PAPER POTENCY

Biodegradable, flexible, and ultra-strong cellulose aerogels can be made from paper waste

PAPER WASTE CONTRIBUTES 20 per cent of the overall waste in Singapore each year. But what if that paper could be put to good use?

Assistant Professor Hai M Duong and his team from the Department of Mechanical Engineering at the National University of Singapore's Faculty of Engineering may have answered that question by successfully developing cellulose aerogels from paper waste.

The aerogels have many potential applications, ranging from cleaning up oil spills to insulating buildings. Cleaning up spilled oil is particularly interesting as the current polypropylene mats which are used can degrade and themselves pose a problem, so there is a strong demand for a more eco-friendly sorbent.

Assistant Professor Duong and his team have developed a simple, cost effective method to fabricate aerogels from paper waste using common industrial reagents in just three days by using Kymene™ as a cross-linker, instead of common sodium hydroxide and urea. The research project received grant support from NEA's Environment Technology Research Programme (ETRP).

After being freeze dried and coated with methyltrimethoxysilane (MTMS) via chemical vapour deposition, the recycled cellulose aerogels exhibit ultra-flexibility, highly porosity, super-hydrophobicity and outstanding oil absorption capability.

Assistant Professor Duong and his team have also discovered a way of expanding the weight capacity of the cellulose aerogels.

This is done by infusing the fibres of the cellulose aerogels with a solution of metallic nanoparticles. The cellulose aerogels are then hammered flat to remove most of the air, resulting in a magnetic thin film that has a weight capacity of over 28 tonnes per square centimetre.

MTMS-uncoated cellulose aerogels are hydrophilic, meaning they can absorb and retain huge volumes of polar fluids such as water and alcohol and can be used in products such as baby diapers and sanitary napkins.

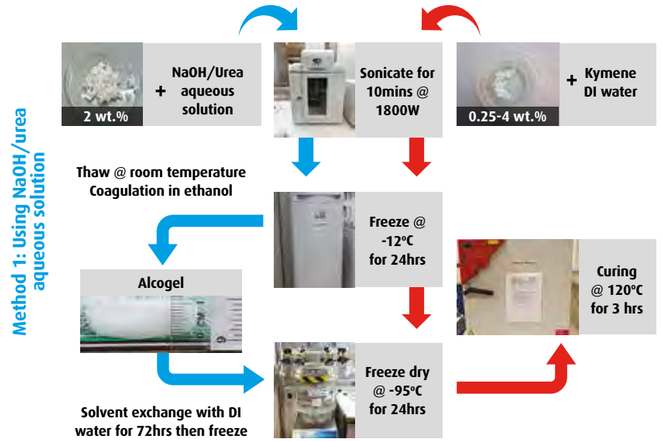
In addition, compressed cellulose aerogels can be used to plug life-threatening wounds such as a gunshot or stabbing lesion by injecting them into the wound cavity.

The sponges expand inside the cavity, creating pressure that can block bleeding and life-threatening haemorrhage in 20 seconds or less. This incredible speed is a remarkable boon, which could greatly enhance survival rates.

According to a forecast by BBC research, the total global aerogel market will grow at an exponential rate of 19.3 per cent from 2012 onwards, and reach global revenue of US$332.2 million by 2017. In particular, the thermal and acoustic insulation sector accounted for 82.3 per cent of all revenue in 2012 and this sector shows the highest potential growth with a five-year compound annual growth rate of 20.2 per cent from 2012 through 2017.

Sales of aerogels for this sector were generated primarily by their utilisation in industrial insulation. Therefore, with its high thermal insulation property, the application of the recycled cellulose aerogels in industrial insulation looks extremely promising.

The product has been licenced to a local SME, Bronxculture Pte Ltd, which intends to manufacture the cellulose aerogels and further expand its applications in insulating materials for packaging boxes, insulating layers for winter garment and oil absorption materials.



KEY FEATURES OF THE CELLULOSE AEROGELS

- The recycled cellulose aerogels displayed excellent flexibility: the large-scale cellulose aerogel is easily bent or rolled without damaging its shape. Moreover, the yield points are not observed up to 70 per cent strain for all the tested cellulose aerogels, demonstrating an excellent deformability.
- The cellulose aerogels which are coated with Trimethoxy-methylsilane (MTMS), giving the aerogel its hydrophobic property, can absorb oil excluding water up to 95 g/g (90 times of its dry weight and four times larger than that of the best commercial sorbents). They can be squeezed to recover over 99 per cent of absorbed crude oil.
- Thermal conductivities of 1.0 - 4.0 wt.% cellulose aerogels are 0.034 - 0.037 W/m.K. The water-repellent aerogel structures are stable over six months in tropical climate. The thermal stability of the cellulose aerogels using Kymene™ binder was much better than that of the cellulose aerogels fabricated from the sodium hydroxide-urea aqueous solution.