Recyclable and superelastic aerogels using aqueous cellulose-assisted dispersions of carbon nanotubes

Alireza Hajian

Wallenberg Wood Science Center, Department of Fiber and Polymer Technology, KTH Royal Institute of Technology, Stockholm, Sweden

Abstract

Aerogels are low-density materials with high porosity that have engineering applications where good mechanical performance needs to be combined with lightweight. One route to make aerogels is by ice-templating and freeze-drying an aqueous dispersion of functional nanoparticles. In the aerogels made up of carbon nanotubes (CNTs), a combination of good mechanical performance and conductivity can be obtained. The cell walls in such aerogels, however, constitute a random-network of CNTs. Therefore, these aerogels do not show shape-recovery after compressing, unless the CNT particles are covalently bonded or connected by a thermoset polymer phase. In this case, it is not possible to recycle the aerogel constituents and more importantly the CNTs without breaking the covalent crosslinks. CNTs are not biodegradable and their environmental impacts are not well-understood yet.

We hereby show a new route to fabricate recyclable and superelastic (shape-recoverable) aerogels with high conductivity and good mechanical properties. We use carboxymethyl cellulose (CMC) solution to disperse and stabilize as-prepared CNTs in water followed by directional freezing and freeze-drying. This results in honeycomb structures with cell walls of random-in-the-plane CNTs in CMC matrix. We further control plastic or elastic deformation of the cell walls as a function of cell wall porosity, CNT type and content. CMC acts as a physical crosslinker in a porous cell wall which makes the aerogels easily recyclable in water. The aerogels show similar electrical and mechanical properties after recycling. This method is all water-based and avoids chemical treatments without the loss of the material components.

Image

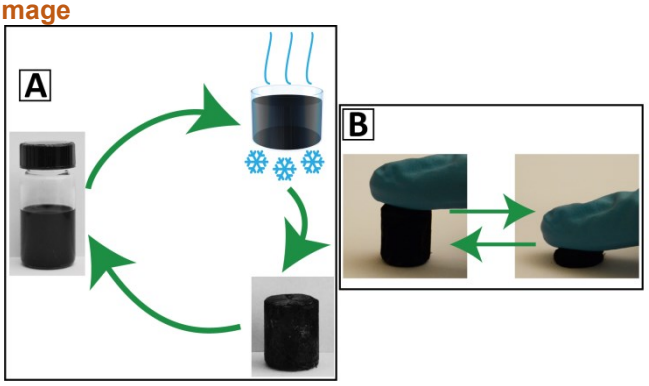


Figure 1. A) Schematic and photos show the process of making the aerogels and recycling. B) Photos show an aerogel when pressed (right image) and released (left image).

Recent Publications

1. Hajian, A., Fu, Q., & Berglund, L. A. (2018). Recyclable and superelastic aerogels based on carbon nanotubes and carboxymethyl cellulose. *Composites Science and Technology*, *159*, 1-10.
2. Hajian, A., Lindström, S. B., Pettersson, T., Hamedi, M. M., & Wagberg, L. (2017). Understanding the dispersive action of nanocellulose for carbon nanomaterials. *Nano letters*, *17*(3), 1439-1447.
3. Hamedi, M. M., Hajian, A., Fall, A. B., Håkansson, K., Salajkova, M., Lundell, F., ... & Berglund, L. A. (2014). Highly conducting, strong nanocomposites based on nanocellulose-assisted aqueous dispersions of single-wall carbon nanotubes. *ACS nano*, *8*(3), 2467-2476.
4. Hajian, A. (2018). *Cellulose–Assisted Dispersion of Carbon Nanotubes: From Colloids to Composites* (Doctoral dissertation, KTH Royal Institute of Technology).



Biography

Alireza Hajian received his Ph.D. in 2018 in fiber and polymer science from KTH Royal Institute of Technology (in Sweden) with focus on cellulose-based composites. He is now working as a researcher at the Wallenberg Wood Science Center at KTH.

Email: hajian@kth.se