Preparation of Cu Nanoparticles (CuNPs) using *Sargassum* sp. and Its Application As A Self-Cleaning Material on Woven Fabrics

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Abstract. The purpose of this study is to prepare Cu nanoparticles using bioreductors from Sargassum sp. and then applied to the woven fabric. Sargassum sp. mixed with distilled water (1:4 w/v) then heated in the microwave for 1 minute. The extract obtained was added to the $CuSO_4$ solution then heated in the microwave for 5 minutes and obtained Cu nanoparticles (CuNPS) which subsequently coagulated to form colloids. Woven cloth measuring 15x15 cm^2 soaked in colloid for 24 hours and dried, then the contact angle test was performed. To study the effect of polymers, CuNPs were modified by preparing CuNPs-Alg, CuNPs-PVA and CuNPs-Alg-PVA, then applied to woven fabrics. Based on the analysis using a UV-Vis spectrophotometer it was found that the extract of Sargassum sp. can be used as a bioreductor in the preparation of CuNPs. The size distribution of the synthesized particles measured using PSA is 315.27-2511.05 nm with an average particle diameter of 823.4 nm. Contact angle test results showed that the sample of woven fabric deposited CuNPs-PVA gave the greatest contact angle value which was 105.11° and included hydrophobic. While the contact angle values of CuNPs; CuNPs-Alg-PVA and CuNPs-Alg respectively 101.53°; 101.02° and 75.38°. Modified CuNPs woven fabrics; CuNPs-PVA and CuNPs-Alg-PVA can change the surface of woven fabric to be more hydrophobic so that it has the potential as a self-cleaning material.

1. Introduction

The methods used for the synthesis of metal nanoparticles include physical and chemical synthesis methods. However, these methods have limitations including requiring expensive chemicals and a longer time [1]. The new method that has been developed in synthesizing nanoparticles is the biological reduction method or biosynthesis. The biosynthetic method uses natural materials as a reducing agent (bioreductor) of metal ions to form nanoparticles [2]. Bioreductor is a reduction method by utilizing biological materials both microorganisms and plants as reducing agents for metal ions. Plants have various secondary metabolites such as flavonoids, alkaloids, polyphenols, terpenoids, steroids, and tannins. The compound is able to act as a reducing agent because it has a strong tendency to reduce metals. The ability to chelate and reduce metals in phenol compounds because it has a high nucleophilic character from aromatic rings [3]. Brown seaweed contains several bioactive compounds that can reduce metal ions to form nanoparticles [4]. Sargassum sp. is a seaweed group of Phaeophyceae found in the tropics, including in Indonesia. Seaweed Sargassum sp. contains dyes or pigments that can be used as natural dyes. In addition, Sargassum sp. contains active compounds such as steroids, alkaloids, phenols, and triterpenoids that function as antibacterial, antiviral and antifungal [5]. The chemical composition and pigment found in brown seaweed is the result of photosynthesis, the amount of which varies greatly depending on the type, development period and growing conditions. Seaweed Sargassum sp. has more ability than other natural materials as bioreductors. Sargassum crassifolium is able to adsorb Cu metal ions at pH = 7 and the optimum contact time of adsorption is 20 minutes [6].

This study aims to utilize local potential of Sargassum sp. as a bioreductor in the preparation of Cu nanoparticles and applied as a self-cleaning material on woven fabrics.

2. Experimental Section

2.1. Preparation of Cu nanoparticles (CuNPs)

Sargassum sp. seaweed powder dry mixed with distilled water (1:4 w/v) then extracted in the microwave at power level 50 for 1 minute. The mixture is then cooled and filtered. Then the filtrate was mixed with 0.1 M $CuSO_4$ solution in a ratio (1:9 v/v) and heated using a microwave at power level 50 for 5 minutes. Then the mixture is cooled and characterized using a UV-Vis spectrophotometer and a particle size analyzer (PSA).

2.2. Preparation of CuNPS-PVA

Cu nanoparticles solution were added with 5 mL of 1% PVA and stirred until homogeneous. Furthermore, it is allowed to stand for 24 hours. The same treatment was used to make CuNPs -Alg and CuNPs-Alg-PVA.

