Lecture 6. Biomass-derived porous carbon materials

Last several decades, researchers interested in carbon aerogels due to their various characteristics, such as high porosity, low density, controllable surface functional groups, etc. Moreover, they are the lightest materials in the world. Since Pekala (Pekala et al., 1990) developed the first resorcinol-formaldehyde carbon aerogel, Kroto et al. (Kroto et al., 1985) discovered fullerenes, the first carbon nanomaterials, than Ijima (Iijima, 1991) discovered carbon nanotubes, further Geim and Novoselov (Novoselov et al., 2004) obtained graphene, 2D nanomaterials, interest to develop carbon aerogels based on carbon nanomaterials have been increased. After these discoveries, in 2007 Bryning et al. (Bryning et al., 2007) and 2009 Wang (Wang and Ellsworth, 2009) reported carbon nanotubes-based and graphene-based carbon aerogels, respectively. In 2011 Pauzauskie (Pauzauskie et al., 2011) synthesized diamond-based carbon aerogels and later a lot of research works (Kabiri et al., 2014; Sultanov et al., 2014; Zhao et al., 2018) in this area have been published. These aerogels have good mechanical characteristics (Bryning et al., 2007), but synthesis methods of these precursors are high-cost and complicated. For instance, the synthesis of graphene by CVD method, which is a widespread method, can produce graphene with high quality, but they have very low production rates. Another method, which can be used to produce graphene is mechanical exfoliation, graphene with lower quality, but with high production rates can be obtained. Moreover, carbon nanomaterials are nonrenewable and their influence on human health has not yet been comprehensively investigated (Chen et al., 2020).

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 1 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.

Table 1. Comparison of S_{BET} and application area of carbon aerogels from different biomass precursors

Type of carbon material	Raw material	SSA, m^2/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

1. Lesbayev B., Auyelkhankyzy M, Ustayeva G., Yeleuov M., Rakhymzhan N., Maltay A., Maral Ye. (2023) Recent advances: Biomass-derived porous carbon materials. South African Journal of Chemical Engineering 43:327–336. DOI:10.1016/j.sajce.2022.11.012.

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