

DMTA study of hydrated soda-lime-silicate glasses

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The internal friction of hydrated soda-lime-silica glasses with total water content (C_W) up to 1.9 wt. % was studied by dynamic mechanical thermal analysis (DMTA) using temperature-frequency sweeps from 723 to 273 K and from 1 to 50 Hz. Total water content and concentrations of H₂O molecules (C_{H_2O}) and OH groups (C_{OH}) in the DMTA specimens were determined by infrared spectroscopy. For low water contents ($C_W \approx C_{OH} < 0.25$ wt. %) two discrete internal friction peaks below the glass transition (α relaxation) were assigned to the low-temperature motion of alkali ions (γ relaxation) and cooperative movements of dissimilar mobile species under participation of OH at higher temperature (β_{OH} relaxation). For large water contents ($C_W > 1$ wt. %), where significant amounts of molecular water are evident ($C_{H_2O} > 0.15$ wt. %), however, internal friction spectra change unexpectedly: the β_{OH} peak heights saturate and a low temperature shoulder appears on the β -relaxation peak. This emerging relaxation mode (β_{H_2O} relaxation) was assigned to the motions of H₂O molecules but contributions of proton-hopping cannot be excluded. β_{H_2O} relaxation was found to be faster than β_{OH} but slower than γ relaxation. Activation energy of the different relaxation modes increased in the order $\gamma < \beta_{H_2O} < \beta_{OH} < \alpha$.