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Application of Nano Particles on Batik Reactive Dyed Fabric for Antibacterial Properties

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Abstract

Batik is an Indonesian traditional cloth which has been recognized as an Intangible Cultural Heritage of Humanity by UNESCO for more than a decade. Batik cloth is popular among Indonesian people for daily use, both for formal and informal occasions. Commonly, batik cloth is made from cotton, which has many advantages, however prone to bacterial growth, particularly in the tropical climate. Therefore, it is important to develop batik cloth with antibacterial properties. The antibacterial properties of batik cloth were achieved by applying ZnO nanoparticles as antibacterial agent. The nanoparticles were Synthesised using precipitation-sonication method. The formed ZnO nanoparticles were in an average particle size of 54.76 nm and 99.77% ZnO content. The batik making process utilized a synthetic reactive dye of Remazol turquoise blue. The effect of process sequence, the level of antibacterial properties, the morphology of the ZnO coated fabric, and the effect of the application of nanoparticle on the dyeing process were investigated. The results showed that ZnO nanoparticle application on the batik fabric led to antibacterial properties. The process sequences in adding the ZnO nanoparticles were confirmed to significantly affect the antibacterial effectivity and the colour strength. The application of ZnO nanoparticles did not affect the colour fastness to washing as the test showed similar value to that of without ZnO treatment. In addition, the application of ZnO nanoparticles affects the mechanical properties by increasing the tensile strength and decreasing the elongation at break. The application of ZnO after batik making process was shown to have a greater effect on the mechanical properties.

Key words: functional textile; batik fabric; ZnO nanoparticles; antibacterial cloth; reactive dye

