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Rapid Synthesis of Mechanically Strong Aerogels for energy applications

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In spite the fact that Native silica aerogels are ultra-light, highly porous, highly thermal insulating materials, and are being considered for many applications such as thermal and sound insulation for aerospace, as absorbents for environmental remediation, and as supports for catalysts [1-4]. However, the major problem with aerogels is their mechanically fragility that impeded their commercialization and limited their fabrication in the form of granules or panels of limited thickness. Aerogel production is a slow and tedious process. Wet gels, termed aquogels or alcogels depending on the solvent can be rapidly synthesized following well-established procedures [5,6] but drying is time-consuming. Because of capillary forces the solvent cannot be evaporated without cracking and shrinking the monolith.

Recently, we report a novel synthesis approach through which mechanically strong aerogels can be fabricated just in few hours instead of few days. The other novelties associated with our process is one pot synthesis for both native and cross-linked aerogels and no need for time consuming process of multiple solvent exchanges. This also significantly truncate large volume of fresh solvent required during the conventional synthesis process. The results are of particular importance, since they dramatically shorten fabrication times for monoliths with large sizes of native and, most importantly, of cross-linked aerogel. Cross-linked silica aerogel materials with exceptional mechanical and thermal strength were synthesized through sol-gel process using in situ photopolymerization of acrylate monomer using visible light laser as source of light. The photo-cross-linkable monomer, HDDA, along with photo-initiator system (Eosin Y + Amine) was incorporated in the solution of silica gel precursors, TEOS and MTMS. The photo-cross-linked aerogel were characterized by FTIR, SEM, TEM and BET analysis that confirmed formation of Nano-porous silica network and polymer structures with uniform distribution of Nano-globules and Nano-pores throughout the materials.

Finally, our group has been developing alternative fabrication methods which enable to produce custom parts which are made mechanically strong by reinforcing the regions of highest solicitation with a polymer. We have fabricated custom parts that may be used as insulation of selected parts of internal combustion engines, passive fire protection of structural elements in building, and lightweight footwear for extreme cold conditions. We also have developed cost-effective and scalable procedures for fabricating these custom- shaped aerogels.

Keywords: Aerogel; thermal insulation; Mechanically strong; porus

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