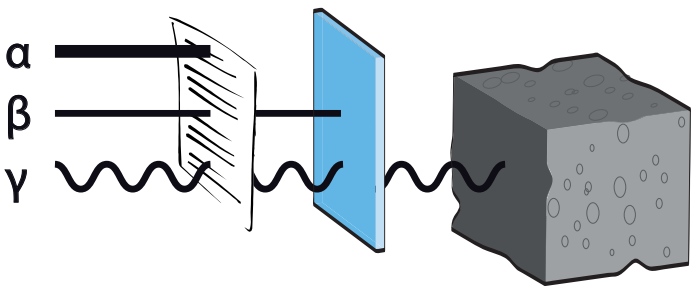
NEWSLETTER 3

The nature and effects of the processes and events used to assess the safety of a geological disposal facility must be considered for timescales of hundreds of thousands of years. One of the main issues is the ability to assess these events and processes with sufficient confidence over these long timescales. Confidence depends on the quality and presentation of the research executed. This newsletter is one of a series of newsletters which are intended to inform stakeholders with a general interest in the CAST project.

CAST (Carbon-14 Source Term) is a research project that aims to develop understanding of the potential release of carbon-14 from radioactive waste materials under conditions relevant to waste packaging and disposal in underground geological disposal facilities. The project focusses on the release of carbon-14 as dissolved and gaseous species from irradiated metals (steels, Zircaloys), irradiated graphite and spent ion-exchange resins.

The CAST consortium brings together 33 organisations from 14 countries in the EU, Switzerland, Ukraine and Japan. The involvement of waste management organisations ensures that the project is aligned to European geological disposal programmes and that end results are of use in the safety assessments.



The progress of CAST is visualised in a digital growing tree and continuously updated on the website of CAST www.projectcast.eu

Carbon-14

Carbon-14 is a natural radioactive substance (radionuclide) that is continuously generated in our atmosphere and on the Earth's surface, from nuclear reactors. Carbon-14 is radioactive, but does not present an external radiation hazard as the radiation cannot penetrate the skin. However, in many cases the external radiation radiation dose is from other radionuclides.

Three types of radiation can be emitted during decay of radionuclides -alpha, beta and gamma - these are shown in the image to the left. Alpha is the least penetrating - it can be stopped by a sheet of paper. Beta can penetrate air and paper, but can be stopped by a thin sheet of aluminium. Gamma is the most penetrating, and can be stopped by centimetres of lead or metres of concrete.

Metals, such as steels, that have been irradiated in a nuclear reactor may require remote handling in shielded facilities because the gamma-activity is too high. The challenge for many of experiments in CAST is to measure potentially low levels of carbon-14 release to gas or to solution and to undertake this in shielded or remote handled facilities. Obtaining information on the chemical form of the carbon-14 at low concentrations is difficult, several decades between discharge and measurement may be necessary to allow decay of the other radionuclides in the waste.

In this newsletter, we describe how some of the experiments in CAST are addressing these challenges.

Challenges to determine the total carbon-14 content in waste

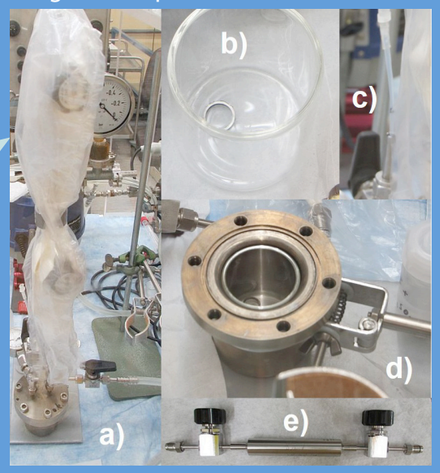
Carbon-14 in wastes needs to be isolated from other radionculides, so that the total carbon-14 content can be determined. To undertake this isolation, a (representative) sample of the waste is changed into a gaseous form, and the gas containing carbon-14 is separated from the rest of the gas. In CAST, irradiated steel, irradiated Zircaloy, irradiated graphite and spent ion exchange resins are investigated. Carbon-14 in the metals was changed to a gaseous form by dissolving the samples in acid, whilst carbon-14 in the resins was changed to a gaseous form by burning the samples.