1. Introduction

Batik is an Indonesian traditional cloth which has been acknowledged to be an Intangible Cultural Heritage of Humanity by UNESCO since a decade ago. Batik cloth has been a part of Indonesian culture for centuries. It is an important part in various ceremonies and rituals, such as in birth, marriage and death, besides daily usage such as clothing and linens. According to the Indonesian National Standard (SNI) 0239:2014, batik is defined as a craft created using selective dyeing technique. The most common materials used for making batik are fabrics, wax as a colour barrier, and dyes. The selective colorization is achieved by applying hot wax onto the surface of a fabric (or non-fabric) using a canting (batik stamp or writing canting) to form desired patterns of covered surface (BSN, 2014). Commonly, batik motifs are developed based on philosophical values relating to social life and their purpose of use (Steelyana, 2012) [1]. When the wax-covered fabric is soaked in dye, the colour of the dye will only be attached to the exposed area, resulting in a unique pattern (Taufiqoh et al., 2018) [2]. Thus, after the dyeing process, the desired colored motifs are formed (Atika & Haerudin, 2013) [3]. After the dyeing process, the wax is removed by heating the colored fabric in boiled water followed by washing and drying by hanging the cloth in the shade (Ristiani, 2017) [4]. The colour in batik making process can be produced using either natural or synthetic dyes. In this work, a type of synthetic dye was selected. The synthetic dyes commonly used in the batik making processes are indigo sol, Remazol, rapid and indanthrene dyes (Susanto, 1974) [5]. Indigo sol is classified as vat dyes. There are two stages in coloring with Indigo sol dye, which are the application of the dye followed by the generation of the colour on the surface of the fabric. Additive substances are required in dyeing using Indigo sol, including sodium nitrite and hydrochloric acid (Murwati, 2005) [6]. Remazol is categorized into a reactive dye. In the dyeing process, this type of dye forms a covalent bond with the substrate (the fabric) during the process (Benkhaya et al., 2017) [7]. The dye fixative agent for Remazol is sodium silicate (water glass). Batik production requires fabrics made from natural fibers which easily absorb colors, such as cotton or silk. In this work, cotton fabric was chosen for experimentation due to a number of advantages, such as smoothness, high absorption capacity, and comfortability (Yetisen et al., 2016) [8]. It is also highly breathable, allowing to be easily dyed using various colorants (Shahidi & Moazzenchi, 2019) [9]. Even though many classes of dyes may be utilized in coloring cotton, reactive (9.7%), vat (19.4%), and direct (27.4%) types of dyes are mostly used. Despite the advantages, there is a problem in using cotton fabric for daily use. As it made from natural fibers, cotton fabric is an ideal medium for bacterial growth (Setiyani & Maharani, 2015) [10]. Considering the vast usage of batik cloth made from cotton among Indonesian people, developing batik cloth which prevents the bacterial growth could help in improving the hygiene of the community. Researches in the advancement of functional textiles have attracted considerable attention for last few decades. In this research, a functional textile which has an antibacterial benefit has been developed by improving the batik making process. The antibacterial function of cotton textiles (in this case is batik cloth) can be achieved by adding antibacterial agents or finishing agents such as commercial synthetic ones, natural compounds, or antibacterial nanoparticles (Eskani et al., 2019) [11]. This paper presents antibacterial functionalization of batik fabrics by applying ZnO nanoparticles to the fabric in the batik making process. The ZnO nanoparticles were selected due to its distinctive properties of antibacterial activity (Verbic et al., 2019; Agua et al., 2018; Mishra et al., 2017) [12-14]. ZnO nanoparticles are widely used for producing antibacterial textiles due to some advantages, such as low price, biocompatibility, and environmentally friendliness (Verbic et al., 2019; Subash et al., 2012) [15,16]. In addition, they are also heat-resistant and stable in a harsh condition (Dimapilis et al., 2018; Agua et al., 2018), nontoxic, highly effective as antibacterial, and do not affect the colour of the dyed fabric (Fiedot-Toboła et al., 2018) [17,18]. Therefore, ZnO nanoparticles are suitable as antibacterial agents for batik fabrics since the batik making process involves hard process conditions due to the use of several chemicals. The antibacterial mechanism of ZnO nanoparticles is caused by its ability to form Reactive Oxygen Species (ROS) which can easily diffuse into bacterial cell membranes and inhibit the respiratory enzymes (Mishra et al., 2017; Upasani et al., 2016) [19]. At low concentrations, the antibacterial activities of ZnO nanostructures are more effective in gram-positive bacteria. The higher the concentration and the longer the contact time are the better the antibacterial properties of ZnO nanoparticles performed on both gram-negative (i.e. Escherichia coli) and gram-positive (i.e. Staphylococcus aureus) bacteria (Verbic et al., 2019). There have been few researchers conducting studies on the creation of a functional batik, especially antibacterial batik. Such antibacterial batik has been developed using natural dyes of Marinda centifolia (Rahman et al., 2018) [20]. The batik fabric was brownish yellow and exhibited antibacterial properties against gram-positive bacteria of Staphylococcus aureus. Another work used Gambier to develop antifungal batik (Rahayuningsih et al., 2020) [21]. The batik dyed using Gambier coupled with formaldehyde or clove oil finishing agents had antifungal properties against Aspergillus Niger. However, to the best of the authors' knowledge, little work has been carried out to use ZnO nanoparticles as an antibacterial agent for batik fabrics. In the previous study (Eskani et al., 2020), commercial ZnO nanoparticles and indigo sol (vat dyes) were used to produce antibacterial batik [22]. It was found that the application of the commercial ZnO nanoparticles coupled with indigo sol dyes onto the batik fabric could provide antibacterial properties (Eskani et al., 2020). In this study, instead of commercial nanoparticles, newly synthesized ZnO nano-powder and Remazol (reactive dyes) were utilized to obtain the antibacterial batik. The ZnO nanoparticles were prepared from ZnCl2 and NaOH using a precipitation-sonication technique. The method was used as it has several advantages such as high reproducibility and ease of the particles size control (Romadhan et al., 2016) [23]. The synthesized ZnO nanoparticles were applied on to batik fabric which was then colored using a reactive dye of Remazol. This work is important to realize the full potential of ZnO nanoparticles in producing the antibacterial batik. Therefore, this paper discusses the results of the work on the application of ZnO nanostructures on cotton fabrics for the development of antibacterial batik. The effect of ZnO nanostructures on the mechanical properties and the coloring of batik fabric with reactive dyes were also investigated.

