Chapter in Book

Activated Carbon for Wastewater Treatment

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Abstract: *Watermelon has high amount of water. Thus, in Malaysia watermelon are easy to get and they are on seasonal fruit. From the peels itself, we will try to prepare and characterization activated carbon. Waste watermelon rind, a waste biomaterial, has not yet been evaluated as a raw material for the production of activated carbon using the chemical activation method by zinc chloride. So, for watermelon, as we know it contained high amount of water with promising levels of solid matters, which makes them even more appealing for the industrial manufacture of high-quality activated carbon. This unique usage of watermelon peels will not only reduce waste, but will also increase income for farmers and food processors, as well as lessen several negative environmental effects. Thus, the main objective of the present work was to evaluate the utility of waste watermelon rind as an abundant and accessible precursor for activated carbon production. The focus of this research is on determining the optimal conditions for pre-treatment of watermelon peel wastes in order to make them useful as adsorbents for contaminated waste from industrial effluents. The impact of operating parameters like carbonization temperature and time was investigated in this study. Some of the activated carbon treatment is a simple separation procedure. The activated carbon used in liquid phase applications is intended to have a large surface area and pore volume. It must also be sufficiently robust and abrasion resistant. In liquid phase applications, both powdered and granular activated carbon have been utilised.*

Keywords: Activated carbon; Watermelon peel; Environment; Treatment

1. INTRODUCTION

Activated carbon is one way to process polluted water and air. It is not uncommon for some industries that use agricultural materials such as fruit waste like skin, fruit seeds, pulp, and others. As in Malaysia, most fruits are seasonal. Yet some fruits are available all the time regardless of the season. Biomass is one of the common materials that has been used to prepare activated carbon. Most of the materials used to prepare activated carbon are often inexpensive and readily available (Abdul Khalil et al., 2013). Thus, the preparation of activated carbon often differs according to the study of each country because each country has different biomass wastes.

In the increased cases of water pollution, several research has been done to treat it. One of the most extensively used standard methods for treating home and industrial wastewater is activated carbon adsorption. However, some are expensive, and regenerating the process has losses the limit of their utility in large-scale applications (Bhattacharjee et al., 2020). As public awareness of global issues grows, the demand for alternative treatment approaches with broad applications that meet environmental standards has become a top focus for researchers around the world.

Activated carbon originally referred to carbon materials that have had their surfaces or structures modified through functionalization, metal or oxide deposition, etc., for specific purposes. All activated carbons contain pores. Not all porous carbons, however, are activated carbons. The porosity of porous carbons encompasses a wide range of pore sizes, whereas activated carbons are fundamentally microporous. Although this essential distinction should not be forgotten, the distinction between activated carbons and porous carbons may not always be so clear, particularly from a processing and application standpoint. Because of its great capacity for adsorption, activated carbon is widely used in the process of dye removal where an adsorbent is required.

Activated carbons are necessary in many different sectors for the treatment of waste water and gaseous effluents in order to comply with environmental requirements. Additionally, activated carbons are necessary for the recovery of materials.

2. ACTIVATION OF CARBON FROM WATERMELON RIND USING DIFFERENT ACIDS

Based on the results, which is a study done by (Gin et al., 2014) showed that activated carbon treated with 1.0 M sulphuric acid performed the best in terms of heavy metal removal from the industrial effluent compared to activated carbon treated with zinc chloride and hydrochloric acid. This showed that the 1.0 M H_2SO_4 treated watermelon activated carbon had the best pore surface and structure of all the treated watermelon activated carbons.

Table 1. Overall percentage reduction of heavy metals using HCl activated watermelon rind

Heavy metals	0.5 M	1.0 M	1.5 M
	Percentage Of Reduction		
Zinc	7.9	2.8	2.6
Copper	91.5	94.3	31.0
Iron	95.1	95.1	81.9
Lead	100.0	100.0	100.0

Table 2. Overall percentage reduction of heavy metals using H_2SO4 activated watermelon rind

Heavy metals	0.5 M	1.0 M	1.5 M
	Percentage Of Reduction		
Zinc	12.9	1.4	2.0
Copper	96.8	99.1	16.1
Iron	60.8	90.6	78.8
Lead	40.0	100.0	100.0

Table 3. Overall percentage reduction of heavy metals using $ZnCl_2$ activated watermelon rind

Heavy metals	0.5 M	1.0 M	1.5 M
	Percentage Of Reduction		
Zinc	2.3	2.6	2.6
Copper	50.6	10.3	35.6
Iron	88.0	25.3	67.5
Lead	100.0	0.0	20.0

3. FINDING THE OPTIMAL CONDITION OF CARBONIZATION OF WATERMELON RIND

Based on the study done by (Gin et al., 2014), Table 1 shows how the parameters changed as the carbonization temperature changed. Using a constant carbonization time of 15 minutes and a constant sample mass of 5 g, all of the parameters investigated were found to change as the carbonization temperature changed. This has demonstrated the dependence of the parameters under consideration on the process's carbonization temperature.

Table 4. Measured parameters of the rind of watermelon material carbonized at different temperatures

S/N	Temperature (°C)	Time (min)	Mass (g)	Ash Content (%)	Volatile content (%)	Moisture content (%)	Fixed Carbon (%)	Charcoal Yield (%)
1	200	15	5	18.6	34.0	2.0	47.4	50.0
2	250	15	5	21.4	28.6	1.0	50.0	43.3
3	300	15	5	26.2	22.9	1.9	50.9	33.3
4	350	15	5	28.6	20.4	2.0	50.8	33.0

Shown in Table 2 are the results from the parameters tested when the carbonization time was adjusted, but, this time, maintaining the carbonization temperature constant at 300°C and the mass of the sample utilised for all the experiments was constant at 5 g. The impacts of the carbonization period on the parameters of the generated watermelon peel activated carbon are as provided in Table.