2.3. Application on Woven Fabrics

Woven cloth measuring 15x15 cm^2 that has been washed is dipped into a container containing Cu nanoparticles until submerged and allowed to stand for 24 hours. Next, the woven fabric is dried and the contact angle is tested. The same treatment is used for CuNPs-Alg; CuNPs-PVA and CuNPs -Alg-PVA

3. Discussion

Preparation of Cu nanoparticles by biosynthetic methods was carried out by mixing Sargassum sp. as a bioreductor with 0.1 M $CuSO_4$ solution as a precursor and then heated using a microwave for 5 minutes. The use of microwaves can accelerate the reaction process because the energy produced in the microwave goes directly to specific target samples and specific ways, so that no heat is lost to the environment, because the heating process takes place in a closed system. This unique heating mechanism can significantly reduce the time needed for the extraction process [7]. In the process, the mixture changes color from brown before it is heated to green and brown deposits are formed. The color changes that occur indicate a reduction reaction from Cu^{2+} ions to Cu^{+} ions. The reduction reaction of Cu^{2+} to Cu^{+} is caused by the presence of the -OH and C=O groups in the dyes that provide free electron pairs. This color change is in accordance with the research of Cu nanoparticle synthesis which produces dark brown deposits [8-9] In addition, the group acts as a ligand that donates free electron pairs to Cu^{2+} orbitals to form complex compounds in nano-sized templates. However, Cu^{+} ions are less stable and tend to disproportionate in solution to form Cu solids and Cu^{2+} solutions as in the following reaction.

$$2\,Cu^{+}_{(aq)} \longrightarrow Cu_{(s)} + Cu^{2+}_{(aq)}$$

Cu nanoparticle produced in the form of colloids were then characterized using a UV-Vis spectrophotometer. The results of the analysis use a UV-Vis spectrophotometer as shown in Figure 1. Testing the sample with a UV-Vis spectrophotometer aims to determine the wavelength and peak absorption of Cu particles. Based on these images shows that Cu nanoparticles can be prepared using extracts of Sargassum sp. as evidenced by the shift in wavelength. In 0.1 M $CuSO_4$ solution it has an absorption peak at a wavelength of 257 nm with an absorbance value of 3.689. After mixing with Sargassum sp. extract, the absorption peak was obtained at a wavelength of 228 nm and absorbance of 3,279. The effect of $CuSO_4$ solution concentration on the formation of Cu nanoparticles can be shown in Figure 1. The higher concentration of $CuSO_4$ solution, to produce more Cu nanoparticles that are formed are characterized by shifting the absorption peak at a larger wavelength at 247 nm and the higher absorbance of 3,961.

