Contribution ID: **364** Type: **Poster**

Nanostructural changes in latex colloid-cellulose nanofibril hybrid films during humidity cycling

Tuesday 21 March 2023 16:00 (2 hours)

Cellulose nanofibrils (CNFs) are widely used due to their attractive properties such as low density, lightweight, thermal stability, and good mechanical properties. These prerequisites make cellulose nanofibrils a promising template material for the design of hybrid colloid-bio composites and bio-inspired functional coatings. Latex colloids are excellently suited to be incorporated in functional, e.g. amorphous photonic crystals, due to the tailored core-shell morphology. Hence, when combining such colloids and CNF, one needs to understand the nanoscale architecture of cellulose nanofibrils in networks and in the presence of other nanoparticles. Especially their reaction to external fields, e.g. humidity changes, is crucial in terms of stability and reversible/irreversible structural rearrangements. Here, we used depth sensitive grazing incidence small-angle neutron scattering (ToF-GISANS) to evaluate the humidity-induced latex colloid (of different sizes) and CNF rearrangements in situ during cyclic humidification. The measured kinetics help to resolve the time- and depth-dependence that particles of different sizes need to penetrate into the porous CNF network. We were able to resolve if the latex nanoparticles remain on the surface or penetrate the CNF matrix. After the first humidity cycle, a change in morphology on the scale of several 10 nm was observed, which is attributed to latex particles which diffused in the network and enlarged the pores of the network.

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Session Classification: Poster session TUESDAY

Track Classification: Thin Films and Interfaces