MOBILITY MISSION REPORT

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MISSION TITLE

Samples and knowledge transfer for cellulose degradation PSI-SCK

DESCRIPTION

Concerned organisations

SCK CEN (Research entity; Boeretang 200 – 2400 Mol (Belgium)
PSI (Research entity; Forschungsstrasse 111 – 5232 Villigen (Swizerland)

Concerned infrastructures or facilities

Other relevant infrastructure or facility to be specified: Laboratories for degradation of organic materials; laboratories for migration studies of radionuclides in clays and cement

Concerned phases

Phase 4: Facility operation and closure

Themes and topics

Theme 4: Geoscience to understand rock properties, radionuclide transport and long-term geological evolution

- Perturbations (gas, temperature and chemistry)
- Aqueous pathways and radionuclide migration

Keywords

Cellulose; long-term degradation; ISA production; radionuclide sorption reduction

EXECUTIVE SUMMARY

Within the CORI WP of the EURAD project, a strong focus was put on the degradation of cellulose and on the impact of the degradation products on sorption and diffusion of key radionuclides in cementitious material. As part of the project, SCK CEN investigated the degradation of cellulosic tissues under irradiation and alkaline hydrolysis over a period up to 2.5 years. The obtained degradation products were further used in sorption experiments to assess their effect on the sorption on Ni on hardened cement paste at different degradation states. The effect of the degradation products from cellulosic tissues was found much more pronounced than observed with the pure isosaccharinic acid (ISA), which is the main cellulose degradation product of pure cellulose and known to form complexes with radionuclides, thereby reducing their sorption to cement. The stronger effect of the degradation products from cellulosic tissues found in CORI WP suggests that some other compound resulting from the degradation of irradiated tissues could have a more significant effect on the sorption of RN on cement.

Almost 30 years ago, PSI had launched long-term cellulose alkaline degradation experiments. The results of the first 12 years allowed to get more knowledge on the kinetics of cellulose degradation and especially on the slow processes occurring over longer time. These experiments were still on-going, though recently PSI decided to not continue them further. Given our contribution and gained expertise within the CORI WP, they wished to pass them to SCK CEN. During this mission we therefore visited PSI to recover the experiments ensuring limited contact with air which could disturb the experiments/samples and discuss the future of the experiments. Furthermore, information on cellulose degradation and more specifically these long-term tests was exchanged in a meeting. Finally, we had the opportunity to visit some of the labs of PSI, *i.e.* the labs for diffusion and sorption experiments, both on cement and on clay, the labs where degradation studies take place (*e.g.* cellulose degradation, C-14 release from activated steel) and the chemical analyses lab.

1. MISSION BACKGROUND

1.1. R&D background

Almost 30 years ago, PSI had launched long-term cellulose alkaline degradation experiments. The results of the first 12 years allowed to get more knowledge on the kinetics of cellulose degradation and especially on the slow processes occurring over longer time. These experiments were still on-going, though recently PSI decided to not continue them further. Given our contribution and gained expertise within the CORI WP, they wished to pass them to SCK CEN.

1.2. Mission objectives

The objective of this mobility action was to pick-up the long-term cellulose degradation experiments launched 30 years ago by PSI and bringing them back to SCK CEN where they will be further continued/analyzed. A meeting between SCK CEN and PSI was also planned to transfer the knowledge on the experiments and discuss the future actions.

The mobility action was composed as:

- Day 1:

- car journey SCK CEN (Mol, Belgium)-PSI (Villigen, Swizerland)
- night in the vicinity of PSI

-Day 2:

- at PSI: Sample recovering, discussion and short visit of the labs
- car journey PSI (Villigen, Swizerland)- SCK CEN (Mol, Belgium)

1.3. Mission request

Samples and knowledge transfer for cellulose degradation PSI-SCK

1.4. Mission composition

Host organisation

Paul Scherrer Institut (PSI) – Villigen - Switzerland

Host facility

Paul Scherrer Institut (PSI) – Research division Nuclear Energy and Safety – Villigen - Switzerland

Mission dates

April 29th 2024 – April 30th 2024

2. MAJOR PRACTICES, TECHNIQUES, METHODS, TOOLS OR SYSTEMS OPERATED OR STUDIED

2.1. Practice, technique, method, tool or system operated or studied during the mission

Recovery of 30-years-old cellulose degradation tests

Description

The experiments were performed under anaerobic conditions, so also transport to SCK CEN needed to occur ensuring limited contact with air which could disturb the experiments/samples.

