Influence of processing temperature and time on the structure evolution and mechanical properties of ion-exchanged soda-lime-silicate glass

Hamid Hassani*[1], Vincenzo Sglavo[1], Morten Smedskjær[2], and Kacper Januchta[2]

[1]University of Trento – Italy
[2]Aalborg University – Denmark

Abstract

Chemical strengthening of glass is carried out in a typical ion-exchange process where sodium atoms contained in the glass are substituted by potassium ions diffusing from the molten salt. The optimization of the fundamental parameters of the process, such as time and temperature, plays role in preventing stress relaxation and to guarantee efficient reinforcement of glass. The effect of different ion-exchange conditions on the mechanical behavior and the structure evolution of soda-lime silicate glass were studied in this work.
Glass samples were subjected to chemical strengthening in pure molten KNO3 at different temperatures and times. Ion-exchanged glass was characterized from a mechanical (residual compression and case depth, strength, surface crack formation, scratch resistivity), chemical (surface composition, potassium penetration) and structural (by Nuclear Magnetic Resonance (NMR) and micro-Raman spectroscopies) point of view.
The results show that the case depth increases with time and temperature of the process at the expense of a reduction in the residual stress. The same occurs for potassium surface concentration and penetration. The crack initiation tendency decreases in samples treated at lower temperature for shorter period. Furthermore, scratch test revealed a decrease in the length of the plastic regime of the samples by increasing the time and temperature of the exchange process. This is in good agreement with the NMR and micro-Raman results, where higher distribution of Q3 and Q2 species are observed and indicated network distortion for longer treatment times.

Keywords: Ion exchange, Chemical tempering, Chemical strengthening, Soda lime silicate glass, Nuclear Magnetic Resonance Spectroscopy, micro Raman Spectroscopy

*Speaker