Role of phosphorous in the nucleation of alkali aluminosilicate glass-ceramics

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Abstract

Alkali aluminosilicate glass-ceramics have been extensively studied and industrially produced due to their low thermal expansion, high transparency and excellent thermal shock resistance. Bulk crystallization is a crucial step that can be controlled by employing various additives. P2O5 added to aluminosilicate glasses has been shown to be effective for bulk crystallization of some crystalline phases. It is thus a crucial issue to understand the role of phosphorus as a function of composition (alkali nature, alumina content). We have thus investigated the changes in the P environment occurring during the first steps of nucleation and growth of crystalline phases.

Glasses of the systems Li2O-Al2O3-SiO2 and Na2O-Al2O3-SiO2 having different Al2O3/R2O ratios (R=Li,Na) and different P2O5 contents (0, 1 and 3 mol%) were prepared by melt quenching. DSC thermal analysis and XRD were performed to determine the crystallization profile of the glasses, and SEM and TEM allowed microstructure observation. The study of the environment around the phosphorous in the glass and its evolution with temperature has been done ex-situ by 31P MAS-NMR and correlation techniques such as 31P/27Al D-HMQC (Dipolar Hetero-nuclear Multiple-Quantum Coherence).

We have evidenced different crystallization behaviors depending upon the Al2O3/R2O ratio. These behaviors have been related to different local environment of the phosphorus in the as-cast glasses. In particular, our study emphasizes the importance of POAl complexes in aluminosilicate glasses.

Keywords: Glass, ceramics, nucleating agent, glass structure, P2O5, NMR spectroscopy

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