Characterization and properties of activated carbon from rambutan seeds by microwave assisted chemical activation
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Abstract: Activated carbon has been widely used for adsorption of metal ions from aqueous solution due to its porous properties. This research aimed to study the preparation of activated carbon from rambutan seeds assisted by microwave irradiation with phosphoric acid as an activator. Effects of various parameters were studied including the concentration of phosphoric acid solution, the charcoal/phosphoric acid ratio on the activation, microwave power and irradiation time. The obtained results showed the optimal preparation conditions as follows: the concentration of 40\% (v/v) phosphoric acid, microwave power of 700 watts, irradiation time of 240 seconds and charcoal/phosphoric acid ratio of 1/30 (w/v). The surface properties of the activated carbon were characterized by scanning electron microscope (SEM) and the results showed that the activated carbon contained high porosity. The relatively high iodine adsorption number ($I_N$) (678.14 mg/g), which indicate high surface area and affinity of the adsorbent, was obtained from the activated carbon prepared by this technique. The adsorption efficiency of the activated carbon for copper ions was also investigated using FAAS. The results showed that the activated carbon was able to adsorb copper ions, which was two times higher than that of untreated charcoal in 0.1 N nitric acid. This confirmed the potential use of the mesoporous activated carbon derived from rambutan seeds for the removal of heavy metals from contaminated water.

1. Introduction A lot of agricultural wastes are produced among trimming process in Thailand. Peels, seeds and other parts of fruit are trimmed and cut-off to retouch its appearance. Mostly, these wastes have been invented to be added more of their values by extracting antioxidants using in cosmetics and pharmaceuticals. Beyond this, there are many alternative ways to turn agricultural wastes into different products beside extraction.

Activated carbon is a product derived from raw materials that contain carbon as the main component. Through a specific chemical or physical process, raw materials arouse the better absorbing properties. In the other words, activated carbons have more porosity and surface area that increase the ability in absorbing organic matter, inorganic substances and various compounds that are in liquid and gas states. Activated carbon is therefore an alternative for various applications, especially water treatment, odor absorption and color absorption. Drying and specific oxygen-limited burning process turn those wastes to form activated carbon as it has absorbing properties. Odors and metal ions are attracted to activated carbon made from coconut shells, bamboo-cellulose fiber, corn cobs. Furthermore, activated carbon is reusable. The process of making activated carbon has 2 steps: carbonization and stimulation. There are two types of...
stimulation: chemical stimulation\(^5\) and biological stimulation\(^6\).

In this research, the wastes of rambutan seeds from consumption are used to produce activated charcoal since it is a seasonal fruit. Rambutan seeds are then used as raw materials to produce activated carbon for absorbing odors and copper ions by microwave method\(^7\)\(^9\) together with the chemical stimulation.

This paper describes the preparation of activated carbons from rambutan with H\(_3\)PO\(_4\) activation under microwave radiation. Evaluation, characterization by iodine adsorption, morphological inspection and surface chemical analysis are thoroughly investigated. Removal of copper from aqueous solution using the proposed activated carbon is performed.

2. Materials and Methods

2.1 Materials

Rambutan seed samples were collected from from Maejo market, located in Chiang Mai, Thailand. All chemicals and reagents used in the study were an analytical grade; phosphoric acid was purchased from Ajax Finechem (New Zealand); nitric acid and standard solution of Cu. Deionized water was obtained by a Milli-Q purification system (Millipore, Billerica, MA, USA).

2.2 Preparation of activated carbon

Raw rambutan seeds were washed with deionized water and dried at 100-120 °C in an oven overnight. Dried rambutan seed was milled into powder and sieved to 2 mm particle size. The carbonization of rambutan was carried out by loading 100 g into a muffle furnace at 500 °C for 1 h. The yield of charcoal was found to be around 25%.

