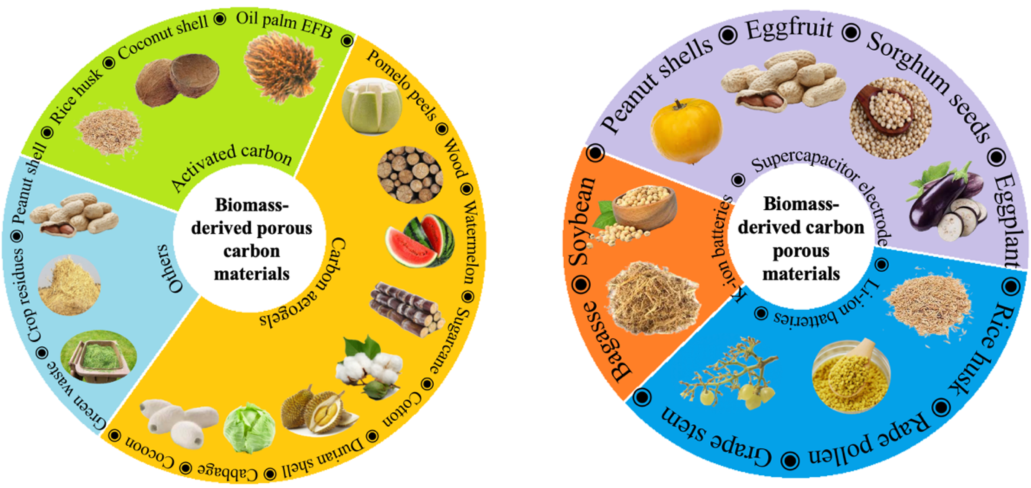
Lecture 3. Cost-effective carbon materials based on rice husk

Activated carbon derived from carbon-rich sources, such as biomass, rice husk, or coconut shells is a highly porous material, which is known by its large surface area and high adsorption capacity. Due to its unique properties, it is an essential material in wide range of applications, specially, in environmental remediation, water treatment, and energy storage. Activated carbon has a specific surface area that ranges from 500 to 1500 m^2/g. AC can be effective in capturing pollutants because of its porous nature, which enables a variety of compounds. Additionally, the surface of activated carbon has a variety of functional groups that can improve its interaction with other adsorbents. The substance endures high temperatures and is chemically resistant, which makes it appropriate for a variety of industrial applications. Activated carbon, a highly porous material with extensive surface area, can be synthesized through physical or chemical activation methods. The synthesis of activated carbon involves two primary processes carbonization and activation. Carbonization is the thermal decomposition of organic material in the absence of oxygen, resulting in a charred product. This is followed by activation, which can be achieved through physical or chemical methods. Physical activation involves heating the carbonized material (biomass precursors undergo carbonization at high temperatures (600–1200°C) under an inert atmosphere (e.g., nitrogen or argon)) in the presence of oxidizing gases, such as steam or carbon dioxide. This process enhances the porosity and surface area of the material. On the other hand, chemical activation involves impregnating the biomass with chemical agents such as potassium hydroxide (KOH), phosphoric acid (H_3PO_4), or zinc chloride ($ZnCl_2$) before carbonization. Chemical activation generally produces a higher surface area and enhanced porosity compared to physical methods due to the dehydrating effect of the chemical agents, which also lowers the required carbonization temperature.



(a) (b)

Fig. 1. Biomass-derived porous carbon materials: (a) divided by types of porous carbon materials (b) divided by application area.

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)

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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