Aerogels based on cross-linked carbon nanotube scaffolds

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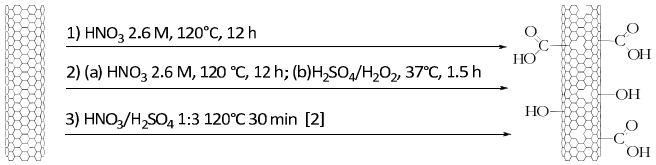
Introduction

Aerogels are low density, highly porous materials with large surface area offering a wide range of applications as thermal and acoustic insulating materials, catalyst support and electrodes for supercapacitors.[1] Carbon nanotubes (CNTs) are nanoscale structures with excellent mechanical and electronic properties, as well as low density, high aspect ratio and large surface area. In an attempt to combine the properties of such materials, we have investigated the production of macroscopic aerogel structures based on covalently crosslinked CNTs networks.

Experimental procedure

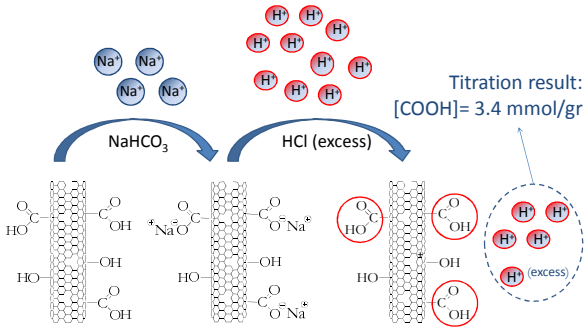
1. Functionalisation of CNTs

Functionalisation of CNTs (ARKEMA multi-walled carbon nanotubes) by the introduction of carboxylic acid and hydroxyl groups on the surface via acid oxidation. Three different oxidising procedures were used.



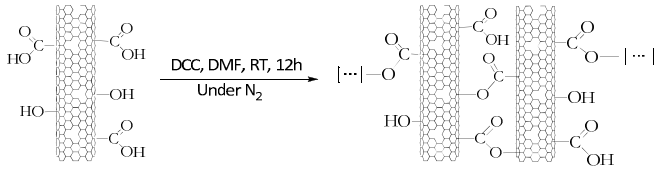
Oxidation of CNTs (left).

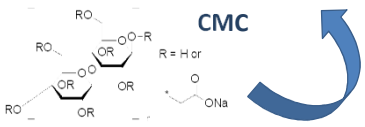
Titration for the quantification of the carboxylic acid groups [3] (right).



2. Crosslinking of CNTs

In order to have a robust network and avoid the collapse in the absence of solvent, covalently crosslinked CNT networks were prepared.

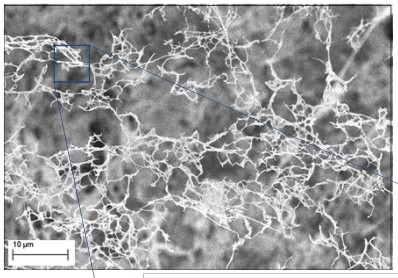


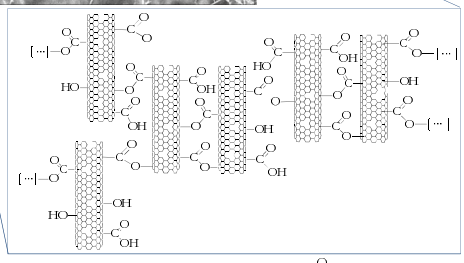


Anionic carboxymethyl cellulose (CMC) sodium salt can be used to improve the CNT dispersion.

Esterification of a carboxylic group with a hydroxyl group in the presence of dicyclohexylcarbodiimide (DCC) (left).

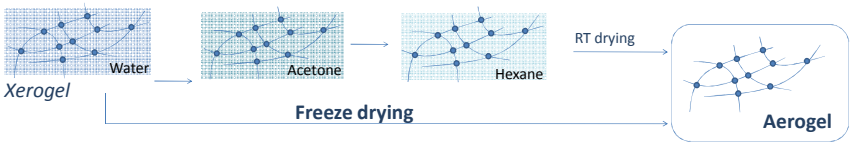
Scanning electron microscopy (SEM) of the crosslinked CNTs (right).

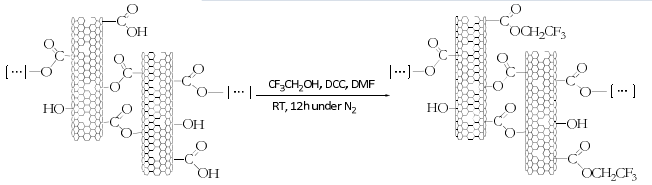




3. CNT-based aerogels synthesis

Solvent exchange





Scheme showing the two methods used for the synthesis of CNT aerogels: Freeze drying and solvent exchange /atmospheric pressure drying.

Esterification with a fluorinated alcohol to obtain hydrophobic CNTs in order to help the removal of solvent without collapsing the network.

Conclusions

- The introduction of carboxylic acid and alcohol groups onto the CNT surface enables covalent crosslinking, via esterification, to form a robust network.
- CNT aerogels were obtained by removing the solvent using either freeze drying or solvent exchange methods. An additional esterification to introduce hydrophobic functional groups onto the CNT surface can assist solvent removal.
- These CNT-based aerogels are promising candidate materials for catalyst supports and environmental applications including sorption, filtration and separation.

Bibliography

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