Irradiated metals

Release of carbon-14 for acidic dissolution of Zircaloy- 4 (KIT)

The release of carbon-14 via acidic dissolution was measured from samples of Zircaloy-4 cladding, taken from an irradiated Pressure Water Reactor fuel rod that was discharged in 1989. The samples were dry cut and digested in acid in an outclave and the released carbon-14 separated from other radionuclides in gaseous aqueous aliquots and analysed by liquid scintillation counting (LSC). The figure on the right show the dismantled parts of the equipment:

a) the sealed autoclave with gas collecting cylinder mounted on the top;
b) the glass liner with the Zircaloy-4 sample;
c) the tub used for the addition of acids;
d) the glass liner with sample in the open autoclave;
e) the gas collecting cylinder with two valves.



Challenges to determine the chemical form at disposal

The release mechanism of carbon-14 from the wastes depends on the chemical composition of the deep underground water, and how this interacts with the waste packages in a geological disposal facility. Many countries assume the use cementituous materials for their waste packages, therefore in CAST, we are investigating carbon-14 release under alkaline conditions.

Development of sensitive analytical techniques

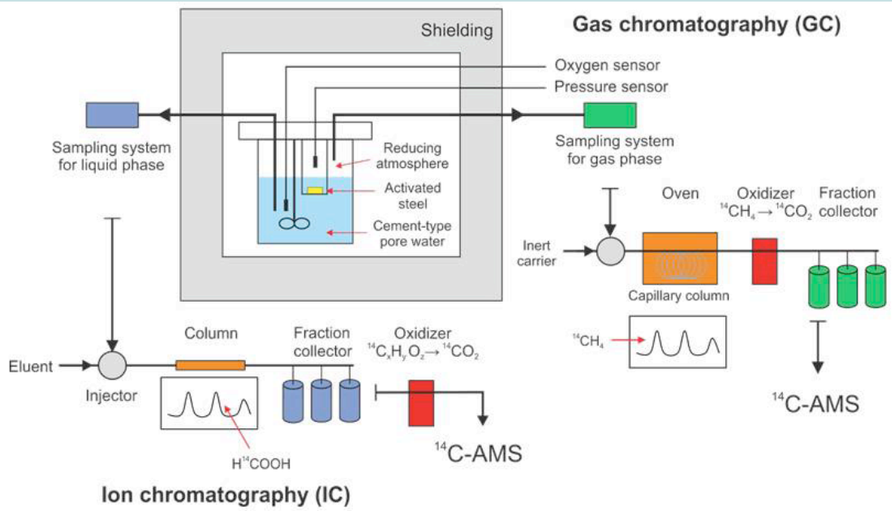
Release of carbon-14 from irradiated steel during corrosion (PSI)

Preliminary calculations indicate that the concentrations of ^{14}C-organic compounds expected to be formed from corrosion experiments with irradiated steel are likely to be extremely low due to:

a) a low ^{14}C-inventory;
b) a low corrosion rate in hyper-alkaline conditions;
c) low amount of material that can be used in experiments due to dose rates of other radionuclides.

This means that to be able to detect and speciate any ^{14}C requires a very sensitive analytical method. A compound specific accelator mass spectrometer technique is being developed. This involves separate methodologies for techniques for liquid and gaseous samples, however both methodologies involve separation of the compounds, fraction collection and on-line measurements.

