Coating of Alginate Aerogel Particles in a Wurster Fluidized Bed

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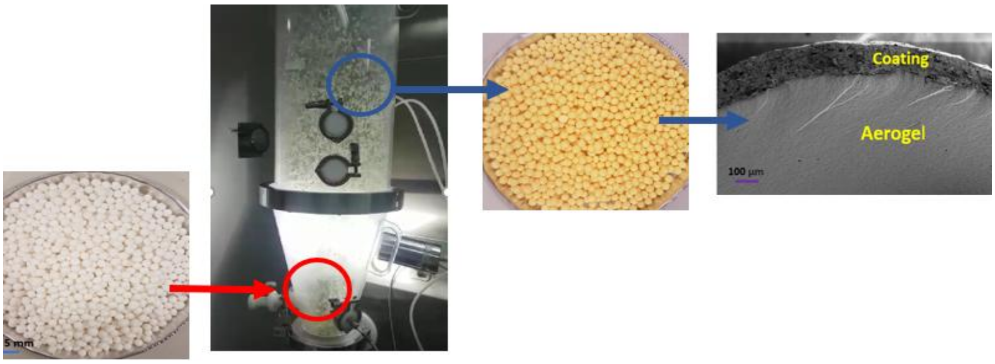

Due to their open pore structures, very high specific surface areas and pore volumes, aerogels in the form of particles are attracting increasing attention for a wide variety of applications such as cosmetics, catalysis and drug delivery. To provide new opportunities for their applications and further enhance their properties, aerogels may be coated or encapsulated with numerous polymers. Coating is an essential component of particle formulations in various industries, particularly in the pharmaceutical industry. Among various processes employed for coating of pharmaceutical tablets, spray coating is carried out in fluidized beds or drum coaters. However, coating of aerogels based on current technologies which are established for tablets is a challenging task since tablets and aerogels have quite different properties such as very different densities, porosities, and mechanical strength. The main objective of the present study was to develop a methodology for successful coating of alginate aerogel particles without damaging their porous structure. Spherical alginate aerogel particles were synthesized by dripping an alginate solution from a nozzle into a $CaCl_2$ solution followed by solvent exchange and drying with supercritical CO_2 in an Applied Separations Speed SFE. The mean particle size and the mean particle density were 4.20 ± 0.02 mm and 0.05 ± 0.01 g/cm^3, respectively. An aqueous solution of a polymer mixture which is based on copolymer of 1-vinyl-2-pyrrolidone, and vinyl acetate (copovidone) was successfully applied to alginate aerogel particles in a Wurster fluidized bed (FBDG-1, O'HARA Technologies). Coating times for all the runs ranged from 5 minutes to 40 minutes and the coating layer thickness (CLT) ranged from 12.4 ± 4.6 µm to 170.6 ± 43.3 µm. Variations occurring in CLT around aerogel particles and changing coating layer surface morphology with coating time, bed temperature, atomizing air pressure and polymer rheology investigated. Several sets of experiments were conducted at three bed temperatures which were 30°C, 50°C and 70°C and three atomizing air pressures (AP) which were 1.3, 1.5 and 1.7 bars. At each bed temperature, AP was set to 1.7 bar whereas at each AP, bed temperature was set to 50°C. The smoothest coating layer surface was achieved at 50°C and 1.7 bar AP with the highest coating efficiency which was 78.2 ± 1.1%. CLT linearly increased with coating time at 50°C both at 1.7 bar and 1.5 bar APs which is desirable for a successful coating process. Due to the moderate polymer viscosity and elastic modulus, the lowest contact angle as ~118° was achieved at 50°C which indicating a good droplet spreading on an aerogel surface. At 30°C and 70°C, CLT slowly and non-linearly increased with coating time and the maximum CLT was approximately 50 µm for both temperatures. At 30°C, polymer solution penetration inside the inner coating layers through cracks and volcanoes on the coating surface resulted in a 'no growth period' where formation of new layers around aerogels was very slow. Moreover, high polymer viscosity which was measured as 0.45 Pa-s was unfavourable for droplet spreading. At 70 °C, drying of some of the coating droplets before an aerogel-droplet interaction and high polymer elastic modulus led to a slow increase in CLT. An increase in AP from 1.5 bar to 1.7 bar resulted a smoother coating layer surface without affecting CLT to a great extent. High velocities of coating droplets with a narrow droplet size distribution led to a homogeneous spreading and less variance in CLT at 1.7 bar. Coatings at 50°C were very similar in smoothness and morphology to coatings on standard pharmaceutical tablets demonstrating the suitability of Wurster fluidized bed for successful coating of aerogel particles.