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Leonard Mateus Sigiro
University of Indonesia, leonard.mateus@ui.ac.id

Ahmad Maksum
State Polytechnic of Jakarta, ahmad.maksum@mesin.pnj.ac.id

Donanta Dhaneswara
University of Indonesia, donanta.dhaneswara@ui.ac.id

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Cover Page Footnote

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Utilization of Cellulose Symbiotic Culture of Bacteria & Yeast (SCOBY) with Sweet Tea Media as Methylene Blue and Brilliant Green Biosorbent Material

Leonard Mateus Sigiro[1], Ahmad Maksum[2], Donanta Dhaneswara[1, 3, a)]

[1] *Department of Metallurgy and Materials Engineering, Faculty of Engineering, Universitas Indonesia, Depok, 16424, Indonesia*
[2]*Department of Mechanical Engineering, State Polytechnic of Jakarta, Depok, 16425, Indonesia*
[3]*Advanced Materials Research Center (AMRC) FTUI*

Corresponding author: [a)]*donanta.dhaneswara@ui.ac.id*

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Abstract. The cellulose from Symbiotic Culture of Bacteria and Yeast (SCOBY) can be used as a biosorbent for dye adsorption, such as methylene blue and brilliant green. This study used sweet tea with a 6% of sugar concentration and 14 days of fermentation time to synthesize biosorbent material from SCOBY. The results from this synthesis are then characterized using FTIR, SEM, and BET. From the result of characterization, it was found that SCOBY has pores formed from cellulose. The results of the average pore size are 1.5976 nm with a pore volume of 0.229 cc/g, while the specific surface area is 143.244 m^2/g. The material that has been characterized is used to absorb the dye using methylene blue and brilliant green. The mass variation of absorbent is used in this study with variations of 0.5 gr, 1 gr, and 1.5 gr and carried out to absorb the dye for three hours. The highest percentage of dye removal after three hours reached up to 100%, which proved that SCOBY is effective for dye removal.

Keywords: Sweet Tea, SCOBY, Bacteria Cellulose, Methylene Blue, Brilliant Green

INTRODUCTION

Every year, population growth increases quickly. As a result of the population growth, there was an increase in the need for food, clothing, and lodging. The industry and production in the textile sector grew as a result of the rise in the demand for garments. Globally, the textile sector generated 1,715 million tonnes of CO_2 emissions and used 79 billion m^3 of water in 2015 [1]. One kilogram of the raw cotton needed to make one pair of pants requires 8,500 gallons of water [1]. Sanitation of the water will be impacted by textile industry waste. Anionic dyes (direct dyes, acid dyes, and reactive dyes), cationic dyes (all basic dyes), and non-ionic dyes (dispersed dyes) are the three categories into which dyes used in the textile industry can be divided [2]. Cationic dyes, which contain amine derivatives, can be utilized in synthetic fibers such as nylon, acrylic, and nylon, as well as cellulose and protein, although they do not stain quickly. This study will use cationic dyes like brilliant green and methylene blue as examples. Water dye removal is crucial because artificial dyes can prevent sunlight from penetrating the water, lowering the amount of dissolved oxygen produced by photosynthetic activity and reducing the amount of dissolved oxygen in the water.

Conventional techniques, such as activated sludge treatment, adsorption, and membrane technology, can remove colors from water. Biological materials such as fungi, bacteria, plants, and algae are adsorbents in biosorption. It has been demonstrated that biosorbents can remove different color categories, including fundamental ones. Bananas, orange, straw, silica, and sawdust peels can distinguish between different hues in the primary dye group. The purpose of this study was to examine the capability of SCOBY sweet tea media in the removal of dyes.

A fermented beverage called kombucha uses SCOBY (Symbiotic Culture Of Bacteria and Yeast) and tea and sugar as the media [3]. Due to its ability to make cellulose, SCOBY is equivalent to bacterial cellulose. Bacteria create cellulose, which is utilized to cling to cells and shield them from harmful elements, including ultraviolet light, high hydrostatic pressure, and other environmental hazards [4]. Compared to plant cellulose, bacterial cellulose is structurally finer and less branched. This has influenced several features, including a large surface area, higher water absorption, and better mechanical strength in wet conditions [5]. Bacterial cellulose is physically finer and less branched than plant cellulose, which impacts properties like surface area, water absorption, and mechanical strength in the wet state [6]. A biosorbent material can be made from SCOBY cellulose. There has already been research done to adsorb methylene blue [7]. Another cationic dye, brilliant green, was utilized by the researcher to preserve the originality of her writing. Researchers additionally use methylene blue to contrast with brilliant green.

