Optimization of hydrophobic nanocomposite thin film from silica/polietilen

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Abstract. An optimization of the hydrophobic nanocomposite thin film has been carried out. A thin layer of nanocomposites is synthesized from natural minerals, which are a mixture of silica and polyethylene. Synthesis was carried out using 5 hours spinning with High Energy Milling (HEM-E3D). Optimization is done through variations in the composition of silica minerals with polyethylene. Contact angle characterization was performed using the Nikon D5200 Camera. The results of this study are the optimum contact angle obtained in the composition of silica/polyethylene nanocomposites that is 0.2 gram/0.5 gram.

1. Introduction

Nanocoating technology on glass is increasingly needed in life. Glass coated with nanoparticles can change properties to be hydrophobic. The benefit obtained from this hydrophobic glass is that glass will be self cleaning [1][2]. Self cleaning is an ability for a material to clean itself [3]. The nature of self cleaning has been exemplified in nature, namely the lotus leaves. The waxy characteristics of the plant form a nano-sized bulge. This protrusion contributes to the surface roughness of the leaf resulting in its hydrophobic nature. The contact angle between water and leaf surface is 137,3° [4].

To be able to produce hydrophobic properties against other materials such as glass can be done through a spin coating method that utilizes nanoparticles. This method was chosen because it has a simple and inexpensive method. The spin coating method can be interpreted as a method of forming a thin layer through a spin or spin process [5]. The nanoparticle material is made in the form of nanocomposite which is a material consisting of a matrix and a filler [6][7]. Matrix is the basis for the formation of composite materials that can bind fillers without chemical bonds. While the filler is a filler that can strengthen the matrix in the composite material [8].

In making nanocomposites natural materials such as silica can be used. Polymers used are those that have low surface energy such as polystyrene. Low surface energy will reduce the wettability (wetness) of the surface of the solid so that it will produce a surface with hydrophobic properties [9]. Silica (SiO2) acts as a filler material and polystyrene (PE) as a matrix material. The composition of the matrix and filler will affect the contact angle of the hydrophobic layer.

Previously there have been studies that use synthetic silica. Nanocomposites are made with variations in the composition of SiO2 / TEOS (Tetraethly orthosilicate). Silica variations used are 1 gram, 2 gram,
3 gram and 4 gram. The results found that the optimum contact angle was 98° in silica composition weighing 3 grams [9]. However, this research still has weaknesses from the point of contact that can still be increased to be used as a self cleaning application by changing the matrix used. The mixture of matrix and filler will form a mixture of nanocomposites, the mixture will be coated on a glass substrate.

However, this study still has weaknesses in the basic ingredients used in the form of expensive synthetic silica and contact angles that are not yet optimum for hydrophobic properties. Therefore, this article will discuss the effect of silica / polyethylene nanocomposite compositions on the hydrophobic properties of thin films.

2. Experimental

The main tools used are High Energy Milling (HEM-E3D), and Nikon D5200 cameras, spin coating and Scanning Electron Microscopy (SEM). The materials used in this study are polyethylene (PE), silica, xylene, phenolphthalein indicator (PP), hydrochloric acid (HCl) and sodium hydroxide (NaOH), and aquades.