Technical details

The materials used for the synthesis of ZnO nanoparticles were ZnCl2, deionized water, methanol, NaOH and filter paper (Whatman No. 42). The chemicals were analytical grade. The batik was prepared using the following materials: batik wax, cotton fabric, reactive dye (Remazol-turquoise blue), non-ionic detergents, soda ash (NaCO3), natrium nitrite (NaNO2), natrium silicate (NaSiO3), and hydrochloric acid (HCl).

The following procedures have been adopted

a) Preparation of ZnO nano particles
b) Calculation of zinc oxide crystal size using Scherrer equation
c) Characterization zinc oxide particles
d) The batik making process
e) Application of zinc oxide nanostructures onto fabric
f) Characterization of the zinc oxide coated batik cloth
g) The dyeing performance of the zinc oxide treated Batik fabric

Conclusion

ZnO nanostructures have been prepared from ZnCl2 precursor using precipitation-sonication technique. The ZnO nanoparticles were observed to have an average particle size of 54.76 nm with 99.77% purity. Antibacterial properties of batik fabric have been successfully achieved by the application of the ZnO nanostructures. The process sequences in adding the ZnO nanoparticles were confirmed to significantly affect the antibacterial effectivity. The application of ZnO nanostructures onto the fabric after the batik process demonstrated better antibacterial properties than that of the ZnO pre-treated batik fabric. The colour strength indicated by the K/S value of the ZnO post-treated batik fabric was also greater than that of the

ZnO untreated batik fabric. The application of the ZnO nanoparticles after dyeing with reactive dyes could increase the strength of the colour in the fabric. However, the colour strength of the ZnO pre-treated batik fabric, shown by the K/S value, is smaller than that of the untreated batik fabric. This finding agrees with previous studies that found that the application of ZnO nanoparticles preceding the dyeing process by reactive dyes might block hydroxyl groups of cellulose fibers to form a covalent bond with the reactive dyes. The application of ZnO nanoparticles on the batik fabric using any process sequences did not affect the colour fastness to washing and the results obtained are the same as that obtained from the batik fabric without the ZnO treatment, at around 4-5 (good). The incorporation of ZnO nanoparticles onto batik fabrics affects the mechanical properties by increasing the tensile strength and decreasing the elongation at break. The application of ZnO nanoparticles after the batik process is shown to have a greater effect on the mechanical properties.

