Development of cornstarch aerogels with high porosity and their impregnation with natural bioactive compounds

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Aerogels are materials with high specific surface area and high porosity, which can be produced from polysaccharides such as starch [1,2]. Starch is an abundant and low-cost polymer with versatility in processing. Aerogel properties are influenced by the process parameters including starch-to-water ratio, gelatinization temperature (T), selection of non-solvent for water replacement in hydrogels, selection of drying method, drying pressure (P) and T, *etc.* [1,2]. Supercritical drying, which employs supercritical carbon dioxide ($scCO_2$), is an environmentally friendly process that allows relatively fast production of aerogels. Despite the superior properties of starch aerogels, they do not express biological activity. This can be overcome by the incorporation of bioactive compounds (BCs) into aerogels using the supercritical impregnation (SCI) process [3,4]. SCI implies the dissolution of BCs in $scCO_2$, diffusion of BC-$scCO_2$ solution into a polymer matrix, possible chemical or physical interaction of BC with polymer, and complete removal of $scCO_2$ from the BC-polymer after a decrease of P and T to atmospheric. This process allows one-step production of solvent-free added value materials at relatively low T and the incorporation of high amounts of BC with various biological activities. Aerogels can be impregnated with pharmaceutical drugs but also with natural BCs (single or mixture) such as plant extracts [3,4]. To produce aerogels, 10 g of cornstarch (amylose content 20–30%, HeMoss, Serbia) was mixed with 100 mL of distilled water, gelatinization T was changed from 70 to 100 °C, water contained in hydrogels was replaced with acetone or ethanol during 1 or 5 days, drying P was varied from 8 to 20 MPa while drying T was 35 or 40 °C. Drying of gels was performed in a 25 mL high-pressure view cell while impregnation of aerogels with BCs was performed in a 280 mL high-pressure unit (Eurotechnica GmbH, Germany). Developed aerogels were tested as possible carriers of hemp and bilberry extracts as well as carriers of neat components such as carvacrol and citronellol. Produced cornstarch aerogels showed high liquid absorption capacity (ca. 400%). Due to high specific surface area, low density, high porosity, and biocompatibility, obtained aerogels present promising candidates for the development of biomaterials that will release BCs in a controlled manner and enable antimicrobial activity. The SCI processes enabled the impregnation of a high amount of tested natural BCs achieving loadings up to 33%. By controlling preparation process parameters, which leads to tuning of pore size and pore size distribution, tailoring of aerogel properties for special purposes is possible.

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