MATERIALS AND METHODS

The synthesis of SCOBY Kombucha was performed in a 16 cm × 16 cm × 7.5 cm container for fermentation. The starter SCOBY 50 ml is then put in the container alongside the master SCOBY. Then 5 grams of tea and 60 grams of sugar are poured with the SCOBY materials. SCOBY with the mixture of black tea and sugar is then kept for 14 days for fermentation. Picture of the fermentation process can be seen in Fig 1. The SCOBY that has been fermented is then weighed using a digital balance with an accuracy of 0.001 nm. After that, it dried for characterization using a dehydrator at 70°C for 24 hours.

Before characterization, the dried SCOBY kombucha needs to be cut into pieces. The characterization is handled using FTIR and BET to identify the characteristics of the pore and SEM to identify the characteristics of its morphology. After it has been characterized, it tests to absorb dye in the water using methylene blue and brilliant green. The variable of this study is the variation of SCOBY kombucha that was used to absorb the dye in the absorption testing. The mass variations of SCOBY kombucha that are used are 0.5 gr (V1), 1 gr (V2), and 1.5 gr (V3). The absorption process uses 100 ml of 1 ppm dye and is carried out for 3 hours [9], [10]. The sample is taken every hour to see how the adsorbent degrade the color of the dye using UV-Vis, and the result is calculated to find the percentage of the dye removal using the following equation [9]:

$$\%Removal = \frac{C_i - C_t}{C_i} \times 100\% \quad (1)$$

C_i is the initial concentration (mg.L^{-1}), and C_t is the concentration at the time t (mg.L^{-1}).

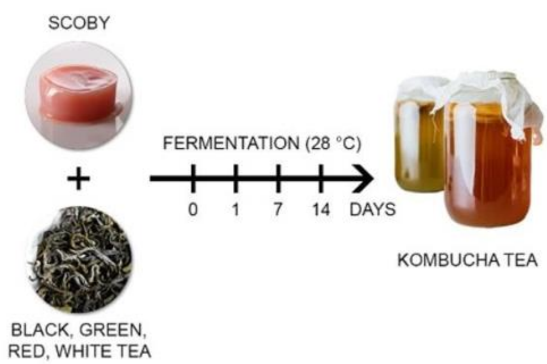

FIGURE 1. Fermentation process of SCOBY materials with tea and sugar [8]

RESULT AND DISCUSSION

Materials Characterization

Three containers served as the breeding grounds for SCOBYs for 14 days. Sweet tea, which has a pH of 2.5, becomes increasingly acidic during breeding. On the last day, the SCOBY from the containers is all harvested. The harvesting has resulted in a wide range of mass and thickness. Figure 2 shows the measurements for mass.

The SCOBY kombucha sample is characterized by Fourier Transform Infra-Red (FTIR) and Scanning Electron Microscopy (SEM). The FTIR was conducted using PerkinElmer Spectrum Two machine to obtain functional groups on the material. From the FTIR result, as shown in Fig 3, several functional groups are identified that are matched to the literature. The cellulose molecule has an O-H hydrogen bonding group (3345 cm^{-1}) [11] that holds the cellulose molecules together and helps keep the structure organized and compact. This cellulose is formed from the fermentation process between SCOBY and glucose [11, 12]. Then, the CH2 carboxyl group (2898 cm^{-1} and 1314 cm^{-1}) is used to calculate the crystallinity rate of cellulose. The H-O-H group (1644–1650 cm^{-1}) also determines the water adsorption rate. The C-O group identified at 1107 cm^{-1} indicates that SCOBY is made from glucose and its derivatives.

SEM testing is used to identify the surface morphology of SCOBY. Based on the results shown in Fig 4, The cellulose that forms and sticks to one another causes random pores to form, which is how the pores are created [14].

