Lecture 2. Activated carbon materials based on rice husk

Activated carbon is a porous carbon material that contains macro-, meso-, and micropores and has a high SSA. Activated carbon can be obtained from almost any carbon-containing material of organic origin, but the main carbon source for its production on an industrial scale are charcoal, coal and petroleum coke, rice husks (RHs), coconut shells, and oil palm empty fruit bunches (EFB), wood, nut shells and various plant wastes. In Table 1 activated carbon from different biomass precursors, their SSA and application area are collected. The activated carbon production technology includes two successive stages of carbonization and activation. The carbonization process is a heat treatment of feedstock without oxygen at temperatures from 450 to 650 °C. Activation is carried out at temperatures above 750 °C and two types of activation are mainly used: vapor-phase and thermochemical. The structural composition of the raw material and the conditions of their carbonization, subsequent activation, and modification of their surface have a significant impact on the structure and properties of activated carbon.

Table 1. Comparison of S_{BET} of activated carbon from RH precursors

Raw material	SSA, m^2/g	Application	Ref.
RH	2696	Supercapacitor electrode	(Teo et al., 2016)
RH	2804-3263	Supercapacitor	(Liu et al., 2019)
RH	1583	Lithium-sulfur (Li-S) battery	(Mai et al., 2019)
RH	2176	Lithium-ion batteries (LIBs)	(Yu et al., 2018)
RH	3292	Electrode materials for supercapacitor	(Yeleuov et al., 2020)

Many researchers showed the advantages of RHs which are a major by-product in the rice milling industry as the raw materials to prepare activated carbon anode and cathode materials for lithium batteries, supercapacitor electrodes, etc. Teo et al. (Teo et al., 2016) fabricated a high surface area (surface area of 2696 m^2/g) activated carbon using RHs as a biomass carbon source. The obtained activated carbon applied as a supercapacitor electrode exhibited good electrochemical performance. Liu et al. (Liu et al., 2019) prepared the RH derived-activated carbons and the obtained samples exhibited a high microporous ratio, high specific area (up to 3263 m^2/g), and high specific capacitance (315 F/g at 0.5 A/g). They started when the silica in rice hucks is removed, the prepared activated carbon exhibits a high mesoporous ratio and good rate capability. Mai et al. (Mai et al., 2019) developed highly porous with micro/meso porosity through carbonizing RH and treating them with K_2CO_3. They loaded elemental sulfur to activated carbon to prepare composite materials and then used it as a cathode material for lithium-sulfur batteries. Yu et al. (Yu et al., 2018) prepared the RH based-activated carbons (RHAC) by an effective and facile method (Fig. 1). Authors noted, NaOH, as an activator, plays a crucial role in forming the hierarchical porous structure in this method. Yeleuov et al. (Yeleuov et al., 2020) prepared a highly porous activated graphene-based carbon (AGC) by using RH as a carbon source. The obtained AGC had a very high SSA of 3292 m^2/g and can be successfully used as electrode material for supercapacitors.

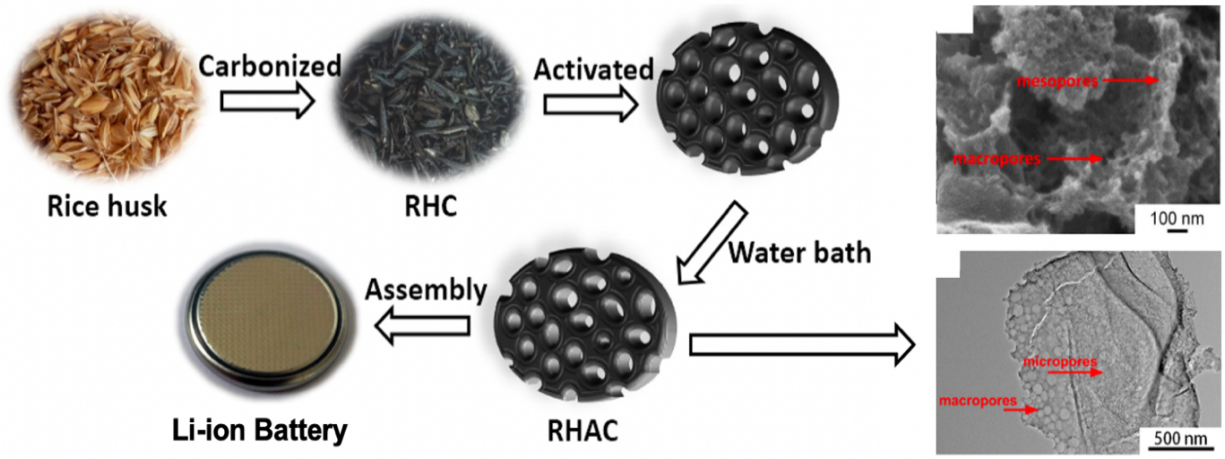

Fig. 1. Scheme of obtained RHAC anode material by a facile method and transmission electron microscopy (TEM) images of RHAC. Reprinted with permission from (Yu et al., 2018).

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.

2. Lesbayev B., Auyelkhankyzy M., Ustayeva G., Yeleuov M., Rakhymzhan N., Maral Y., Tolynbekov A. (2023) Modification of Biomass-Derived Nanoporous Carbon with Nickel Oxide Nanoparticles for Supercapacitor Application, Journal of Composites Science, 7:20, doi.org/10.3390/jcs7010020