Silica nanoparticles that have been through a 200 mesh filter were milled using HEM-E3D for 5 hours. After finishing the milling, then stirrer with 50 ml dilute Hydrochloric Acid (HCl) for 1 hour at a speed of 250 rpm. The solution is deposited for 24 hours. Then the precipitate is washed and dried and then stirrer with 50 ml of dilute Sodium Hydroxide (NaOH) using a temperature of 250°C within 2 hours. Then the solution is mixed with 200 ml of distilled water slowly and stirring for 1 hour. After that the solution is filtered. The solution that passes the filter is stirred and titrated with HCl to PH = 7. Then the solution was deposited for 24 hours. Then the sludge is dried in an oven using a temperature of 100°C within 1 hour. After drying, the precipitate is crushed to get silica powder. Silica powder is used to make silica/polyethylene nanocomposite coatings. The solution for the coating is made by stirring 0.5 grams of polyethylene with 10 ml of xylene solvent for 15 minutes to form a polyethylene solution as a matrix. Then add silica with variations of the composition of 0 gram, 0.1 gram, 0.2 gram, 0.3 gram and 0.4 gram into 5 pieces of polyethylene solution so that there are 5 variations of the composition of the nanocomposite. Then the solution is stirred with a magnetic stirrer for 15 minutes. Glass substrate with a size of 0.5 cm x 0.5 cm and 1 cm x 1 cm for the coating is washed first with an ultrasonic cleaner. The formed solution is coated on a glass substrate using a spin coating with a speed of 1000 rpm with a time of 30 seconds. The coating that has been coated on the glass is dried using an oven with a temperature of 60°C. Then testing the contact angle using the camera.

3. Result and discussion

The measurement results of SiO2 / PE contact angles of nanocomposite thin films with composition variations 0: 0.5; 0.1: 0.5; 0.2: 0.5; 0.3: 0.5 and 0.4: 0.5 can be seen in Figure 1. Figure 1 shows that variations in the composition of SiO2 and PE affect the contact angle of the thin film. The largest contact angle obtained was 143° occurred in the composition 0.2 / 0.5. The complete results can be seen in Table 1.
Figure 1. Effect of variations in the composition of SiO2 / PE on contact angles of thin films (a). 0 / 0.5 gram, (b). 0.1 / 0.5 gram, (c). 0.2 / 0.5 gram, (d). 0.3 / 0.5 gram (e). 0.4 / 05 grams

**Table 1.** Effect of SiO2 / PE Composition Variation on the Contact Angle of the layer

| No | Composition (gram) | Contact Angle (°) |
|----|--------------------|-------------------|
| 1  | 0/0.5              | 58                |
| 2  | 0.1/0.5            | 140               |
| 3  | 0.2/0.5            | 143               |
| 4  | 0.3/0.5            | 140               |
| 5  | 0.4/0.5            | 134               |

The effect of adding silica to polyesters can be explained as follows. Polyestirene without silica has weak strength with a very tenuous polymer structure, as illustrated through Figure 2.

Figure 2. Polymers without the addition of nanoparticles [10]

Polyethylene without a mixture of other ingredients has a contact angle of 58°. To increase the contact angle of the layer, nanoparticles were added from other materials. Figure 3 is an illustration of the structure of a polyestirene with the addition of nanoparticles from other materials.
Figure 3. Polymers with the addition of nanoparticles [10]

Seen in the illustration Figure 3, the polymer mixed with nanoparticles will have a stronger and denser structure. Polyestirene added with nanosilica can increase the contact angle of the coating. So to make the hydrophobic layer by using polyethylene silica nanoparticle composition added to it, here will be seen the effect of giving variations in the composition of the nanoparticles to the contact angle of the hydrophobic layer, in Figure 2b through Figure 2e silica with a composition of 0.1 gram, 0.2 gram respectively, 0.3 grams and 0.4 grams. After going through the testing and measurement process, contact angles are not too different from the four variations of the silica composition, contact angles have sizes of 140°, 143°, 140° and 134° so that it can be said that the composition of silica nanoparticles in silica / polyethylene nanocomposites does not significantly affect the angular enlargement contact. But all four variations have been successfully made and are hydrophobic. Where the highest contact angle is in the composition 0.2 / 0.5 that is equal to 143°. And the lowest in the composition without silica nanoparticles is 580. The wetness model that matches the silica / polyethylene nanocomposite layer is the Wenzel Model because the water droplets are still sticky above the hydrophobic surface, and are influenced by surface roughness.

4. Conclusions
The silica content in the nanocomposite greatly influences the layer to be hydrophobic, but the variation of the composition of the given silica does not greatly affect the formation of the contact angle to make the layer hydrophobic. The optimum composition obtained and the contact angle formed is at a composition of 0.2 / 0.5 with a contact angle of 143°.

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