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SYNTHESIS AND CHARACTERIZATION OF RUBBER SEED SHELL-DERIVED ACTIVATED CARBON BY KOH ACTIVATION

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ABSTRACT

This study presents the preparation and characterization of activated carbon derived from rubber seed shells using potassium hydroxide (KOH) activation. The raw material for this investigation was obtained from rubber seed shells collected from local rubber plantations in Palangka Raya. The activation process involved the use of the chemical activator KOH at a 1:1 carbon-to-KOH ratio in 200 mL of distilled water for a duration of 24 hours. X-ray Diffraction (XRD) analysis confirmed that the resulting activated carbon exhibited an amorphous structure, and all Fourier-Transform Infrared Spectroscopy (FTIR) spectra indicated the presence of functional groups in the activated carbon. The activated carbon possessed a porous structure with a surface area and total pore volume of 2.24 m2/g and 0.02 cm3/g, respectively. These findings necessitate further optimization of the activation process to achieve a larger surface area, thus enabling its application in electronic materials, water treatment, and various other fields.

Reseach Paper

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Keywords: Activated Carbon, KOH, Rubber Seed-Shell (RSS).

INTRODUCTION

The use of activated carbon in Indonesia is increasingly widespread in various fields, so the need for an activated carbon supply is increasing. Activated carbon is a low-cost adsorbent that has a high specific surface area and large pore volume. Activated carbon with better properties is produced by this chemical activation at a lower activation temperature when compared to physical activation. Due to post-treatment concerns, alkaline agents are attracted to chemical activation methods. Previous studies reported various bases such as KOH, NaOH, and CaOH (Pagketanang et al., 2015).

Indonesia has a good demographic so it has an abundance of natural resources, including a wide variety of that can be used as raw material for the manufacture of activated carbon for the manufacture of activated carbon. Carbon biomass has been widely studied as a precursor for the manufacture of activated carbon. Several previous studies have used several types of lignocellulosic biomass as raw materials for activated carbon. Lignonesulosic biomass is considered the main material in the formation of activated carbon because it has a high composition of lignin and carbon composition (González-García, 2018). This raw material supports a sustainable environment due to its renewability.

Some materials that can be used as activated carbon in previous studies are rubber fruit shells with a pore size of 5-9 µm as an absorber of iodine, methylene blue, and benzene compounds (Efiyanti et al., 2020); cassava peel with the ability to reduce metal elements in well water (Maulinda et al., 2015); banana peel as iod absorber (Masriatini et al., 2020); durian shell with a surface area of 44.372 m^2/g (Husin & Hasibuan, 2020); and corn cob for vehicle exhaust gas emission

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reducer (Gunawan et al., 2020). In Palangka Raya, rubber trees are used as rubber smoke sheets, latex, and crepe rubber. The waste product is used as other industrial raw materials. Rubber seed shell is a rubber seed oil extraction residue for biodiesel production. For now, the utilization of rubber seed shells has not been optimized.

In this study, rubber seed shell from the rubber tree plant was selected as a precursor in synthesizing AC due to their abundant availability, cheapness, and promising adsorbent capacity (Mokti et al., 2021). On the other hand, the rubber seed shell is made up of about 30–50% of carbon compounds, which makes it a highly porous AC in comparison with the other biomass wastes. Rubber seed shell-activated carbon has been prepared using KOH as an activating agent. Then, structure and morphology will also be investigated.

METHODS

Synthesis of activated carbon

The raw material in this study was rubber seed shells collected from local rubber plantations in Palangka Raya. Firstly, the rubber seed shells were burned in a burning vat until they became charcoal. The charcoal was crushed using mortar to obtain a rough charcoal powder. After that, the charcoal powder was sieved through an 80 mesh sieve to get a homogeneous powder size. Furthermore, the homogeneous powder was semi-carbonated at 250 °C for 2 hours. The activation process applies the chemical activator KOH from Merck at ratios by carbon:KOH (g/g) of 1:1 in 200 mL distilled water for 24 hours. The sample was filtered and washed with distilled water several times until the pH was neutral. Finally, activated carbon was obtained by drying in an oven at 150 °C for 6 hours.

