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Biocellulose as Platform for the Development of Multifunctional Materials

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Abstract : Nowadays the interest on green nanocomposites and on the development of more environmental friendly products has been increased. Bacterial cellulose has been recently investigated as an attractive environmentally friendly material for the preparation of low-cost nanocomposites. The formation of cellulose by laboratory bacterial cultures is an interesting and attractive biomimetic access to obtain pure cellulose with excellent properties. Additionally, properties as molar mass, molar mass distribution, and the supramolecular structure could be control using different bacterial strain, culture mediums and conditions, including the incorporation of different additives. This kind of cellulose is a natural nanomaterial, and therefore, it has a high surface-to-volume ratio which is highly advantageous in composites production. Such property combined with good biocompatibility, high tensile strength, and high crystallinity makes bacterial cellulose a potential material for applications in different fields. The aim of this investigation work was the fabrication of novel hybrid inorganic-organic composites based on bacterial cellulose, cultivated in our laboratory, as a template. This kind of biohybrid nanocomposites gathers together excellent properties of bacterial cellulose with the ones displayed by typical inorganic nanoparticles like optical, magnetic and electrical properties, luminescence, ionic conductivity and selectivity, as well as chemical or biochemical activity. In addition, the functionalization of cellulose with inorganic materials opens new pathways for the fabrication of novel multifunctional hybrid materials with promising properties for a wide range of applications namely electronic paper, flexible displays, solar cells, sensors, among others. In this work, different pathways for fabrication of multifunctional biohybrid nanopapers with tunable properties based on BC modified with amphiphilic poly(ethylene oxide-b-propylene oxide-b-ethylene oxide) (EPE) block copolymer, sol-gel synthesized nanoparticles (titanium, vanadium and a mixture of both oxides) and functionalized iron oxide nanoparticles will be presented. In situ (biosynthesized) and ex situ (at post-production level) approaches were successfully used to modify BC membranes. Bacterial cellulose based biocomposites modified with different EPE block copolymer contents were developed by in situ technique. Thus, BC growth conditions were manipulated to fabricate EPE/BC nanocomposite during the biosynthesis. Additionally, hybrid inorganic/organic nanocomposites based on BC membranes and inorganic nanoparticles were designed via ex-situ method, by immersion of never-dried BC membranes into different nanoparticle solutions. On the one hand, sol-gel synthesized nanoparticles (titanium, vanadium and a mixture of both oxides) and on the other hand superparamagnetic iron oxide nanoparticles (SPION), Fe2O3-PEO solution. The morphology of designed novel bionanocomposites hybrid materials was investigated by atomic force microscopy (AFM) and scanning electron microscopy (SEM). In order to characterized obtained materials from the point of view of future applications different techniques were employed. On the one hand, optical properties were analyzed by UV-vis spectroscopy and spectrofluorimetry and on the other hand electrical properties were studied at nano and macroscale using electric force microscopy (EFM), tunneling atomic force microscopy (TUNA) and Keithley semiconductor analyzer, respectively. Magnetic properties were measured by means of magnetic force microscopy (MFM). Additionally, mechanical properties were also analyzed.

Keywords : bacterial cellulose, block copolymer, advanced characterization techniques, nanoparticles
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