Similar to the findings noticed in the case of modifying the carbonization temperature, it has been observed in this case also that the analysed variables were found to respond to changes in the carbonization time of the process. This was an indication that the carbonization duration of the procedure was also among the significant parameters impacting this process (Gin et al., 2014).

Table 5. Measured parameters of watermelon rind material carbonized for various times

S/N	Temperature (°C)	Time (min)	Mass (g)	Ash Content (%)	Volatile content (%)	Moisture content (%)	Fixed Carbon (%)	Charcoal Yield (%)
1	300	15	5	26.2	22.9	1.9	50.9	33.3
2	300	30	5	27.5	19.5	2.5	53.0	33.0
3	300	45	5	27.8	12.4	2.9	59.8	32.4
4	300	60	5	26.2	12.2	3.5	61.6	32.1

From the data of the watermelon peel carbonization represented in Tables 4 and 5, it was determined that the highest percentage of fixed carbons were obtained when the carbonization temperature and the carbonization time were 300°C and 60 min, respectively. As such, this temperature, 300°C and time which is 60 min were selected as the best conditions for the process.

4. FINDING THE ABSORBENT PROPERTIES OF THE WATERMELON RIND

Both figures below show the surface morphologies of activated carbon obtained by carbonising watermelon rinds before and after heavy metal removal from produced water. The SEM image of produced activated carbon figure 4.1 shows the production of a somewhat unevenly distributed pore formation with consolidated particles on a relatively rough surface.

This could be described to the significant evaporation of water from the particles during calcination, which resulted in the formation of additional holes inside the particles (Popoola et al., 2022). Figure 2 depicts the SEM micrograph of activated carbon following the elimination of heavy metals. The results obtained were the closure of pore apertures due to interference in the particle arrangement. This could be attributable to the heavy metals extracted from the generated water entering the pores of the particles.

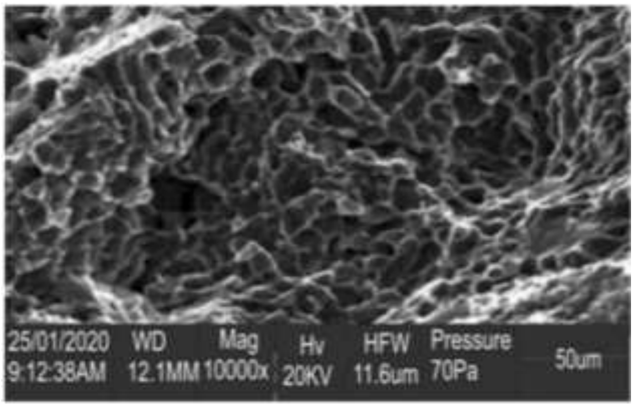

Figure 1. SEM images of activated carbon before heavy metals removal from produced water.

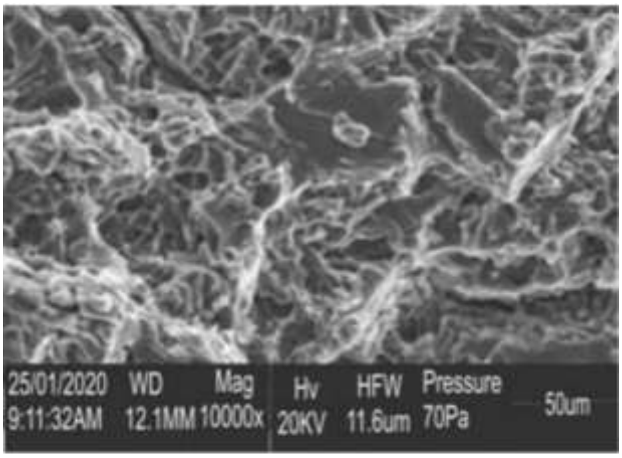

Figure 2. SEM images of activated carbon after heavy metals removal from produced water.

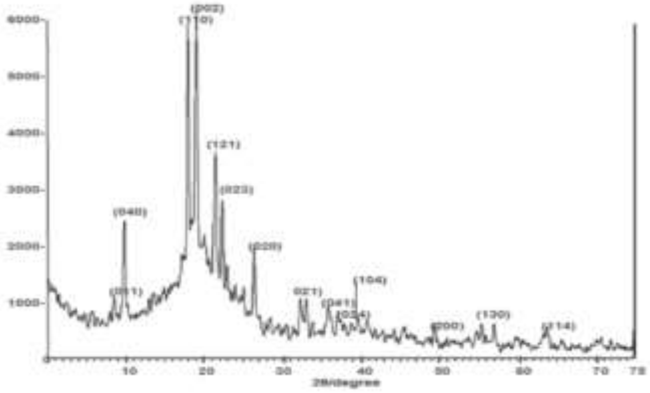

Figure 3. XRD of activated carbon prepared from watermelon rind.

Figure 3 illustrates the XRD pattern of activated carbon produced from watermelon rind at 681.10 C for 2.61 hours. Weak diffraction peaks were spotted at 2 = 10, 21, 23, and 27. Strong diffraction peaks were observed at 2 = 18 and 20. These are strong signs that graphite crystallite exists in the walls of activated carbon, making it more porous and increasing its surface area. These peaks also indicated an increase in crystal structural regularity, which resulted in improved layer alignment (Popoola et al., 2022).

4. CONCLUSION

This review present a future application of activated carbon for wastewater treatment. Researchers show a promising properties of the activated carbon based on different acids and absorbent properties.

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