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Design of aerogels, cryogels and xerogels of cellulose with hierarchical porous structures

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Abstract

Cellulose-based biocomposites from nature exhibit remarkable mechanical properties which inspire to prepare synthetic biocomposites. The detailed studies of the porous cellulose materials having hierarchical structures are essential to understand how the cellulose nanofiber network and interconnected macro- and mesoporous structures exclusively influence the mechanical properties. We have designed the hierarchical open porous structures of cellulose scaffolds by a novel method in which an intricate trap of oil droplets in the cellulose-dissolved molten salt hydrate acts as a structural template assisting the formation of interconnected macroporous structures. After washing, the wet gels of cellulose were employed in three different drying techniques, namely supercritical drying, freeze drying and ambient drying. The diversity in physical and mechanical properties of the cellulose scaffolds were characterized by X-ray µ-computed tomography, density analyzer, scanning electron microscopy, nitrogen adsorption–desorption analysis, X-ray powder diffraction, FTIR spectroscopy and mechanical testing. In the resulting products, the variations in physical properties were the size of the macropores produced by the emulsion template, the change in surface features of the cell walls and the presence of nanopores in the cell walls. The mechanical properties of hierarchically porous cellulose materials were diverged from lightweight soft materials to hard, stiff and dense material.

Keywords: Cellulose; Aerogels; Cryogels; Xerogels; Hierarchical structure; Porous network.