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The Effect of Variation in SiMn/PS Nanocomposite Composition on Hydrophobic Properties

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ABSTRACT

Many researches on hydrophobic synthesis have been carried out on coatings, but they still have drawbacks, such as the coating being easily scratched, easily damaged by contact with other objects and easily corroding, thereby reducing the quality of the coating. This can reduce the application of hydrophobic coatings in industry and others. Therefore, it is necessary to develop a hydrophobic layer that is strong and durable and does not corrode so that it can improve the quality of a surface. For this reason, research is carried out by mixing a substrate that has non-corrosive properties such as silica and is hard such as manganese in order to overcome the problems that occurred previously by using the spin coating method. The precursor was prepared by adding 0.5 grams of polystyrene composition, with varying SiMn compositions. The coating was carried out using the spin coating method and the calcination temperature was 60oC using an oven for 1 hour. The results of this variation of composition indicate that the SiMn/PS nanocomposite layer is hydrophobic based on the contact angle test. The largest contact angle at 50%:50% composition with a large contact angle of 104.7°.

Keywords :*hydrophobic, Silica Oxide (SiO2), Manganese (Mn), polystyrene, contact angle, durability, nanocomposite.*

I. INTRODUCTION

Currently, research on hydrophobic surfaces has been carried out by many other researchers. However, the results obtained still have many shortcomings such as easy to scratch and easy to corrode. Therefore, the development of a strong and durable hydrophobic coating and corrosion resistance by an easy and efficient method is urgently needed.

A surface can be said to be hydrophobic if it has certain characteristics. The hydrophobic nature has anti-wet properties, has a large contact angle of 90ºC [3]. The hydrophobicity of a surface can be determined with the angle formed between the water and the glass surface coated by the SiMn nanocomposite and measure the contact angle [2]. A hydrophobic surface has a contact angle between 90°-150°, while a contact angle >150° is called superhydrophobic [6].

Silica is a metal oxide compound that is widely found in nature, silica also has anti-corrosion properties [5]. The arrangement of atoms in amorphous silica occurs randomly with a low degree of regularity. Therefore, it is necessary to carry out a silica sand purification process to remove impurities. [12]. Manganese is one of the most abundant elements found in the earth's crust which has a gray black color[9]. Manganese ore has the potential to be developed as an industrial material along with technological advances [10]. Nanocomposite is a matrix measuring 1.0 x 10-9 m. For the manufacture of the coating required polystyrene polymer. This polystyrene is resistant to acids, bases and other rusting materials [4]. Many methods are used for this purpose, such as electrochemical reactions, phase separation, sin coating, dip coating, sol-gel, coprecipitation and filler particles.

The method used to make SiMn/PS nanocomposite layers is spin-coating, because this method is easy to do and can make a homogeneous layer. The coating matrix is polystyrene because it is resistant to acids, bases and other rust materials [10].

II. METHOD

This study examines the effect of variations in the composition of SiMn/PS nanocomposites on hydrophobic properties. This research is an experimental research type. This research was conducted at the Material Physics and Biophysics Laboratory, Faculty of Mathematics and Natural Sciences and the Chemistry Laboratory, Padang State University. The materials used are nanoparticles of silica, manganese, polystyrene (PS), tetrahydrofuran (THF) and aquadest. The tools used are measuring cups, beakers, magnetic stirrer, glass, camera, XRD, FTIR, furnace, oven and spin coating.

There are several steps taken:

A. Sample Preparation Stage

First, the synthesis of silica and manganese nanoparticles by weighing 8 grams of silica and manganese and then grinding using HEM-E3D for 5 hours for silica and 16 hours for manganese. The next step is the manufacture of Silica Manganese/Polystyrene Precursor by dissolving 0.5 grams of polystyrene and 15 ml of tetrahydrofuran using a magnetic stirrer at a temperature of 500C. Then mix it with SiMn with a varied composition where the composition used is 20%: 80%, 40%: 60%, 50%: 50%, 60%: 40%, 80%:20% with the amount of SiMn 0.4 grams, then stirred for 1 hour using a magnetic stirrer until homogeneous. The next step is sample preparation by preparing glass preparations with a size of 0.5cm x 0.5cm and 1cm x 1cm then washing using an ultrasonic cleaner by soaking the glass in a solution of PEG and aquadest for 2 hours. The next step is to make a thin layer using a spin coating by doing a Spin Coating by placing a glass substrate and then dripping it with a prepared SiMn/PS solution, then rotating it at a speed of 500 rpm for 60 seconds. Furthermore, the manganese silica nanocomposite layer formed was heated in an oven at 60ºC for 1 hour. Then take photo for contact angle using camera in dark room. Then to measure the contact angle using ImageJ software. Here's how the ImageJ software looks and works.

