Low-Cost Carbon Membrane Synthesis from Natural Resources and Its Use in Batik Waste Turbidity and Dye Reduction

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Abstract

Wastewater from the batik business is too turbid and contains too many dyes to be released into the environment. It cannot be thrown away in the environment directly. This study uses synthetic membranes to lower the amount of color and turbidity in wastewater from batik processes. The natural carbon membrane that was created is inexpensive. After that, the membrane is set up on apparatus and goes through three cycles of processing. The study's findings demonstrated that adding more processing cycles can lower turbidity and dye by as much as 88.27% and 71.79%, respectively. Overall, the production of membranes and their use offer a low-cost, simple, and effective substitute method for handling waste material.

Keywords: *wastewater, synthetic membrane, environtment* .

1. Introduction

The colorful and intricate designs of batik, a traditional cloth dyeing technique, are widely recognized. But it also comes with drawbacks, like turbidity in wastewater and organic dye leaks, which are extremely dangerous for the environment. In this regard, we are investigating a unique strategy that uses carbon membranes made from natural precursors as an affordable and environmentally beneficial means of addressing these issues.

The province of Jambi currently has a large number of batik businesses; the more quickly this industry grows, the more garbage it produces. The liquid waste from the batik business comprises a variety of pollutants, including the heavy metals Pb and Cr, which have the potential to contaminate water supplies (Murniati et al, 2015). Liquid batik industrial waste must first be treated before being disposed of in the environment since it contains numerous hazardous elements that prevent it from being put directly into the environment.The province of Jambi currently has a large number of batik businesses; the more quickly this industry grows, the more garbage it produces.

Membrane technology is one method of handling batik waste. The process of dividing a material into two or more phases using a semipermeable membrane is known as membrane technology. Membrane technology is typically used in mechanical separation operations to separate gas or liquid streams. Membrane technology offers several benefits, including excellent water quality, reduced chemical usage, consistent water quality, ease of use (automatic), and the ability to remove pollutants over a wide area without requiring a lot of space (Indriyani et al, 2017).

The creation of affordable and ecologically friendly materials has assumed a central role in research and innovation during a period characterized by escalating environmental concerns and an increasing need for sustainable solutions. In particular, carbon membranes have become a viable option because of their adaptability and promise for a variety of uses. Within this framework, the present study sets out to integrate the concepts of sustainability and advanced materials science. It focuses on the synthesis of carbon membranes from easily accessible natural resources and their potential applications in resolving relevant issues associated with the textile sector.

2. Literature Review

2.1. Carbon Membrane

A membrane that is composed entirely of carbon or that has a carbon core is known as a carbon membrane. They have been the subject of extensive research in the field of separation and filtration due to their unique properties, which include high porosity, mechanical strength, chemical durability, and the ability to separate various types of molecules. A growing area of research interest is the use of carbon membranes in various separation applications. Carbon membranes have demonstrated efficacy in the separation of diverse molecular and particle types due to their minuscule pores and remarkable adsorption capacity. Waste treatment, gas separation, and water purification are typical uses. With their extraordinary qualities, carbon membranes have drawn a lot of interest as a possible remedy for a range of filtration and separation problems. They are appropriate for use in a variety of industries, such as gas separation, sewage remediation, and water treatment, due to their performance characteristics and versatility. The search for cheaper and more sustainable materials has prompted researchers to look into other sources of carbon membranes. Using natural resources as precursors to create inexpensive carbon membranes is one way to achieve this.

