Fabrication of superhydrophobic CuO/polystyrene nanocomposite coating with variation concentration

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Abstract. Copper oxide (CuO) from Solok District has been successfully purified and can be reduced in size to nanode order. CuO and polystyrene powder is combined into a hydrophobic coating. The purpose of this study was to determine the effect of concentration variation on the coating of CuO / polystyrene composite in the form of contact angle between air and the surface of the test layer. The results showed that for concentrations of 0.0 M, 0.4 M, 0.5 M, 0.6 M, 0.7 M, 0.8 M, 0.9 M, 1.0 M, and 1.1 M increased the contact angle of the CuO / polystyrene layer to the limit stability of the test layer. The water contact angles at the surface of the CuO / polystyrene composite coating for each CuO concentration are 54°, 75°, 80°, 96°, 105°, 122°, 133°, 162°, and 100°. The maximum contact angle obtained at 162° indicates that the surface is superhydrophobic.

1. Introduction
Copper oxide (CuO) is a p-type semiconductor material with a band gap of 1.4-2.1 eV [1]. CuO has a specific application that is as self cleaning material [2] [3], catalysts [4], supercapacitor [5], sensor [6], anti-corrosion [7], anti icing [8] and water-repellency [9]. Copper is one of the minerals found in western Sumatra, Indonesia [10]. Copper can be used as copper oxide (CuO) through the calcination process [11] [12]. Copper oxide powder can be reduced in size to nanometer order using high energy milling methods [13] [14]. Modification of micro and nanostructure hierarchy structures attracted the attention of researchers because of the potential for micro nan nan on a substrate or with composites having low surface energy can be obtained hydrophobic surface [3].

The hydrophobic surface mimics the concept of the natural hydrophobicity of the lotus leaf surface (lotus effect) [15]. The hydrophobicity of a surface can be determined from the water contact angle (WCA), the angle between the water droplets and the surface of an object on a contact line. If the water contact angle on the surface of the material is more than 90 ° [16], then the surface of the material is called the hydrophobic surface [17]. If the water contact angle is > 150 °, then the material is superhydrophobic [18] [19]. The superhydrophobic properties are influenced by two factors: roughness in the micro-nano order and chemical composition on the surface [20]. In this paper, we focus on making hydrophobic surfaces using a combination of CuO with polystyrene as a hydrophobic inductor, which produces hydrophobic surfaces.
2. Research Method

2.1. Preparation of copper oxide nanoparticles powder
Copper nanoparticle powder is prepared by high energy milling method using copper powder obtained from Sulit Air village, Solok regency, West Sumatera, Indonesia (90.63%) as starting material. The tool used for the preparation of silica is the Ball Mill of High Energy Milling Ellipse 3D Motion (HEM-E 3D). The rolling time used is 20 hours.

2.2. Phase Formation of hydrophobic coating
The first step before making a layer is to do glass preparation as much as 9 pieces which are then cleaned with ultrasonic cleaner using alcohol for 30 minutes, then dried at room temperature. For the formation of hydrophobic coating varied CuO concentrations of 0.0 M, 0.4 M, 0.5 M, 0.6 M, 0.7 M, 0.8 M, 0.9 M, 1.0 M and 1.1 M in 15 ml Tetrahydrofuran (THF), add 1 gr polystyrene and stirred for 60 minutes using stirred magnetically. The solution formed was coated onto the glass using Spin Coating for 15 seconds for each sample. The drying was carried out at room temperature for 30 minutes and annealed for 60 minutes at 200°C.

2.3. Characterization
The CuO / polystyrene layer is characterized by X-ray powder diffractometer (XRD, CubiX3Cement) using Cu-Kα radiation (λ = 1.5406 Å) at 45 kV and 40 mA and is used to determine the identity of each phase and crystal. Characterization of contact angles with the method of sessile drop.

3. Results and Discussion

3.1. Characterization of Crystal Structures
After coating of CuO / polystyrene at annealing at temperature 200 °C for 60 minutes with CuO concentration of 0.6 M, diffraction pattern analysis was obtained from X-Ray Diffractive (XRD) test. The test is performed at an angle of 20 between 30 ° to 80 ° using x-rays. Based on XRD test result, diffraction pattern was analyzed using high score plus software and obtained qualitative data in the form of monoclinic phase. Matching is done using a pattern derived from Crystallography Open Database (COD) code 96-900-8962. Based on the results of the analysis of the peaks of the x-ray diffraction the sample has a high fit with reference to the x-ray diffraction pattern. This can be explained by the emerging field of hkl where they are monoclinic areas.
Figure 1. Results of diffraction pattern of CuO / polystyrene nanocomposite coating

Figure 1 is a plot of intensity against 2 theta angles (2θ) of the X-ray diffraction pattern from a sample of a thin layer of CuO / polystyrene nanocomposite with a CuO concentration of 0.6 M. The result of the diffraction pattern shows that the highest peak is dominated by copper oxide (CuO). While the diffraction that appears copper oxide with monoclinic crystal structure.

3.2. Water contact angle on the test surface
Chemically wetting can occur because the molecules making up the surface tend to be polar. So that there will be a tug-of-war between the surface molecules and the H₂O molecules that are also polar. Hydrophobic material coating is able to modify the surface, making the substrate tends to be nonpolar. The hydrophobicity of a layer can be determined by measuring the contact angle.

The amount of contact angle of the material surface against the liquid droplets is obtained based on the results of direct observation through the shooting of the digital camera connected to the computer. The result of the shooting is shown in the form of a scaled-scale projector, then the contact angle on the left and right side of the test sample is measured using a degree arc. Figure 2 shows the measurement of the contact angle between the water with the CuO/polystyren layer.
Figure 2. Contact angle of CuO / polystyrene layer with concentration variation, (a) 0.0 M, (b) 0.4 M, (c) 0.5 M, (d) 0.6 M, (e) 0.7 M, (f) 0.8 M, (g) 0.9 M, (h) 1.0 M, and 1.1 M.

Figure 2 shows the graph of the relation of concentration to the point of contact angle, the increase in CuO concentration is proportional to the increase of the angular value of the contact.

Figure 3. Graph of effect of addition of CuO concentration to contact angle on CuO/polystyren coating
Figure 2 and 3 illustrate at a concentration of CuO 0.0 M (without addition of CuO) the contact angle formed is 54°, when given a 0.4 M CuO concentration the contact angle formed is 75° change in contact angle of 21°. When a concentration of 0.5 M of contact angle is formed 80°, this indicates that the coating is hydrophilic (contact angle <90°). However, when the concentrations of CuO 0.6 M, 0.7 M, 0.8 M and 0.9 M are respectively 96°, 105°, 122° and 133°. This shows the coating formed is hydrophobic (contact angle> 90°). However, when the concentration of CuO 1.1 M of contact angle decreases from 162° to 100°. The optimum concentration in this paper is 1.0 M with a contact angle of 162°, indicating a superhydrophobic coating (contact angle> 150°). The results of the influence of CuO concentration on the contact angle indicate that more CuO is deposited on the layer the larger the resulting contact angle, to the limits of the stability of the CuO/polystyren nanocomposite layer. Figure 3 shows fluctuations in the change in contact angle to the addition of CuO concentration.

4. Conclusion
Coupling of superhydrophobic CuO/polystyren coatings using CuO (natural ingredients) ingredients has been successfully performed and obtained a maximum contact angle of 162° at a concentration of 1.0 M. The concentration variations performed show at concentrations of CuO 0.5 M to 1.0 M, the contact angle has increased. Then decreased at the concentration of CuO 1.1M.

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