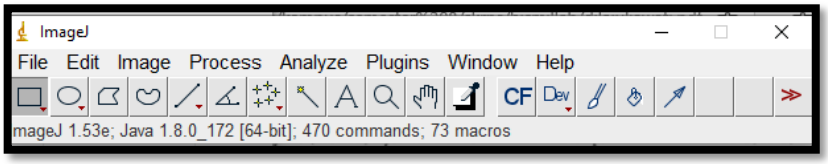

Fig.1. ImageJ Software Display

To measure the contact angle, select the image to be measured in the file tool, after the image appears then select the angle tool and then draw a straight line between the surface and the water droplet and draw the line up until it forms an angle between the sample surface and the droplet.

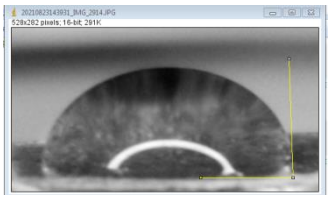

Fig.2. Measuring Contact Angle

To find out the contact angle, select Analyze then select Maesure and the results of the contact angle will be displayed. After making repeated measurements and then looking for the average.

B. Analysis Stage

The contact angle analysis obtained from the measurement results of the SilicaManganese/Polystyrene (SiMn/PS) nanocomposite layer can be calculated by the following formula:

$$\text{Contact angle} = \frac{right\ contact\ angel + left\ contact\ angel}{2} \quad (1)$$

Then the resulting data is described in the form of a graph. The effect of temperature on the contact angle can be determined by plotting the data on the X and Y coordinates using the Microsoft Excel program. The general technique used to plot data on an XY graph is that the independent variable is plotted on the X axis and the dependent variable is plotted on the Y axis.

III. RESULTS AND DISCUSSION

The result of this study is the identification of the contact angle taken from measurements on a thin layer of Silica Manganese/Polystyrene (SiMn/PS) nanocomposite with composition variations of 20%: 80%, 40%: 60%, 50%: 50%, 60%: 40 % and 80%:20% were tested using Image-J software.SiMn/PS

A. Variation in the composition of SiMn 20%:80%

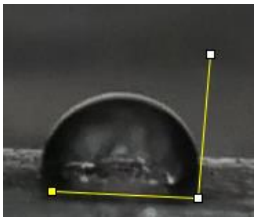

Fig.3. Contact Angle Measurement with 20%:80% SiMn composition variation

Table 1. Result of contact angle measurement with 20%:80% SiMn composition variation

Contact Angel		
Measurement Results		**The Calculation Results**
ΘRight	θLeft	Θ
92.245 º	92.072 º	92.158
92.726 º	91.513 º	92.119
92.984 º	91.441 º	92.212
92.821 º	91.122 º	91.971
92.153 º	91.214 º	91.686
Average		92.029

In the table it can be seen that the composition of the 20%:80% SiMn nanocomposite is already hydrophobic because the resulting angle is >90° with a large angle of 92.029°.

B. Variation in the composition of SiMn 40%:60%

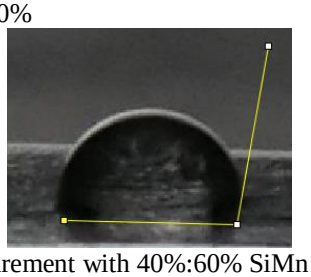

Fig.4. Contact Angle Measurement with 40%:60% SiMn composition variation

Table 2. Result of contact angle measurement with 40%:60% SiMn composition variation

Contact Angel		
Measurement Results		**The Calculation Results**
θRight	θLeft	Θ
97.063 º	97.326 º	97.194
97.634 º	97.474 º	97.554
97.884 º	97.627 º	97.755
97.462 º	97.608 º	97.746
97.379 º	97.235 º	97.307
Average		97.511

In the table it can be seen that the composition of the 40%:60% SiMn nanocomposite is already hydrophobic because the resulting angle is >90° with a large angle of 97.511°.

C. Variation in the composition of SiMn 50%:50%

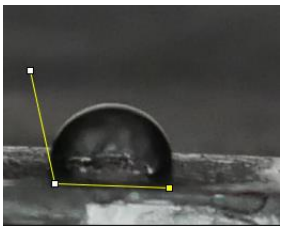

Fig.5. Contact Angle Measurement with 50%:50% SiMn composition variation

Table 3. Result of contact angle measurement with 50%:50% SiMn composition variation

Contact Angel		
Measurement Results		**The Calculation Results**
ΘRight	θLeft	Θ
104.986 º	105.457 º	105.221 º
104.484 º	104.339 º	104.411 º
105.287 º	105.097 º	105.197 º
104.706 º	104.925 º	104.817 º
104.321 º	103.389 º	103.855 º
Average		104.7 º

In the table it can be seen that the composition of the 50%:50% SiMn nanocomposite is already hydrophobic because the resulting angle is >90° with a large angle of 104.7°.