Usage

For this, the samples were packed in aluminum bags under vacuum pressure. Transport occurred by car to SCK CEN. At arrival, the samples were removed from the aluminum bags and immediately brought inside an anaerobic glove box at SCK CEN. There, they will be stored for the next years / decades

Benefits

The benefits on retrieving the samples ourselves is that we can control whether the samples were opened or not during transport (e.g. at the Swiss border) and thus to ensure anaerobic conditions during transport. Furthermore, transport time was limited this way.

Limitations

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Applicability

Similar techniques to ensure anaerobic conditions during storage and transport are implemented at SCK CEN as well.

2.2. Practice, technique, method, tool or system operated or studied during the mission

Cellulose degradation under alkaline conditions.

Description

Thirty years ago, PSI started alkaline degradation studies on cellulose and cellulosic materials (cotton, paper and tissues) to study the degradation products and kinetics. For this, suspensions of cellulose in ACW (artificial cement water) were prepared according to Van Loon and Glaus (1998). Sampling was performed regularly over the past 28 years

and discussed in Van Loon and Glaus (1998), Glaus and Van Loon (2008) and within the CORI WP final report of task 2.

Usage

At SCK CEN, the effect of pre-irradiation on the long-term degradation of cellulosic materials was studied within CORI WP, using similar materials and conditions. The 30-years old tests will be continued in the future and analyses will be performed to compare the degradation products and physicochemical properties of the non-irradiated materials in ACW from PSI with those from irradiated materials in ACW obtained by SCK CEN. Furthermore, the effect of the real degradation products from cellulose / cellulosic materials on sorption of radionuclides on cement will be investigated and compared with the effect of degradation products from irradiated tissues observed within CORI WP.

Benefits

See above

Limitations

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Applicability

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2.3. Practice, technique, method, tool or system operated or studied during the mission

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Description

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Usage

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Benefits

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Limitations

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Applicability

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2.4. Practice, technique, method, tool or system operated or studied during the mission

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Description

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Usage

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Benefits

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Limitations

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Applicability

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3. MISSION FINDINGS AND CONCLUSIONS

3.1. Lessons learned and conclusions

The knowledge exchange with the experts at PSI allowed us to ask for the specific details concerning these specific tests and best practices, resulting in information and data transfer from PSI to SCK CEN. Furthermore, discussions were held informing one another on their progress in certain studies and the current knowledge concerning for instance cellulose degradation and sorption of radionuclides on cement and clay.

3.2. Relevant findings and conclusions for home organisation

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3.3. Relevant findings and conclusions for host organisation

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3.4. Relevant findings and conclusions for other organisations

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4. POTENTIALS FOR IMPROVEMENT OR DEVELOPMENT

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4.1. Generic potentials

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4.2. Potentials for home organisation

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4.3. Potentials for host organisation

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APPENDICES

Mission journal

- April 29th 2024:

- 10:00 – 18:00: Car journey SCK CEN (Mol, Belgium)-PSI (Villigen, Swizerland)
- 19:00: Diner with colleagues from PSI, allowing an informal introduction and discussion on obtained results
- 21:30: Night in the vicinity of PSI

- April 30th 2024:

- 9:00-13:00: At PSI: Sample recovering, discussion and visit of the labs
- 13:00-21:00: Car journey PSI (Villigen, Swizerland)- SCK CEN (Mol, Belgium)

Mission bibliography

References discussing the 30-years-old cellulose degradation studies:

L.R. Van Loon and M.A. Glaus, Experimental and theoretical studies on alkaline degradation of cellulose and its impact on the sorption of radionuclides. 1998, PSI, Villigen, Switzerland.

M.A. Glaus and L.R. Van Loon, Degradation of cellulose under alkaline conditions: new insights from a 12 years degradation study. Environmental Science & Technology 42 (2008) 2906-2911.

MISSION BENEFICIARY

Nele Bleyen
Research project leader on studies related to organic waste
Waste and Disposal Expert Group
SCK CEN, Belgium

PARTNER EXPERTS CONTRIBUTING TO THE MISSION

Host organisation experts

- Martin Glaus, researcher at the Nuclear Energy and Safety Division of PSI (Switzerland)
- Jan Tits, researcher at the Nuclear Energy and Safety Division of PSI (Switzerland)
- Luc Van Loon, researcher at the Nuclear Energy and Safety Division of PSI (Switzerland) – currently retired

Home organisation experts

- Nele Bleyen, Delphine Durce, project leaders, Waste and Disposal Expert Group (SCK CEN, Belgium)
- Norbert Maes, Elie Valcke, unit heads, Waste and Disposal Expert Group (SCK CEN, Belgium)

Other organisations experts

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REPORT APPROVAL

Date	Beneficiary	Home mentor/supervisor	Host mentor/supervisor
2024-05-21	Nele Bleyen	Elie Valcke	Martin Glaus