The effect of gamma irradiation on Fe-rich slag-based inorganic polymers

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- **Fe-rich inorganic polymers**
- **gamma irradiation**
- **radiation-induced strengthening**
- **radiation-induced iron oxidation**

Abstract
In search for alternative cementitious materials for radioactive waste encapsulation, geopolymers and inorganic polymers (IPs) have received wide attention. The absence of portlandite, the low water content and the high alkalinity, make IPs interesting candidates for the conditioning of certain radioactive waste streams. Moreover, Fe-rich IPs offer an interesting alternative to high density concretes for use in radiation shielding applications. Materials can though be altered when subjected to ionizing radiation, therefore the material's behaviour under irradiation have to be studied.

The effect of gamma irradiation was investigated on $CaO\text{-}Fe_xO_y\text{-}SiO_2$ slag-based IPs. IPs with different curing times (1 h, 24 h and 28 days) prior to the irradiation were irradiated at a dose rate of 8.85 kGy/h, to a total absorbed dose of 200 kGy. The effects were evaluated by means of compressive strength, porosity measurements, thermogravimetric analysis, infrared spectrometry, nanoindentation and ^{57}Fe Mössbauer spectroscopy. For each irradiation test, non-irradiated samples were kept as a reference at the same environmental conditions as the irradiated samples.

The effect of gamma radiation is observed to be dependent on the curing time prior to irradiation. 28 days cured samples are found to be resistant to the gamma irradiation for the dose(rate) tested. No change was found in strength, indentation characteristics, porosity and Fe^{3+} content. On the other hand, multiple effects were observed for the 1 hour cured samples: an increase of the compressive strength, a lower Young's-modulus, a lower creep in time, a decrease in porosity and an increased Fe^{3+}/Fe ratio. The increased macromechanical strength is a result of radiation-induced heating and water radiolysis in the IPs. Both processes affect the oxidation reactions and the carbonation taking place leading to a changed microstructure/porosity eventually leading to an increased strength.

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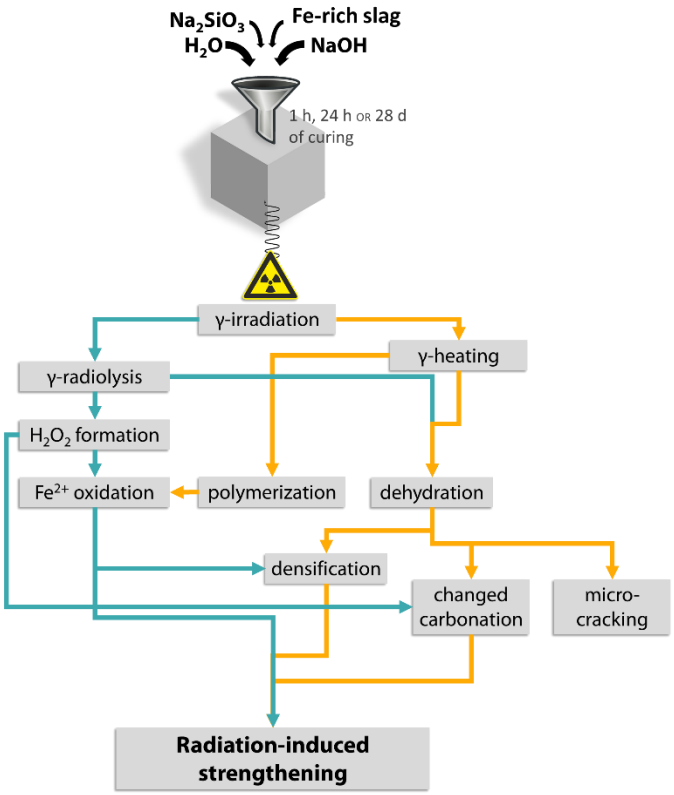
Na_2SiO_3
H_2O
Fe-rich slag
NaOH
1 h, 24 h OR 28 d
of curing
γ-irradiation
γ-heating
γ-radiolysis
H_2O_2 formation
Fe^{2+} oxidation
polymerization
dehydration
densification
changed carbonation
micro-cracking
Radiation-induced strengthening