D. Variation in the composition of SiMn 60%:40%

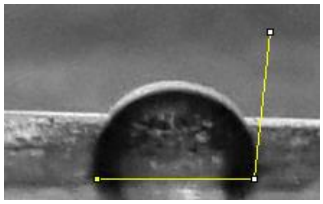

Fig.6. Contact Angle Measurement with 60%:40% SiMn composition variation

Table 4. Result of contact angle measurement with 60%:40% SiMn composition variation

Contact Angel		
Measurement Results		**The Calculation Results**
θ Right	θLeft	Θ
96.459 º	95.811 º	95.635
95.816 º	95.474 º	95.645
96.282 º	94.627 º	95.477
95.711 º	95.608 º	95.659
96.226 º	95.235 º	95.730
Average		95.629

In the table it can be seen that the composition of the 60%:40% SiMn nanocomposite is already hydrophobic because the resulting angle is >90° with a large angle of 95.629°.

E. Variation in the composition of SiMn 80%:20%

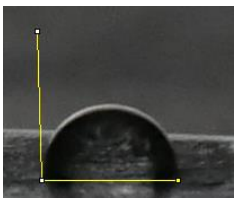

Fig.7. Contact Angle Measurement with 80%:20% SiMn composition variation

Table 5. Result of contact angle measurement with 80%:20% SiMn composition variation

Contact Angel		
Measurement Results		The Calculation Results
θ Right	θLeft	Θ
92.141 º	92.729 º	92.435
92.675 º	91.567 º	92.121
92.102 º	92.775 º	92.438
92.548º	91.546 º	92.047

92.027 º	91.346 º	91.686
	Average	92.146

In the table it can be seen that the composition of the 80%:20% SiMn nanocomposite is already hydrophobic because the resulting angle is >90° with a large angle of 92.146°.

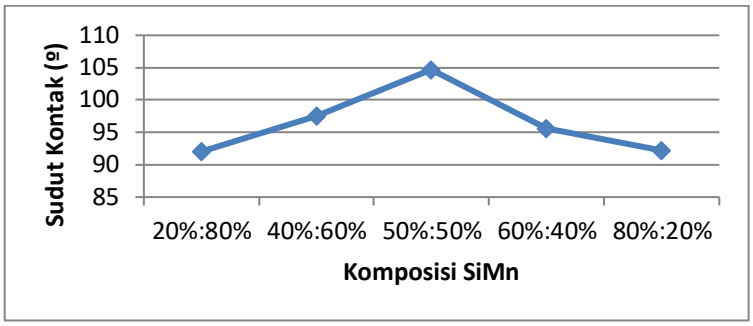

Fig.8. Relationship Between Composition Variation and Contact Angle Measurement

After going through the tests and measurements, it was found that the contact angles were not too different between the five variations of the silica composition, the contact angles had sizes of 92.029°, 97.511°, 104.7°, 95.629°, 92.146° so that it can be said that the composition of silica and manganese nanoparticles in the SiMn nanocomposite /polystyrene affects the magnitude of the contact angle, and the five variations have been successfully made hydrophobic. Where the highest contact angle is found in the 50%:50% SiMn composition, which is 104.7°. And the lowest is in the composition of SiMn 20%:80% with a contact angle of 92.029°

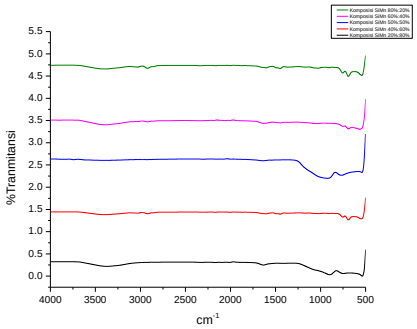

Fig. 9. FTIR measurement result data

From the data above, it shows that the group is in the composition of SiMn 50%:50% and SiMn 40%:60%. In the composition of SiMn 40%: 60% and SiMn 50%: 50% there are several very significant main absorption bands located at wave number 547.49 cm^{-1} indicating the Mn-O bond stretch, the CH functional group at wave numbers 919.50 cm-1, 751.58 cm^{-1} comes from the Si-O stretch with a range of 782 - 805 cm^{-1}

IV. CONCLUSION

Based on the research that has been done, it can be concluded that the SiMn composition affects the contact angle and has shown a hydrophobic layer where the contact angle exceeds 90°. And the highest contact angle is found in the composition of SiMn 50%:50% with a contact angle of 104.7°.

ACKNOWLEDGMENT

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