One gram of charcoal was soaked in solution of H\(_3\)PO\(_4\) of different concentrations and different impregnation (1:20, 1:30 and 1:40 w/v). Then, activating by microwave oven (model GE711K, Samsung, Korea). An irradiation power and irradiation time were set at the range from 200-800 W and 30-300 seconds, respectively. The produced activated carbon was then washed with deionized water until the washing solution reached a constant pH of 7. The finally of activated carbon was dried in oven at 100 °C for 3 h and cooled to ambient temperature in desiccator for further characterization and analysis.

2.3 Activated carbon characterization

The surface morphology of the activated carbon was identified by scanning electron microscope (SEM; model JSM-5410LV, Japan). The surface area and pore structure were evaluated with I\(_2\) adsorption number. The adsorption tests were carried out by adding a fixed amount of active carbon (0.1 g) into 250 mL erlenmeyer flasks containing 100 mL of 5.0 mg L\(^{-1}\) copper nitrate (Cu(NO\(_3\))\(_2\)·3H\(_2\)O) solution. The flasks were shaken at 150 rpm for 10 min. The remaining concentration of copper ion in solution was analyzed with FAAS. The absorption measurements were made with Perkin Elmer Model A Analyst 100 flame atomic absorption spectrometer (Perkin Elmer, England).

The instrument's condition for determination of copper was as follow: lamp current 15 mA, wavelength 324.8 nm, slit width of 0.70 nm and an air-acetylene flame.

3. Results & Discussion

3.1 Preparation of activated carbon

The effects of various parameters were studied including H\(_3\)PO\(_4\) concentration, phosphoric acid impregnation ratio (w/v), and microwave power and irradiation time. The highest of iodine adsorption number was observed at 1:30 impregnation ratio (Fig. 1 (a)) at H\(_3\)PO\(_4\) acid concentration of 40% (v/v) (Fig.
1 (b)) and the microwave irradiation power of 700 W (Fig. 1 (c)) for 240 seconds (Fig. 1 (d)). The proximate analysis (ASTM D 3172-89.1993) results of the produced activated carbon are shown in Table 1.

### Table 1. Proximate analysis of rambutan seed activated carbon

<table>
<thead>
<tr>
<th>Material</th>
<th>Moisture (%)</th>
<th>Volatile (%)</th>
<th>Fixed carbon (%)</th>
<th>Ash (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activated carbon</td>
<td>5.96</td>
<td>64.64</td>
<td>31.78</td>
<td>3.58</td>
</tr>
</tbody>
</table>

![Graph](image.png)

**Fig. 1.** Effects of (a) Charcoal/ H$_3$PO$_4$ impregnation ratio (w/v) (b) H$_3$PO$_4$ concentration (%) (c) micro-wave irradiation power (d) radiation time on iodine uptake of activated carbon.

### 3.2 Characterization of Activated carbon

The microscopic structure of rambutan seed char and activated carbon were assessed by scanning electron microscopy (SEM). Surface area and pore structure were determined with copper ion adsorption. SEM micrographs are presented in Fig. 2. The original rambutan seed chars are shown in Fig. 2 (a)-(b) and activated carbon structure is shown in Fig. 2 (c)-(d). More pores were developed on the surface of rambutan seed after H$_3$PO$_4$ treatment and microwave heating.
Fig. 2. SEM micrographs of rambutan seed char (a, b) and activated carbon (c, d)

3.2 The absorption efficiency

The results show that activated carbon removed copper ion from 5.00 mg L⁻¹ standard solution better than untreated charcoal. The percentage of copper ion removal of untreated charcoal and activated carbon were found to be 28.8 and 56.6, respectively. The results showed the activated carbon was able to adsorb copper ions, which was two times higher than that of untreated charcoal because untreated charcoal has lower specific surface area than the activated carbon.

4. Conclusion

In this work, effects of H₃PO₄ concentration, phosphoric acid impregnation ratio (w/v), and microwave power and irradiation time on preparing activated carbon were investigated. It was found that preparation of activated carbons from rambutan with H₃PO₄ activation under microwave radiation was successful. The activated carbon has fair pore structure and adsorption capacity. This alternative method escalates value of agricultural waste.

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References (In ACS style)


