 Bq per gram solid matter, and for neutron irradiated Zircaloy 10^4 Bq per gram solid matter i.e. a few ppm in neutron irradiated steel or tenths of ppm in neutron irradiated Zircaloy. The speciation of released carbon-14 species could not be quantified within CAST. These materials also contain non-radioactive carbon, for example in steel the non-radioactive carbon content is three orders in larger magnitude than the carbon-14 content.

In CAST, significant progress has been made to quantify the speciation of released non-radioactive carbon from steel. The major carbon-14 species were dissociated anionic compounds from carboxylic acids in the case when these dissociated anionic compounds and gaseous organic carbon were measured; gaseous organic carbon was negligible compared to dissolved organic compounds. An analytical strategy for the quantification of released alcohols and aldehydes has been developed. For neutron irradiated steel, carbon is released as dissolved non-gaseous non-ionic compounds i.e. alcohols and aldehydes.

Determination of the speciation of released carbon-14 is for neutron irradiated Zircaloy even more challenging than for neutron irradiated steel, due to the smaller carbon-14 content and smaller corrosion rates than stainless steel. A quantification of released stable carbon species such as performed for steel is to be made.

A quantification of released carbon species in a gaseous and dissolved fraction has been made for neutron irradiated graphite. A gaseous fraction of 5% of the released carbon-14 species or smaller has been found at room temperature, alkaline and anaerobic conditions. It is unknown whether the dissolved organic carbon is released as carboxylic acids, alcohols or aldehydes.

Although not part of the CAST project, but important for the calculated safety, is the scientific progress obtained in understanding the determination of anaerobic corrosion rates for neutron irradiated metals in alkaline media. The oxide layer on metal has a large impact on the corrosion rate since the corrosion process is bounded to equilibrium between diffusion of water through the oxide layer and dissolution at the solid-liquid interface. The release rate of dissolved non-radioactive metallic compounds is the representative corrosion rate for disposal but is frequently not measured.

A few experimental methodologies have been evaluated in CAST and highlights are:

- Acceleration tests: the used potentials in accelerated corrosion tests cause water hydrolysis and contribute to the measured current. In CAST, it is indicated that an overestimated corrosion rate is achieved if all current is attributed to corrosion.
- Hydrogen release: hydrogen can be absorbed by the metal; this is especially the case for Zircaloy, by which an underestimated corrosion rate can be obtained if the hydrogen release rate is assumed to represent the corrosion rate. Measurement of the hydrogen released, and hydrogen absorbed, result in similar corrosion rates, as verified with the release rate of dissolved non-radioactive metallic compounds. These hydrogen investigations are important for the fate of released dissolved organic carbon compounds.