2.2. Carbon Membrane Synthesis

The synthesis of carbon membranes traditionally involves the use of synthetic precursors such as polymeric materials, which can be costly and environmentally taxing. In recent years, researchers have turned their attention to natural resources, including biomass and agricultural waste, as sustainable and low-cost carbon membrane precursors. The conversion of these natural materials into carbon membranes through carbonization and activation processes is an area of active investigation. By optimizing synthesis parameters, researchers aim to produce carbon membranes with tailored properties suitable for specific applications. The first step is to select a precursor material that contains a high carbon content. Precursors can include polymeric materials, natural sources like biomass, carbon nanotubes, or other carbon-rich compounds. After selecting the precursor material, the carbonization happening. Carbonization is a crucial step where the precursor material is heated in an inert atmosphere (typically nitrogen or argon) at elevated temperatures. During this process, organic components in the precursor are decomposed, leaving behind a porous carbon structure. The temperature and duration of carbonization are carefully controlled to achieve the desired carbon structure and porosity. Some carbon membranes may undergo activation to enhance their porosity and adsorption capabilities. Activation is achieved by exposing the carbonized material to activating agents, such as steam, carbon dioxide, or certain chemicals. This process further develops the porous structure of the carbon membrane.

The carbonized or activated carbon material is shaped into a membrane. This can be done through various techniques, such as casting, coating, or spin-coating. The choice of method depends on the intended application and desired membrane structure. The synthesized carbon membrane is characterized through various techniques, including scanning electron microscopy (SEM), nitrogen adsorption-desorption isotherms, and permeability testing. These analyses help assess the membrane's structure, porosity, and performance characteristics. The final step is to apply the carbon membrane to the intended separation or filtration process. This could involve water purification, gas separation, or other specific applications. The membrane's effectiveness in selective permeation or adsorption of target molecules is evaluated through testing and performance analysis. Depending on the intended uses and characteristics of the carbon membrane, various circumstances and parameters might be relevant in each of these steps. To adjust the membranes for particular industrial and environmental applications, researchers continue to study and refining a variety of synthesis techniques.

2.3. Carbon Membrane Utilization in Wastewater Treatment

The textile sector, in particular the batik industry, produces a large amount of wastewater that is turbid and contains organic dyes. This wastewater requires efficient treatment techniques because it presents significant environmental challenges. Owing to their distinct porosity and adsorption capacity, carbon membranes have demonstrated the potential for the elimination of organic dyes from industrial wastewater. Wastewater can effectively be treated by adsorbing and eliminating organic pollutants and dyes using carbon membranes, especially activated carbon membranes. The large variety of organic molecules that can be captured by their porous structure includes phenols, dyes, and other contaminants.

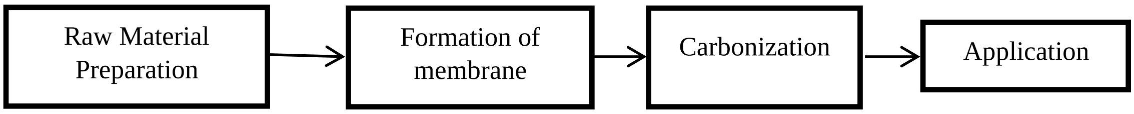
3. Research Method

In this study wood dust was the precursor utilized in this study to create carbon membranes. The sawdust used is leftover from woodworkers who typically create household utensils made of wood. Natural materials such as organic sawdust waste can be used as adsorbents to neutralize metal levels in batik waste. Advantages of using natural adsorbents in the adsorption process, apart from having good adsorption ability, are also more economical (Jalali et al., 2002). According to previous research regarding water pollution treatment, adsorption methods are often carried out using activated carbon adsorbents, such as reduction of Iron and Manganese ions with camphor wood powder (Mandasari and Purnomo, 2016).

Figure 1. Wood dust from woodwork

3.1. Research Procedure

The flow diagram of this research procedure



The process begin with raw material preparation in which the wood dust prepared as the precursor of the carbon membrane. After that the process continued with the carbonization of the precursor. Then the membrane formed and applied to the batik wastewater filtration.