CAST report D2.3: Report on selected analytical procedures at PSI



Spent ion exchange resins

Release of carbon-14 for combustion and acid stripping (INR)

Canadian reactor type CANDU spent ion exhange resin samples originating from the Cernavoda Nuclear Power Plant Unit 1 (Romania) are being analysed for total carbon-14 using two methods. Combustion by flame oxidation is used to measure total carbon-14. Acid stripping will be used to determine the carbon-14 present as carbonate, the methodology for this is under development. The experimental equipment is shown in the figure below and consists of the reaction vessel which contains the resin sample, with associated cooling coil and dropping funnel for addition of acid and a set of gas washing bottles to trap evolved ^{14}C-carbon dioxide.

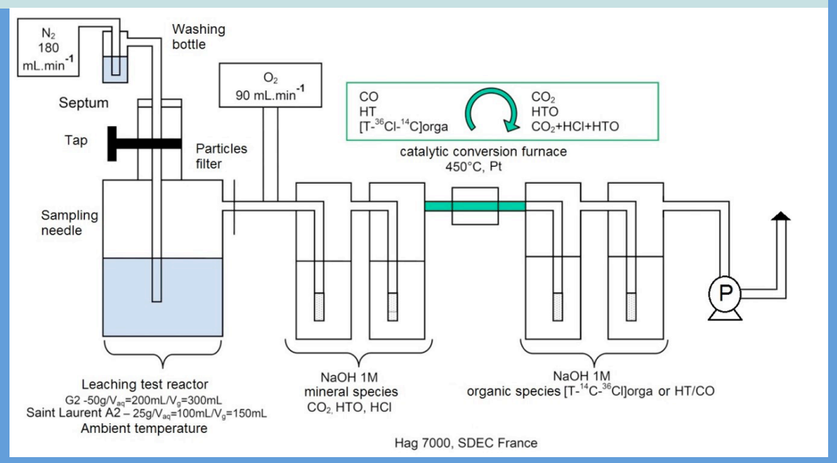
CAST report D4.3: Annual Progress Report on WP4 - year 2

Irradiated Graphite

Determination of carbon-14 in leaching liquid (EdF, ANDRA)

Graphite samples were obtained from two different reactors in France with different operational conditions (temperature, neutron flux, etc.) and originating graphite produced with different cokes. Leaching tests were performed on powdered samples to enhance ^{14}C release by increasing the contact surface between liquid and irradiated graphite. Test parameters were chosen to ensure that ^{14}C measurements were above detection limits. ^{14}C in the leaching liquid is measured using the combustion method with $^{14}CO_2$ trapped in a specific scintillating liquid. Part of the sample liquid is analysed to obtain the organic and inorganic ^{14}C-content. Another part of the sampled liquid is acidified to remove the organic content, then it is analysed to obtain the inorganic ^{14}C content of the solution. The difference between the two analyses gives the organic ^{14}C content of the leaching solution.

CAST report D5.8: Synthesis report on 14C speciation in solution and gas from French graphite waste



Further reading?

Please visit the 'publications' section of the website at: http://www.projectcast.eu/publications there is a special section for CAST Reports.

Past events

General Assembly meetings are held to periodically update and review the project status and progress. The CAST Expert Advisory Group reviews the key deliverables from the project. This group consists of the end-users (national waste management organisations executing the safety assessment in Work Package 6 of CAST) and two independent experts. These experts are Dr. Fraser King,a corrosion specialist, and Dr. Irka Hadjas, a carbon-14 specialist. Four meetings have been held so far.

The third meeting was in Bucharest in October 2015 and was hosted by INR/IFIN-HH. The fourth meeting took place in Luzern in October 2016 and was hosted by NAGRA. The minutes of the General Assembly Meetings are published on www.projectcast.eu.

Upcoming event

Organisations not participating in CAST but with an interest in waste containing carbon-14 are invited to attend the General Assembly meetings, as observers. The final CAST symposium will be held in January 2018 in Lyon, France. Details have not yet been announced, but please e-mail ellie.scourse@mcmenvironmental.co.uk or check www.projectcast.eu if you are interested in attending the final symposium.

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