FIGURE 2. Weight of SCOBY materials

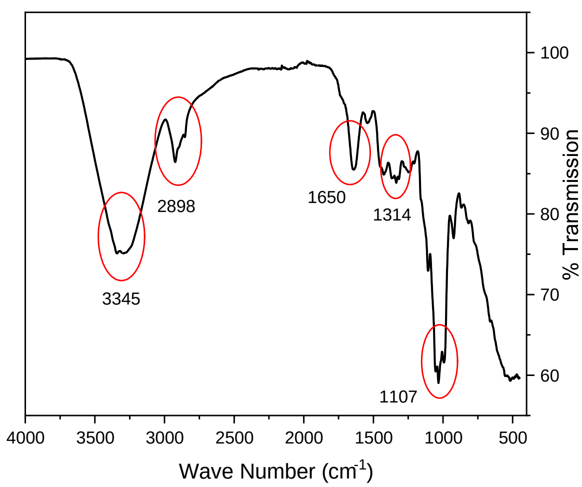

FIGURE 3. The result of FTIR SCOBY kombucha materials

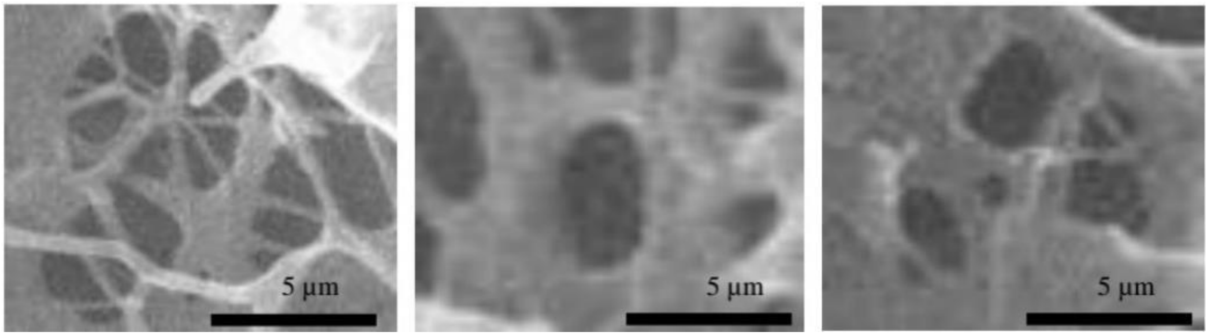

FIGURE 4. SEM result for SCOBY kombucha materials

Because of the presence of cellulose in the amorphous regions, pores are created. Cellulose is generated parallel to the crystalline region. Amorphous is a term used to describe a region where the cellulose is firmly packed or irregularly interwoven. Certain regions do not generate pores in this morphology, while others do. These two factors are what caused this to occur.

The pores formed and then characterized using Baumer, Emmet, and Teller (BET) to identify the pore structure, volume, diameter, and materials-specific surface area. Based on testing results, the SCOBY kombucha has an average specific surface area of 143.244 m^2/g. The pore diameter in this testing also averages 1.5979 nm with a pore volume of 0.229 cc/g. The graph of BET result in Fig 5 also indicates the type I curve [15], indicating the pore created in SCOBY kombucha is micropore. Based on the [16] [17], [18], a micropore is a pore that has a diameter of less than 2 nm, and it is aligned with the diameter pore in SCOBY, which is only 1.5 nm.

Adsorption Characteristics

The material that has been characterized is then tested to adsorb dye using methylene blue and brilliant green. The result from the UV-Vis testing is shown on Fig 6 for the adsorption using 1.5 gram SCOBY materials. Based on Fig 7, it can be seen that the percentage of dye removal increase with more contact time between the SCOBY and dye in every variable. After three hours of stirring, the percentage of methylene blue dye removal is increased to 100% on V2 and V3. On V1, the maximum percentage of dye removal for three hours is 51.18%.