Characterization

The activated carbon X-ray diffraction (XRD) pattern was examined by the Rigaku Miniflex II x-ray diffractometer with Cu-Kα (λ = 1.54056 angstrom). XRD pattern was collected with a step size of 0.02° and a range of 2θ from 10° to 70°. The functional group of the sample was analyzed by Fourier transformation infrared spectroscopy (FTIR) using Shimadzu IR Prestige 21. The surface morphology was characterized by using scanning electron microscopy (SEM: Thermo Scientific Quanta 650). Specific surface area (SSA) and pore size distribution were investigated using the Brunauer-Emmett-Teller (BET) method.

RESULTS AND DISCUSSION

XRD analysis

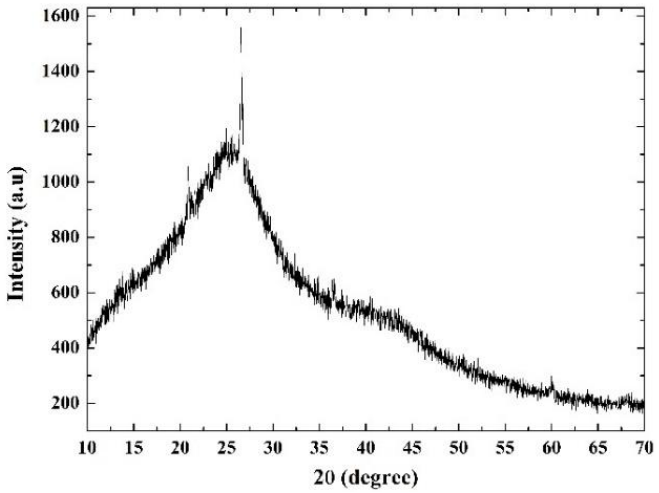

Figure 1 XRD pattern of rubber seed shell-derived activated carbon

XRD is one of the techniques commonly used for structural characterization of activated carbon. **Figure 2** shows the XRD pattern using Cu-Kα of rubber seed shell-derived activated carbon. The qualitative analysis of the XRD pattern confirmed that the activated carbon was in an amorphous state. The broad peak 2θ around 25 can be indexed to the (002) diffraction plane of RSS activated carbon with an amorphous or low crystallinity

carbon phase (Suhdi & Wang, 2021). Diffraction peak at 26.58° is ascribed to the presence of the graphite sheet layers. The remarkable peak is caused by the superposition of the diffraction peaks of graphite and quartz (Hu et al., 2020). Sharp peaks at 2θ~20.84°, 36.48°, and 60.80° appear due to crystallites of some inorganic impurities, e.g., silicon oxide (Yakout et al., 2015).

FTIR analysis

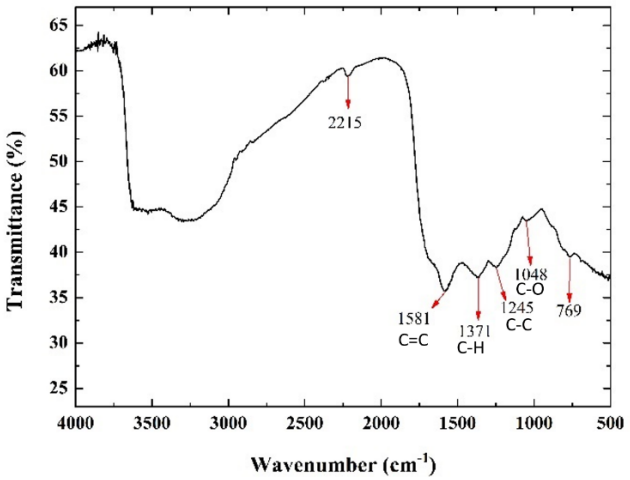

Figure 2 FTIR spectra of rubber seed shell-derived activated carbon

The FTIR spectra as a qualitative technique were used to identify the functional groups on the adsorbent surface. **Figure 2** shows the FTIR spectra of rubber seed shell-derived activated carbon. The infrared transmission peak was recorded at a wavenumber range of 500–4000 cm^{-1}. The peak at 1581 cm^{-1} belonged to the stretching of CC bonds ascribed to aromatic C=C vibration (Pagketanang et al., 2015; Song et al., 2013; Zhao et al., 2020). The peaks at 1245 cm^{-1} and 1371 cm^{-1} correspond to CH bending and OH stretching (Hu et al., 2020; Perdani et al., 2021). The absorption band that appeared at 1048 cm^{-1} was attributed to the C–O group (Altalhi et al., 2021; Romanos et al., 2013; Zhao et al., 2020). The peak at 769 cm^{-1} belonged to C-O or O-H (Song et al., 2013). In addition, the absorption peaks around 2200–2400 cm^{-1} are due to residual CO_2 either in the chamber or adsorbed to the surface (Saleh & Danmaliki, 2016).