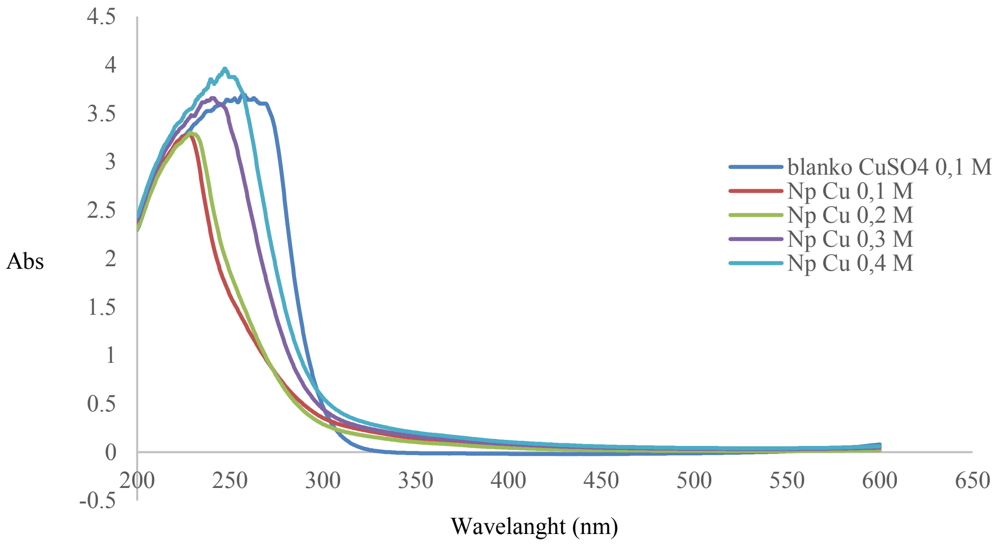

Figure 1. UV-Vis spectra of Cu Nanoparticle

The size of Cu nanoparticle diameter and its distribution in solution were analyzed using Particle Size Analysis (PSA). Particle distribution of Cu nanoparticles as shown in Figure 2. Based on the graph in figure 2 shows the size of the synthesized Cu nanoparticles having varying diameters. Particle size distribution from 315.27-2511.05 nm with an average particle diameter of 823.4 nm.

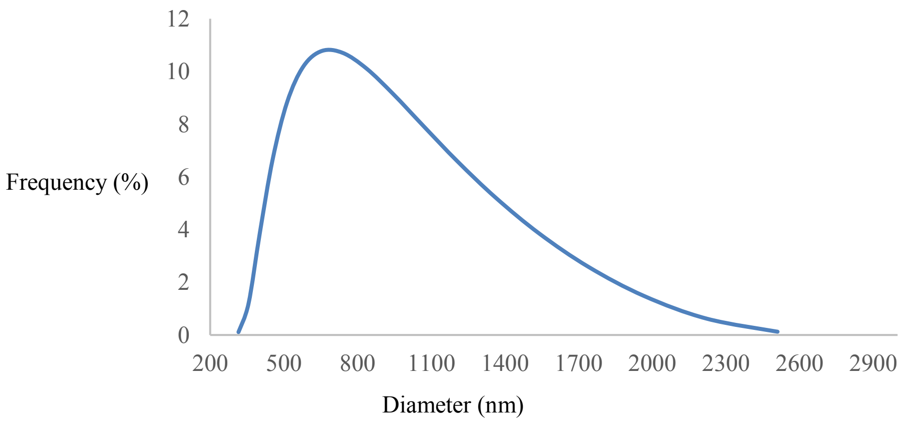

Figure 2. Particle Distribution of Cu Nanoparticles

The results of contact angle test that have been carried out on five variations of woven fabric samples obtained contact angle values (θ) as shown in Figure 3. Based on the contact angle values of each fabric sample are superhydrophilic, hydrophilic and hydrophobic. Fabric samples without modification produce contact angle values of 0º, so woven fabrics are included in the superhydrophilic category. The water that is dropped on the woven fabric is all absorbed by the fabric. Woven fabric samples deposited with copper nanoparticles (NpCu) gave a contact angle value of 101.53º and the sample was hydrophobic. The contact angle value of woven fabric deposited NpCu is greater than the contact angle value of woven fabric without modification. This shows that Cu nanoparticles deposited on the surface of the fabric sample have an influence on the surface properties of the woven fabric. Samples of NpCu deposited woven fabric with the addition of alginate as crosslinking gave a contact angle value of 75.38° and included hydrophilic. The same thing happened in NpCu deposited woven cloth with the addition of alginate and PVA gave a contact angle value of 101.02° and was hydrophobic. Whereas NpCu deposited woven fabric samples with the addition of PVA provides the greatest contact angle value compared to other woven fabric samples which is 105.11° and includes hydrophobic.