3.2. Raw Material Preparation

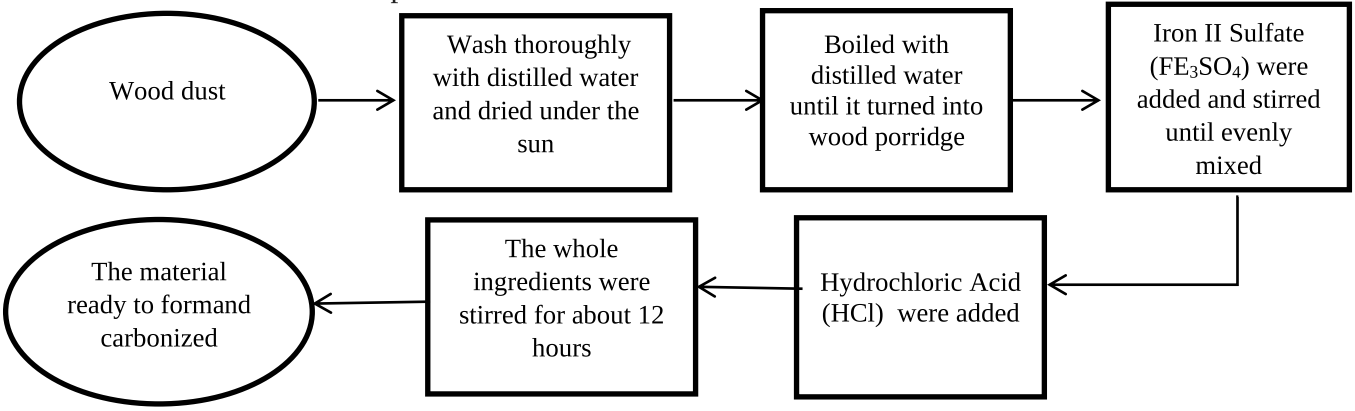


Figure 2. Raw material (wood dust) preparation

HCL 0.5 M and Iron II Sulfate are the two chemicals used. In the process of purifying water, iron II sulfate can be utilized as a coagulant—a chemical required for the precipitation process. Hydrochloric acid (HCL) has a very important role in controlling the pH of waste water in addition to being used to clean rust or scale and regulate acidity or pH levels.

3.3. The Formation of Membrane

Following preparation, teflon was used to form the membrane. After that, it is carbonized and cooled in a furnace that is 700 ^oC.. Then, the carbon membrane is ready to be applied.

Figure 3. The carbon membrane

4. Result

If the wastewater is dumped into the environment untreated, the heavy metals it carries will damage the ecosystem. Therefore, rather than being dumped directly into the environment, this effluent needs to be cleaned. A filtration device and carbon membrane are then used to filter the waste water from batik.

The membrane that was created was added to the filtrate of a wastewater filtration system. Natural filtrate, such as gravel, sand, and coconut fibres, make up the wastewater system. These natural filtrates were discovered. In order to lessen the quantity of contaminants that could cause the system to malfunction, these filtrates must first be cleaned and dried. The batik wastewater is emptied from the filter after it has been constructed.

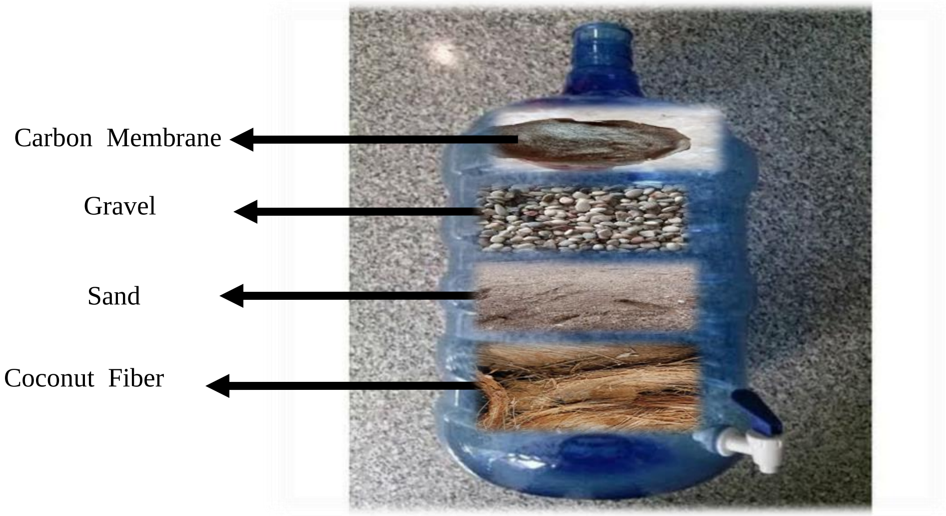


Figure 4. The wastewater filtration system

The membranes help to decrease the turbidity and remove the bad odor from the wastewater after being filtrated. Figure 5 shows that the more the filtering process, the clearer the final result.