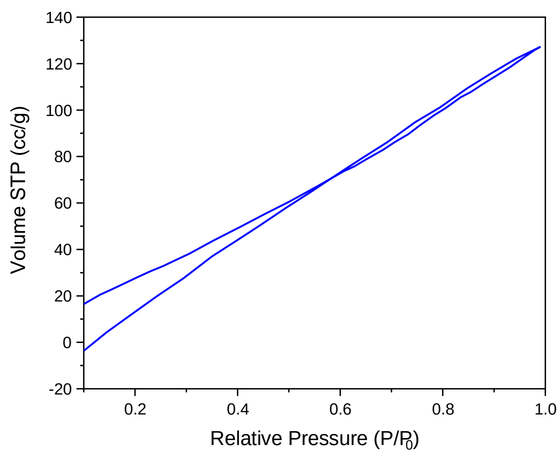

FIGURE 5. Adsorption-desorption isotherm curve for SCOBY kombucha materials

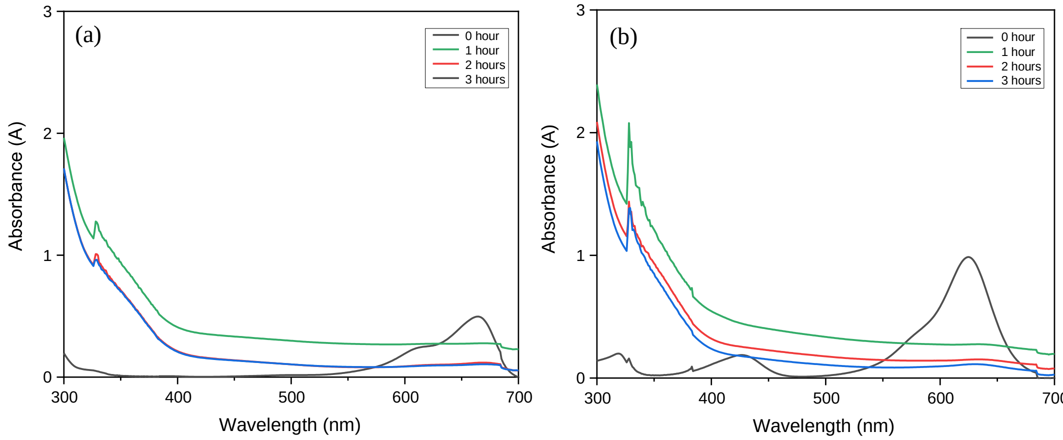

FIGURE 6. UV-Vis result on adsorption testing using 1.5 grams SCOBY materials on (a) methylene blue and (b) brilliant green

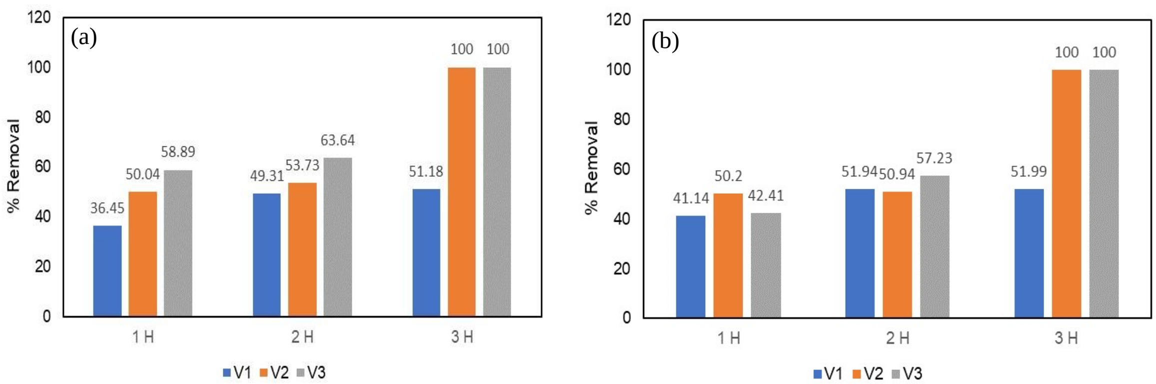

FIGURE 7. %Removal of (a) methylene blue and (b) brilliant green

On the other hand, the result of adsorption testing with brilliant green reaches the maximum percent removal of 100% on V2 and V3. Meanwhile, the maximum percent removal on V1 only reaches 51.99%. From the figures above, it can be seen when %removal of dye is reach 100%, the UV-Vis result will show no more peak. The picture of dye removal at every hour of dye adsorption with methylene blue and brilliant green is shown in Fig 8. The %removal of V2 and V3 is higher than V1 because of their larger specific surface area. The larger specific surface area can cause more contact between dye and SCOBY so that the materials can adsorb more dye [9], [19]. The dye adsorption in this study also happened due to the electrostatic force between the dye and SCOBY surface; therefore, the larger the specific surface area, the more dye it can absorb.

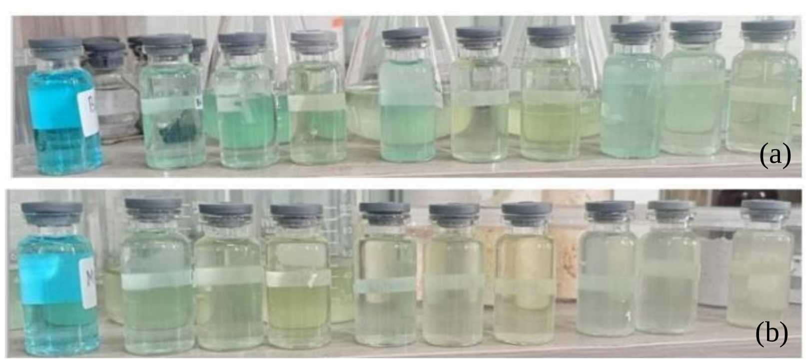

FIGURE 8. Samples after 3 hours of (a) brilliant green and (b) methylene blue dye adsorption

CONCLUSION

In conclusion, the SCOBY materials are proven effective in removing methylene blue and brilliant green dye with their surface area. The material synthesis with this method can produce micropores and a high specific surface area to adsorb more dye with electrostatic force. Based on this research, the more biosorbent and contact time used can increase the effectiveness of dye removal, as shown from V2 and V3 in this research that removes methylene blue and brilliant green with % removal up to 100%.

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