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Self-healing capacity of nuclear glass observed by NMR spectroscopy

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Borosilicate glasses have been recognized as valuable materials for the conditioning of nuclear wastes. An important issue for their long-term behavior is radiation effects which may impact their performance and stability. To address these concerns, a fundamental understanding of the origin at the atomic scale of the macroscopic property evolutions must be established. To this aim, magic-angle spinning nuclear magnetic resonance (MAS NMR) has firmly established itself as one of the most powerful tool to investigate glass structure. Recently, using external heavy ions irradiation (Xe, Au and Kr) to simulate alpha decays, dramatic changes in the local network structure were evidenced: Conversion of tetrahedral BO_4 units into planar trigonal BO_3 units (^{11}B), appearance of high-coordination aluminum units (AlO_5, AlO_6); glass depolymerization (^{29}Si) and changes in the distribution of alkali cations (^{23}Na). Additionally, the spectra broaden globally which supports the hypothesis of an increased topological disorder after irradiation. All these structural changes are similar to those observed with increasing the glass temperature or quenching rate and support therefore the model of ballistic disordering fast quenching events which induce a new glassy state with higher fictive temperature. Until recently, such studies were limited to externally irradiated samples (enabling the different components of irradiation to be dissociated for their precise investigation), but recently, the first MAS-NMR experiments could be performed on radioactive glasses (doped with ^{244}Cm 0.1 % mol.) paving the way for future MAS NMR examinations of self-irradiation damages in glasses. Experiments were performed at the Joint Research Centre Institute for Transuranium Elements (JRC-ITU) where a commercial NMR spectrometer were integrated with a radioactive glovebox and a MAS commercial probe. First results will be presented. Competitive effects between the recoil nuclei and alpha decays were evidenced and the high resistance of the nuclear waste glasses corroborated.

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Bioinspired wettability-controlled surfaces with gradient micro- and nano-structures

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Biological wettability surfaces with various-style gradient micro- and nanostructures (MN) greatly provide with excellent functions via natural evolvement. In nature, a combination of multiple gradients in a periodic spindle-knot structure take on surface of spider silk after wet-rebuilding process in mist. This structure drives tiny water droplets directionally towards the spindle-knots for highly efficient water collection. Inspired by the water collecting ability of spider silk, a series of functional fibers with unique wettability has been designed by various as-inspired techniques. Various geometrically-engineered thin fibers with the bead-on-string structures achieve droplet driving, transport of droplet for water collection in efficiency, etc. Besides, inspired by gradient effects on butterfly wing and lotus leaves, the surfaces with ratchet MN, flexible lotus-like MN are fabricated successfully by improved methods, which demonstrate that the gradient MN effect rises up distinctly anti-icing, ice-phobic and de-ice abilities. These multifunctional materials can be designed and fabricated for promising applications such as water-collecting, anti-icing, anti-frosting, or anti-fogging properties for practical applications in aerospace, industry, etc.

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