Impact of structural water on sub-Tg relaxations in glass

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Abstract

Structural relaxation at temperatures below glass transition provides the basis for aging and fatigue phenomena of glasses. Different water species are discussed to contribute to sub-Tg relaxation. Their dynamics are found to be decoupled from the cooperative rearrangements of the glassy network (alpha-relaxation) and the local motions of diffusional transport of ionic species (gamma-relaxation). Using mechanical spectroscopy, two types of new relaxations peaks (beta-relaxations) are evident in hydrous soda-lime silicate and hydrous sodium borosilicate glasses, which are assigned to the contributions of OH-groups and H2O molecules. Projected characteristic times at ambient temperatures of water-induced internal friction are ca. 10ˆ1 seconds for beta(H2O) and ca. 10ˆ3 seconds for beta(OH). In general, beta-relaxations are assumed to involve stress accommodating rearrangements that are located at non-bridging oxygen (NBO) containing silicon tetrahedra, but in case of the faster beta(H2O)-relaxation, the discussion also addresses possible jumps of H2O molecules between network cavities besides a hopping mechanism of protons between H2O and NBO.

Keywords: Relaxation, Water species, Mechanical spectroscopy

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