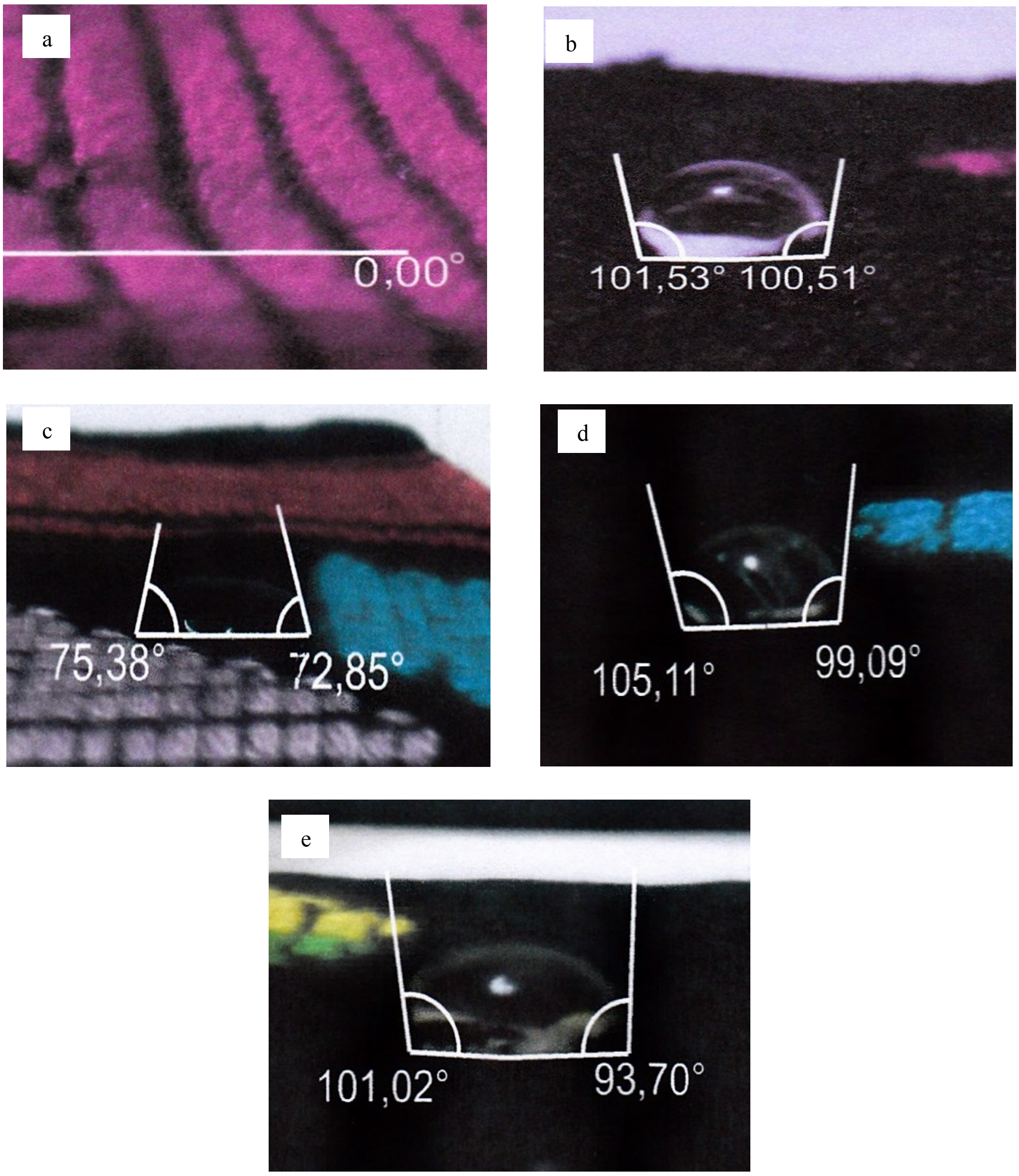

Figure 3. Contact Angel on Woven Fabric: a) without modification; b) modified CuNPs; c) CuNPs-Alginate; d) CuNPs-PVA and e) CuNPs-Alginate-PVA

4. Conclusion

Sargassum sp. can be used as a bioreductor in the preparation of copper nanoparticles (CuNPs). The size distribution of the synthesized particles is 315.27-2511.05 nm with an average particle diameter of 823.4 nm. Modified woven fabric of Cu nanoparticles (CuNPs); CuNPs-PVA and CuNPs-Alg-PVA can change the surface of woven fabric to be more hydrophobic so that it has the potential as a self-cleaning material. Contact angle test results showed that the sample of CuNPs-PVA deposited woven fabric gave the greatest contact angle value which was 105.11 and included hydrophobic.

5. References

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