Cement-Organics-Radionuclides-Interactions

FNSPE contribution





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"Czech Team" – close cooperation with R. Vašíček (FCE CTU in Prague), P. Večerník (ÚJV Řež, a.s.), Z. Hlaváč (CVŘ s.r.o.)

DNC: 6 new students in 2020/21

Effect of organic concrete admixtures (plasticizers) and their degradation products as well as degradation products of organic radioactive wastes (including ion exchangers/PAN sorbents) fixed in the cement matrix on the migration of radionuclides in the cement/concrete environment

Task 2 – Organic degradation

Degradation products from radiolysis/hydrolysis of organic in strong alkaline environment

Task 3 - Organic-Cement-Interactions

Behavior of degradation products in presence of cementitious material

Task 4 – Radionuclide-Organic-Cement-Interactions

Task 3 + 🙀

MATERIALS – SOLID (Tasks 2-4)

Hardened cement pastes CEM I (stage I and II; with/without plasticizer)

Concrete Richard (CEM III) – approx. 10 years old material from repository

All crushed and sieved (≤ 0.4 mm)

CSH phase – calcium-silicate-hydrate

Material selection for the Czech Republic:
Richard LLW/ILW repository life prolongation
Data for safety evaluation (drum in drum)
Concrete containers – future LLW/ILW + HLW repository (decommissioning)

HCP CEM I – reference material



MATERIALS – ORGANIC, LIQUID (Tasks 2-4)

Superplasticizer CX ISOPLAST 531 – polycarboxylic ether and lignosulfonate, for winter use

Polyacrilonitrile sorbents – PAN, AMP-PAN, KNiFC-PAN

Degradation products - EDTA, adipate, ftalate, formate/oxalate

- Degradation products identified in Task 2

Working concentration 5·10⁻³ and 5·10⁻⁵ mol L⁻¹

L/S 10; 100; 250; 500; 1000 L kg⁻¹

Liquid Phase – Portlandite water – saturated Ca(OH)₂ – 2·10⁻² mol L⁻¹

– NaOH of comparable pH (≥ 12.5)

MATERIALS – RADIONUCLIDES (Task 4)

U (under strong alkaline conditions solubility limit approx. 10⁻⁶ mol L⁻¹, ²³³U), Pb and Eu (10⁻¹² – 10⁻⁴ mol L⁻¹, initial experiments with stable nuclides, ²¹⁰Pb, ¹⁵²Eu)

TASK 2 – ORGANIC DEGRADATION

Task leaders – Andra and CNRS-SUBATECH

Characterization and quantification of soluble organic species generated by radiolytic/hydrolytic degradation

- Radiolytic degradation of chosen plasticizer and sorbents in alkaline conditions
 Gamma irradiation chamber in CVŘ
 (60Co source), 1.5 kGy/hour
 Dose up to 12 MGy (0.5; 1; 2; 4; 8; 12 MGy)
 Sealed glass vials 10 mL
- Degradation of chosen plasticizer and sorbents by hydrolysis in alkaline conditions
 Time of hydrolysis up to 1 year
- Degradation of organic additives (plasticizers) in cement materials (HCP CEM I and Concrete Richard samples) by radiolysis

Cement materials prepared by FCE – cylinders, pucks

• Identification (and quantification) of the organic substances present after both degradation processes

HRMS analysis – raw material characterization
FT-IR and MS analyses
(4000 – 400 cm⁻¹, Drift, ATR)
HPLC combinable with
UV/VIS – organic compounds
refractometry – organic compounds
radiometric determination

conductivity measurement – ions

Preparation of ion exchangers based on PAN

matrix (PAN, AMP-PAN, KNiFC-PAN)

Liquid phase (for both degradation processes)
 CX Isoplast 531 pH = 2.7
 Ca(OH)₂, NaOH – added as solid, resulting pH > 12

• Controlled atmosphere during hydrolysis x risks of carbonation

TASK 3 – ORGANIC-CEMENT-INTERACTIONS

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Task leaders – KIT, Amphos21 and Andra

TASK 4 – RADIONUCLIDE-ORGANIC-CEMENT-INTERACTIONS

Task leaders – CEA and CIEMAT

Behavior of organic degradation products (including that identified in Task 2) in highly alkaline environment in presence of cementitious materials (Task 3) and in presence of radionuclides RA (Task 4)

- Migration/interaction of organic with cementitious materials using sorption experiments (Task 3)
- Release of organic from cementitious materials (matrix) using leaching tests (Task 3)
- RN migration in cement environment in the presence of degradation products using sorption and diffusion experiments (Task 4)
- Interaction of RN-organic complexes with cementitious materials by sorption, diffusion or column experiments (Task 4)

Mixing order – organic + RN into cement or RN into EDTA +cement

- Release of RN-organic complexes from the cement matrix by leaching experiments (Task 4)
- Determination of radionuclides concentration/activity in highly alkaline environment

Problematic use of scintillation cocktail in highly alkaline environment for uranium determination

TRLFS determination

Determination of organic – same as in Task 2

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