Lecture 12. Application of carbon aerogels for the removal of organic pollutants/oils

The unique combination of properties enables them to function effectively across diverse applications. Their sustainability enhances their appeal for use in energy storage, catalysis, thermal insulation, and environmental remediation, meeting both performance and environmental requirements. One of the primary applications of these aerogels is in energy storage devices. Their high conductivity and expansive surface area are particularly advantageous in super-capacitors and batteries, where they serve to enhance energy storage capacity and cycling stability. In super-capacitors, carbon aerogels function as electrode materials that can store large amounts of charge quickly, contributing to efficient energy use. For batteries, they provide stable and durable anodes or cathodes, increasing the battery's lifespan and reliability.

Another important type of carbon aerogels is biomass-derived carbon aerogels. This is because, unlike other types of carbon aerogels that use petroleum products as precursors, biomass-based carbon aerogels use biomass or biomass waste, so they are environmentally friendly and cost effective (Sam et al., 2020). In Table 2 carbon aerogels from different biomass precursors and their SSA and application area are collected. Wu et al. (Wu et al., 2013) obtained carbonaceous gels, including carbonaceous hydrogels and aerogels by using watermelon as raw materials. Li et al. (Li et al., 2014) prepared 3D carbon aerogels by using winter melon as the carbon source through the hydrothermal and post-pyrolysis process. The obtained winter melon-based carbon aerogels are shown excellent hydrophobicity, and low density and they can be the absorption of oils and organic solvents 16-50 times their weight. Chen et al. (Chen et al., 2015) fabricated carbonaceous aerogels from natural cotton waste and used them as adsorbents for wastewater clean-up. Zhu et al. (Zhu et al., 2017) prepared carbon aerogels using pomelo peels as the carbon sources via pyrolysis process at 600, 700, and 800 °C (Fig. 3a). Obtained pomelo peel-based carbon aerogels are shown that their characteristics depend on pyrolysis carbonization temperature. These aerogels had an interconnected 3D porous morphology and SSA between 466 and 759.7 m^2/g. Cai et al. (Cai et al., 2018) synthesized nitrogen-doped 3D network porous carbon aerogels by using cabbages as the raw materials through hydrothermal, freeze-drying, and carbonization processes (Fig. 3b). These aerogels had a hierarchical 3D network porous structure and shown a high-performance as electrode materials for supercapacitors, as well as high adsorption capacity and recyclability for different organic solvents and oils. Wang et al. (Wang et al., 2017) proposed the preparation method of the carbon aerogel using waste durian shell (DSCA) as the biomass precursor and its application in the removal of organic pollutants (Fig. 3c). Li et al. (Li et al., 2018) converted the biomass of cocoon into a heteroatom (N, S and Fe) ternary-doped, porous carbon aerogel (HDCA) catalyst. Vazhayal et al. (Vazhayal et al., 2020) developed carbon aerogels using waste tissue paper (WTP) and poly(vinyl alcohol) (PVA) as a carbon source. Chen et al. (Chen et al., 2020) proposed a facile and sustainable strategy to fabricate a wood-derived elastic carbon aerogel with a tracheid-like texture from cellulose nanofibers (CNFs) and lignin. Yang et al. (Yang et al., 2021) prepared carbon aerogel using the cellulose extracted from the luffa sponge for adsorption of diesel oil (Fig. 3d). Authors modified obtained carbon aerogels using trichlorosilane to enhance the adsorption capacity for diesel oil. Modified carbon aerogel had better adsorption capacity for diesel oil (49.62 g/g) than aerogel (5.2 g/g) and carbon aerogel (32.34 g/g).

Table 2
Comparison of S_{BET} and application area of carbon aerogels from different biomass precursors

Type of carbon material	Raw material	SSA, m²/g	Application	Ref.
Carbon aerogels	Natural cotton waste	1160	Adsorbents for wastewater clean-up	(Chen et al., 2015)
Carbon aerogels	Pomelo peel	466.0-759.7	Absorbent for removal of organic pollutants/oils	(Zhu et al., 2017)
Carbon aerogels	Cabbage leaves waste	536	For supercapacitors and oil/water separation	(Cai et al., 2018)
Carbon aerogels	Durian shell	735	For removal of organic pollutants	(Wang et al., 2017)
Carbon aerogels	Cocoon	714	As efficient catalyst for the oxygen reduction reaction in alkaline medium	(Li et al., 2018)
Carbon aerogels	WTP-PVA	1384	Adsorbent, catalyst supports and in energy storage devices	(Vazhayal et al., 2020)
Carbon aerogels	Wood	1124	For pressure sensing and energy storage	(Chen et al., 2020)
Carbon aerogels	Cellulose	-	For adsorption of diesel oil	(Yang et al., 2021)
N self-doped carbon aerogel	Chitosan	1480	For high-performance supercapacitors	(E et al., 2021)
N-O-P co-doped carbon aerogel	Abundant radish	1648.91	For high-performance supercapacitors	(Zhou et al., 2021)
A N-doped carbon aerogel	Cellulose	1196	For high-performance supercapacitors	(K. Zhao et al., 2022)
ALC	Sugarcane	390	Sensor, energy conversion and storage, and EMI shielding	(Li et al., 2015)
HCFSs	Catkins	438	Absorbent for oils and organic solvents	(Zang et al., 2016)

Literatures

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