Production of Aerogels Using a Biodegradable Polymer: Mathematical Modeling of Supercritical Drying

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Aerogels are materials with an open nanoporous structure and large specific area. Nowadays biodegradable polymeric compounds, such as polysaccharides, have received attention to be used on the production of aerogels. So, the objective of this work was to investigate the drying kinetics of alcogel in supercritical CO_2, using sodium alginate as polymer. The surface area and pore size distribution were determined by nitrogen adsorption and desorption. Two methods to the formation of alginate beads at different sizes were used resulting in bigger particles and smaller particles. The bigger hydrogel beads were formed dropping the alginate solution using a liquid pump in gelling solution with a tubing of 0.56 mm of internal diameter. The smaller beads were formed by the atomization of alginate solution using carbon dioxide as atomization gas. The hydrogel was converted to alcogel using steps of solvent exchange with ethanol. Two different gradient of ethanol concentration were tested in the solvent exchange step, with a gradient of 10:90, 30:70, 50:50, 70:30, 90:10 and 100:0 (ethanol:water, % v/v) and, without gradient, 100:0 (%, v/v) of ethanol. The production of aerogel was carried out by the extraction of ethanol from the alcogel using supercritical carbon dioxide (SC-CO_2) as extractor solvent. Shrinkage of the particle size of alginate microspheres was observed after supercritical drying when comparing the surface weighted and the volume weighted mean diameters of the alcogels and aerogels. The same behavior was observed to particles produced without gradient in the solvent exchange step. However, the particles polydispersity showed constant values independently of the solvent exchange gradient or the step of the process. Furthermore, it was possible to observe that within the first 10 minutes of SC-CO_2 drying about 90 % of the solvent in the porous gel network was removed, while for the conventional drying only 25 % of ethanol was evaporated from gel particles. The diffusion coefficient values obtained in this work were lower than the diffusion coefficient obtained by the Wilke and Chang equation for the calculation of diffusivity of pure ethanol in SC-CO_2 at the same drying conditions (4.1×10^{-8} m^2/s). Probably, this difference is due to the diffusion resistance arising from the gel network (e.g., voidage and tortuosity). High surface area and pore volume were obtained to atomization process with exchange solvent gradient, 484 m^2/g, and 0.70 cc/g, respectively. Aerogels obtained by dropping without gradient of ethanol showed surface area of 381 m^2/g and pore volume of 0.68 cc/g. These results could be useful for cost evaluation of the process and future application.

Keywords: supercritical; difussion; ethanol; surface area; pore volume