References

1. Steelyana, E. (2012). Batik, a beautiful cultural heritage that preserve culture and support economic development In Indonesia. *Binus Business Review*, 3(1), 116–130.
2. Taufiqoh, B. R., Nurdevi, I., & Khotimah, K. (2018). Batik Sebagai Warisan Budaya Indonesia, in Seminar National Bahasa Dan Sastra, *Malang*, pp. 58–65.
3. Atika, V., & Haerudin, A. (2013). Pengaruh komposisi resin alami terhadap suhu pelorodan lilin untuk batik warna alam. Din. *Kerajinan Dan Batik*, 30(1), 23–30.
4. Ristiani, S. (2017). Pengembangan Teknik Smock pada Batik Untuk Meningkatkan Daya Saing Produk Fesyen.
5. Susanto, S. (1974). Seni Kerajinan Batik Indonesia. Balai Penelitian Batik dan Kerajinan.
6. Murwati, E. S. (2005). Teknologi Proses Batik Kombinasi Sasirangan pada Kain Voalisima, Primissima dan Sutera, Din. *Kerajinan dan Batik*, 22(1), 28–38.
7. Benkhaya, S., Harfi, S. E., & Harfi, A. E. (2017). Classifications, properties and applications of textile dyes: A review. *Applied Journal of Environmental Engineering Science*, 311–320.
8. Yetisen, A. K., Qu, H., Manbachi, A., Butt, H., Dokmeci, M. R., et al. (2016). Nanotechnology in Textiles. *ACS Nano*, 10(3), 3042–3068.
9. Shahidi, S., & Moazzenchi, B. (2019). The influence of dyeing on the adsorption of silver and copper particles as antibacterial agents on to cotton fabrics. *Journal of Natural Fibers*, 16(5), 677–687.
10. Setiyani, R., & Maharani, K. (2015). Pemanfaatan Komposit Kitosan ZnO-SiO2 Sebagai Agan Antibakteri Terhadap Bakteri Staphylococcus aureus pada Kain Katun. *UNESA J. Chem*, 4(2), 88–93.
11. Eskani, I., Haerudin, A., Setiawan, J., Lestari, D. W., & Astuti, W. (2019). Batik Fungsional Sebagai Salah Satu Strategi Pengembangan Industri Batik Dalam Memasuki Era Industri 4.0 [Paper presentation]. *Seminar Nasional Batik D*.
12. Verbic, A., Gorjanc, M., & Simoncic, B. (2019). Zinc oxide for functional textile coatings: Recent advances. *Coatings*, 9(9), 550–523.
13. Agua, R., Branquinho, R., Duarte, M., Mauricio, E., Fernando, A., et al. (2018). Efficient coverage of ZnO nanoparticles on cotton fibers for antibacterial finishing using a rapid and low cost in situ synthesis. *New Journal of Chemistry*, 42(2), 1052–1060.
14. Mishra, P. K., Mishra, H., & Ekielski, A. (2017). Zinc oxide nanoparticles: a promising nanomaterial for biomedical applications. *Drug Discovery Today*, 6446(17), 1825–1834.
15. Verbic, A., Gorjanc, M., & Simoncic, B. (2019). Zinc oxide for functional textile coatings: Recent advances. *Coatings*, 9(9), 550–523.
16. Subash, A. A., Chandramouli, K. V., Ramachandran, T., Rajendran, R., & Muthusamy, M. (2012). Preparation, characterization, and functional analysis of zinc oxide nanoparticle-coated cotton fabric for antibacterial efficacy. *Journal of the Textile Institute*, 103(3), 298–303.
17. Dimapilis, E. A., Hsu, C., Marie, R., Mendoza, O., & Lu, M. (2018). Zinc oxide nanoparticles for water disinfection. *Sustainable Environment Research*, 28(2), 47–56.
18. Fiedot-Toboła, M., Ciesielska, M., Maliszewska, I., Rac-Rumijowska, O., Suchorska-Wo zniak, P., et al. (2018). Deposition of zinc oxide on different polymer textiles and their antibacterial properties. *Materials (Materials)*, 11(5), 707–716.
19. Upasani, P. S., Sreekumar, T. V., & Jain, A. K. (2016). Polyester fabric with inherent antibacterial, hydrophilic and UV protection properties. *Journal of the Textile Institute*, 107(9), 1135–1143.
20. Rahman, A., Muktiningsih, M., Andika, F. L., Kartini, I., & Slamet, R. (2018). Extraction of natural dye powder from Morinda citrifolia and its application as antibacterial dyes for cotton fabrics [Paper presentation]. *IOP Conference Series: Materials Science and Engineering*, in, pp. 1–6.
21. Rahayuningsih, E., Setiawan, F. A., Ayanie, C. J., Antoko, A. A., Ayuningtyas, Y. I., et al. (2020). Optimization model on the effect of clove oil, formaldehyde, and chitosan added to batik fabric colored with gambier (Uncaria gambir Roxb): Antifungal properties and stability. *Indonesian Journal of Chemistry*, 20(1), 210–222.
22. Eskani, I., Haerudin, A., Setiawan, J., Lestari, D. W., & Astuti, W. (2019). Batik Fungsional Sebagai Salah Satu Strategi Pengembangan Industry Batik Dalam Memasuki Era Industry 4.0 [Paper presentation]. *Seminar Nasional Batik Dan Keraj*.
23. Romadhan, M. F., Suyatma, N. E., & Taqi, F. M. (2016). Synthesis of ZnO nanoparticles by precipitation method with their antibacterial effect. *Indonesian Journal of Chemistry*, 16(2), 117–123.