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Figure 5. The wastewater after being filtrated by carbon membrane and filtration system

In the filtration system itself, the existing filtrate also helps the batik waste water filtration process, such as gravel holding large dirt, then sand holding small dirt, then coconut fiber helps to purify the water and reduce the odor in batik waste water. The turbidity of the water is one factor that helps evaluate whether waste water is clean again. The level of pollutants in the water increases with its turbidity. Consequently, one may compute water turbidity to determine the degree of clarity of the filtered waste water. One can compute turbidity using the following formula :

$$Turbidity\ (\%) = \frac{(Cf - Cp)}{Cf}\ x\ 100\%$$

Note = Cf : Initial concentration
Cp : Permeate concentration

After the calculation, the turbidity can be measured and the purity of the treated wastewater can be identified. The table below show the turbidity and the colour purity of the wastewater after being filtrated.

Sample	Turbidity(%)	Colour Purity (%)
First Filtration	56,8	0,121
Second Filtration	82,668	54,307
Third Filtration	88,276	71,798

Table 1. Turbidity calculation result

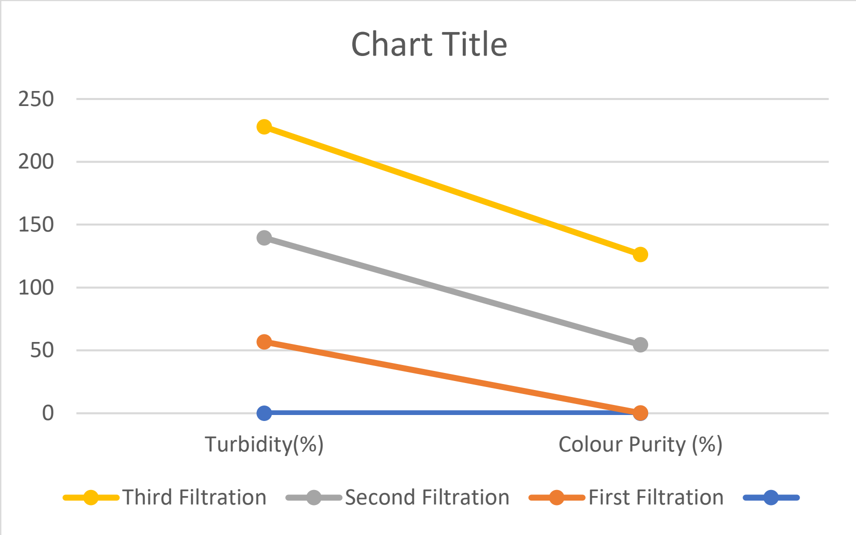

Figure 6. The turbidity result in graph form

The table and graph above shows that, the carbon membrane has huge impact in the wastewater filtration system. The carbon membrane helps to reduce the chemical composition inside the wastewater. This shown by the turbidity of the wastewater after being filtered. The colour getting brighter after being filtered. Beside colour, the bad odor from the wastewater also become lessen, and after second filtration, the smell also gone.

6. Conclusion

There are 4 water qualities resulting from filtration, namely pH, turbidity, amount of dissolved solids and amount of suspended solids (Jaksen et al, 2021). Because we were limited by tools, we only identified it with group discussions, namely:

1. Turbidity, where dark colored batik waste after filtration becomes lighter.
2. Aroma, before filtration the smell is very strong after filtration it has reduced.
3. There was a lot of dissolved solids before filtration, but after filtration it has decreased

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