Supercritical fluid extraction for production of aerogels and aerogel-related materials

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Supercritical extraction of gels and gel-like porous materials results in the dry matrix with high porosity and high surface area. An example of this materials are aerogels, which are applied in different fields as insulation materials, catalysts carrier, filling material etc. Furthermore aerogels have been shown to be promising candidates for drug delivery systems, since adsorption of drugs to aerogels allows a long-time stabilization of amorphous drugs (Rolison, 2003; Smirnova et al., 2004). Traditionally only a limited amount of gels were dried with the help of supercritical CO_2. Efforts have been traditionally focused on silica aerogel and carbon aerogel development with a wide range of applications in different fields, e.g., aeronautics, biomedicine, construction, environmental remediation or agriculture (Akimov, 2003). In the last years the variety of the matrix materials increases rapidly. In this contribution an overview about the application of supercritical extraction for different gels is given. The properties of the resulted materials are compared with each other in order to demonstrate both general and specific limitation associated with the process. Main focus is maid on the organic aerogels, like polysaccharides. The preparation of aerogels from polysaccharide precursors gives rise to a highly porous (ε=90-99 %), lightweight (ρ=0.07-0.46 g/cm3) drug carrier with high surface area properties (Sa=70-680 m2/g), able to enhance the drug bioavailability and to provide a superior drug loading capacity. Further, different ways of the aerogels production are discussed (figure 1).

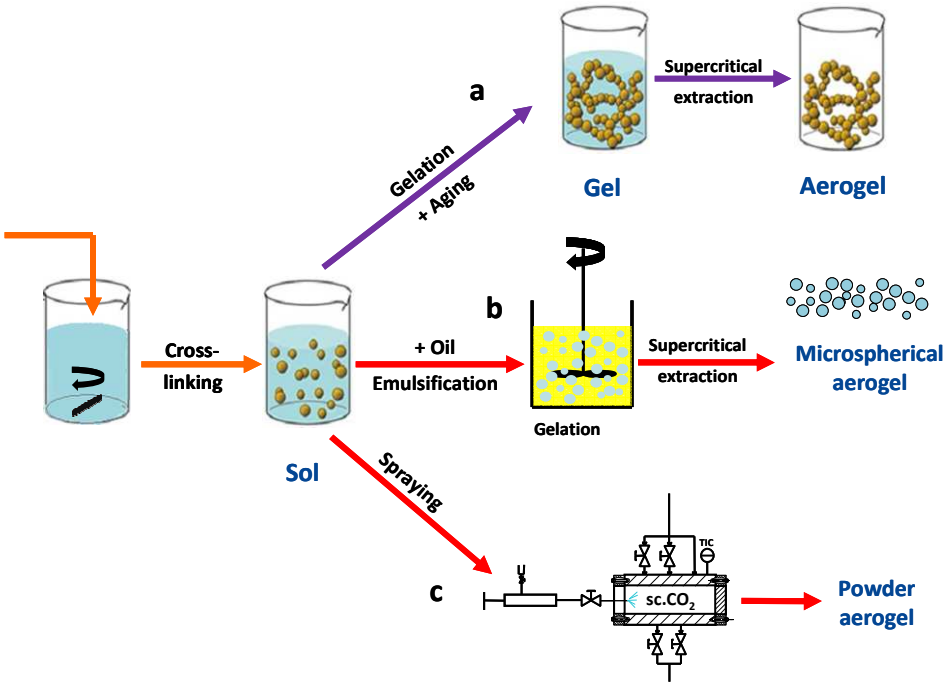

Figure 1. Differenty pathways for aerogel production

The production of monolithic bodies (pathway a) and microspherical particles are demonstrated, whereas the main focus is given to the extraction time and its influence on the properties of the matrix itself and the particle size distribution of the product. Supercritical extraction of emulsions and dispersion (pathway b, Figure 1) is regarded as a promising rout for the mass production. Effects of gelation temperature, oil-to-water ratio and surfactant content on the textural and morphological properties of the aerogel material are discussed in (Alnaief 2011, 2011 a, 2011b).

The limitation of aerogels in a number of applications is their open-pore structure, allowing the penetration of liquids therein. This drawback could be overcome by coating of aerogels with polymeric materials. This is a challenging task, since usually in case of standard carriers, aqueous coating with polymeric materials in a fluidized bed is used. In case of aerogels their structure might be destroyed by contact with water so that the contact time has to be as short as possible. Moreover, fluidization of silica aerogels is difficult due to their low density (< 0.1 g/cm³). Novel methods for production of aerogel microspheres and their coating in the fluidized bed apparatus are discussed. In our work aerogel particles were coated using a novel slit-shaped spouted fluidized bed with two horizontal gas inlets and adjustable gas supply. This technology offers the fluidization of small and light or very large particles, which can be strongly non-spherical or sticky with a broad size distribution. For the aerogel coating process, polymers were sprayed in form of aqueous solution or melts (Figure 2).

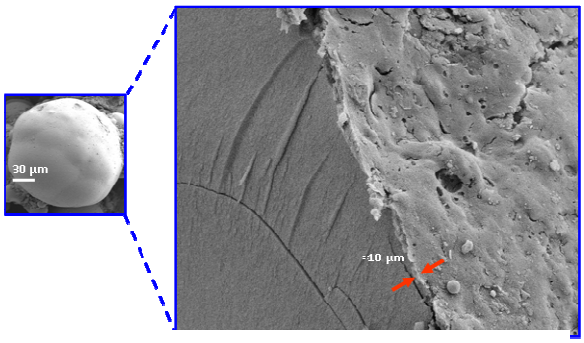

Figure 2 : SEM of Aerogel coated with Eudragit

Drying of the coated aerogel was achieved by heating the bed with a hot air stream. This technology allows to provide a specific release mechanism of pharmaceuticals (thermal, pH-sensitive or enzyme triggered release) from aerogels and to broaden aerogel applications in pharmaceutical technology.

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