Table 1 Functional Group of Activated Carbon

No	Functional Group	Absorption peak (cm^{-1})		Source
		Reference	Rubber Seed Shell Activated Carbon	
1	C=C	1660-1580	1581	(Pagketanang et al.,2015)
2	C-H	1475-1300	1371	(Perdani et al., 2021)
3	O-H	1300-1000	1245	(Hu et al., 2020)
4	C-O	1300-1000	1048	(Altalhi et al., 2021)

The morphology of activated carbon

Scanning electron microscopy (SEM) examined the surface morphology and microstructure. **Figure 3** shows the SEM image of rubber seed shell-derived activated carbon. The SEM image clearly shows the morphology of the activated carbon, which has a microporous structure. The micropores might be formed due to the evaporation of the volatile material during chemical activation (Mokti et al., 2021). Carbon activating agent result in the reduction of impurities on the surface of carbon, so that micropores have formed (Khan et al., 2018). KOH etches the carbon matrix in order to generate pores by oxidizing carbon into carbonate ions followed

by intercalation of remaining potassium species (Kar, 2020).

KOH activation has led to etching of surface and formation of visible pores with a diameter of around two µm (Idrees et al., 2018). Further analysis using the BET methods confirmed that the BET surface area and total pore volume were 2.24 m^2/g and 0.02 cm^3/g, respectively.

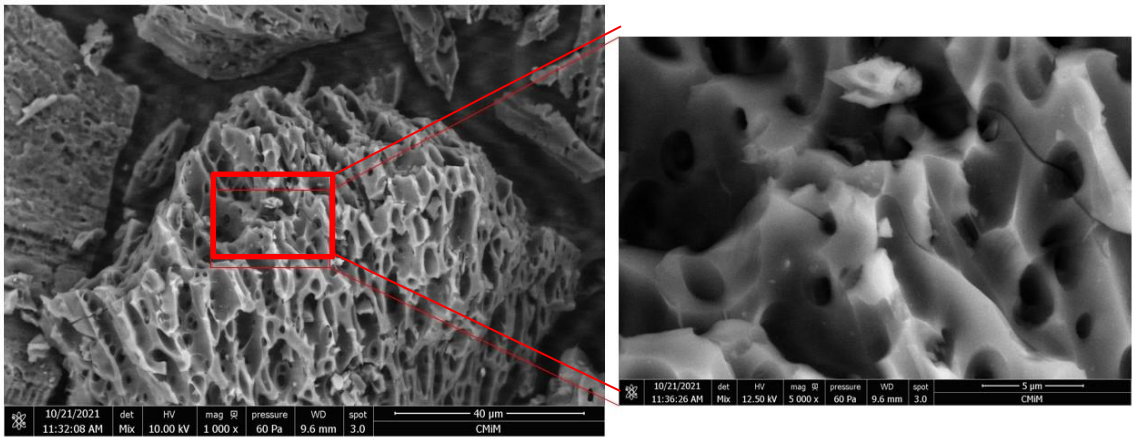

Figure 3 SEM image of rubber seed shell-derived activated carbon

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CONCLUSION

This study successfully synthesized a rubber seed shell-derived activated carbon using KOH activation confirmed by XRD pattern and FTIR spectra. Activated carbon has a porous structure with a surface area and total pore volume of 2.24 m^2/g and 0.02 cm^3/g, respectively. This result needs to be optimized through the activation process to obtain a larger surface area, so it can be applied in electronics materials, water treatment, and other fields.

Author's declaration

Authors' contributions and responsibilities

The authors made substantial contributions to the conception and design of the study. The authors took responsibility for data analysis, interpretation and discussion of results. The authors read and approved the final manuscript.

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Availability of data and materials

All data are available from the authors.

Competing interests

The authors declare no competing interest.

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