The effect of high dose rate gamma irradiation on the curing of Fe-rich inorganic polymers

Bram MAST[1], Yiannis PONTIKES[2], Bram VANDOREN[3], Wouter SCHROEYERS[1], Sonja SCHREURS[1]

[1] Hasselt University, NuTeC, CMK, Nuclear Technology - Faculty of Engineering Technology, Agoralaan building H, B-3590 Diepenbeek, Belgium
[2] KU Leuven, Department of Materials Engineering, Kasteelpark Arenberg 44, 3001 Heverlee, Belgium
[3] Hasselt University, CERG, Faculty of Engineering Technology, Agoralaan building H, B-3590 Diepenbeek, Belgium

Abstract

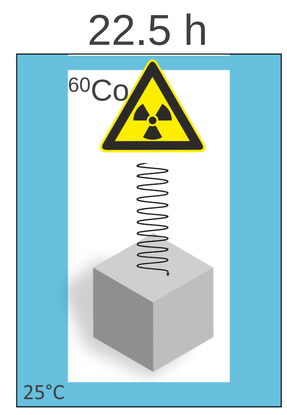
In search for alternative cementitious materials for radioactive waste encapsulation, geopolymers and inorganic polymers (IPs) have received wide attention. In this research study, the effect of gamma radiation on Fe-rich IPs during hardening was investigated. Mechanical and microstructural properties were identified. It was found that the compressive strength increased due to gamma irradiation. Also, a decrease in Young's-modulus and a decrease in creep was observed. The decrease in porosity and the radiation induced Fe-oxidation explain these observations.

Introduction

Ordinary Portland cements are currently used to condition low and intermediate level radioactive waste. However, several studies have already proven the detrimental effect of gamma radiation on ordinary Portland cement matrices, due to changes in average pore diameter, radiation induced carbonation and the formation of microcracks. Therefore, alternatives as inorganic polymers (IPs) are increasingly being studied. Moreover, Fe-rich IPs offer an interesting alternative to high density concretes for use in radiation shielding applications.

Materials and Methods

1 h, 24 h OR 28 d of curing



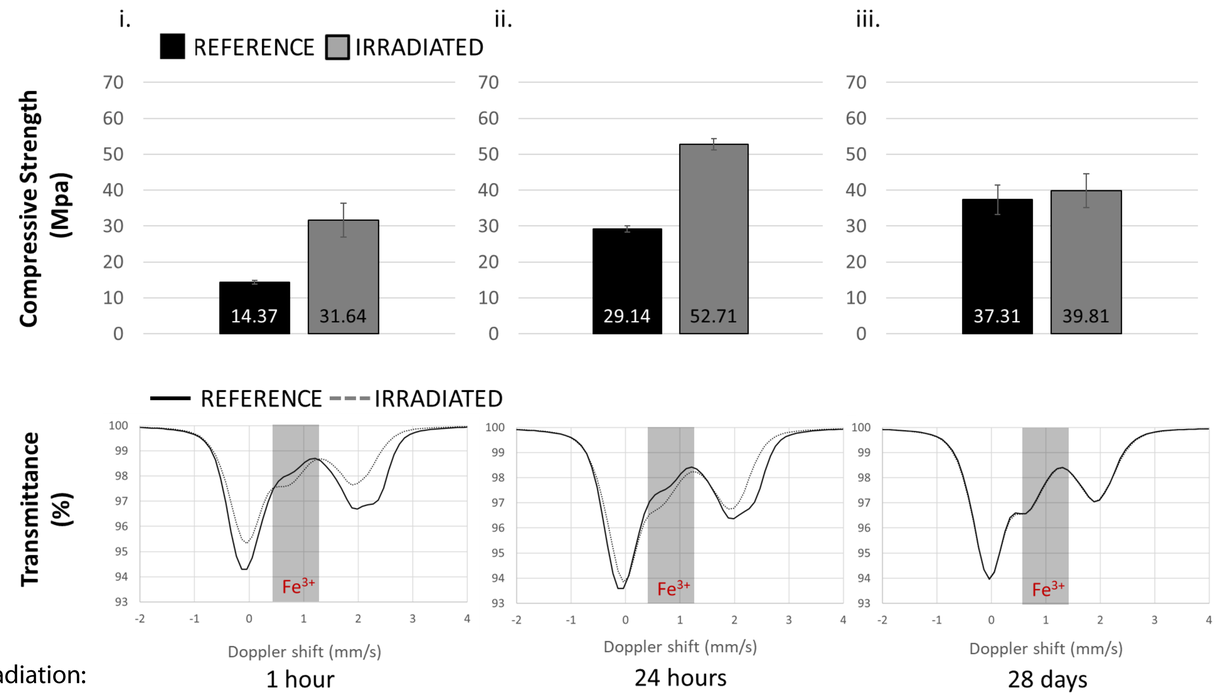
Set-up	Source	Dose rate
Brigitte SCK CEN	^{60}Co	8.85 kGy/h

Characterisation techniques:

- Compressive strength test
- Nanoindentation
- ^{57}Fe Mössbauer spectroscopy
- Mercury Intrusion Porosimetry
- Infrared Spectroscopy
- Thermogravimetry

Results

For non-fully hardened samples, gamma irradiation **increased the macromechanical compressive strength** as a result of dehydration, causing densification of the samples. Strengthening was also caused by the **radiation induced Fe-oxidation** since Fe^{3+} can take place in the IP network.



Conclusions

The irradiation effects highly depend on curing time prior to irradiation.

For 1 hour cured IP samples:

Property	Effect	Factor
Compressive strength	↑↑	2.20
Hardness of binder	↓	0.73
Elasticity of binder	↓	0.67
Creep time of binder	↓	0.72
Porosity	↓	0.92
Fe^{3+} content	↑↑	1.95
Free water content	↓	
Carbonates	≈	

UHASSELT
KNOWLEDGE IN ACTION

bram.mast@uhasselt.be

BOF16DOC16 UHasselt, ENEN+, FWO, ActUsLab-FMR IP4NA project Nr. 35433, project MIS 5002772 NSRF 2014-2020.