Cellulose aerogels functionalized by silica and titania

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Cellulose fibrils possess high mechanical strength but they lose it after the water absorption. Furthermore, there is a sharp decrease in their chemical and dimensional stability. They are also exposed to microorganism action, experiencing biodegradation in the wet state. Here our approach is considered for the fabrication of a cellulose aerogel with dimensional stability. However, its mechanical strength is decreased with absorbing the water as well. Aerogels are protected and functionalized through mineralization.

Mechanically strong, superhydrophobic, photocatalytic and self-cleaning aerogel bionanocomposites of high porosity and low density varying between 0.02 – 0.1 g/cm^3 are prepared. To strengthen and protect aerogels against the microorganisms, fibrils are coated by silica. It is deposited in one stage by using a biocompatible precursor in neutral aqueous solutions at ambient conditions without the addition of an organic solvent [1]. When a new water-soluble silica precursor with a methyl group attached to the silicon atom is applied, superhydrophobic cellulose is prepared. These aerogel bionanocomposites can work as an efficient oil absorbent, removing spills from a water surface.

Titania (TiO_2) coating was formed by another new route [2]. It consisted in regulation of the mineralization through limited hydration of polysaccharide fibers in nonaqueous media. This allowed obviating the common precipitation of titania after a precursor addition into aqueous or water-containing solutions. When titania precursor was admixed in nonaqueous media with the aerogel, it was involved into the instant hydrolysis and following condensation reactions where contacting with the hydrating water going to work as a reaction center. This resulted in TiO_2 formation mainly on cellulose fibrils [3]. It was treated at various temperatures to transfer titania into a crystalline state. It was possible to regulate the ratio of anatase to rutile as well as dimension of nanocrystals. Some of prepared samples had a photocatalytic activity comparable with commercial photocatalysts.

Cellulose demonstrating significant self-cleaning ability under the outdoor sunlight irradiation was prepared at the moderate conditions (80^{o}C) [3]. The polysaccharide template was also removed by calcination or carbonized that resulted in novel materials with crystalline titania.

All the made aerogels and bionanocomposites were characterized by a set of physico-chemical techniques including scanning and transmission electron microscopy, synchrotron based small and wide angle X-ray scattering, porosity measurement and spectroscopic methods to gain into an insight into the morphology, structure and crystallinity as well as into the structure-functionality relationship.

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