CHANGE OF TEXTILE WETTABILITY BY TIO_2 PARTICLES

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Abstract
Surface roughness can change the wetting characteristics of solids. In this study is used SOL-GEL method based on hybrid polymers to stabilize TiO_2 nano particles on fiber surfaces. The wettability of structures was estimated by contact angle measurement. This experimental method was used with different TiO_2 particles.
Key words: SOL-GEL, CONTACT ANGEL, HYDROPHOPIC TREATMENT

1. Introduction

The purpose of the contact angle measurement is to study the surface wettability of the textiles materials as it was on the objectives in this work. As it is known from theory that some fibers are more hydrophilic than others, for examples cotton substrates, had the contact angle for original cotton was 0°, because water drops spread instantly when placed on the surface of the substrate. This is due to the cellulose hydroxyl groups of cotton that make cotton super-hydrophilic. But after treatment with sol-TiO_2 and application hydrophobic finish the cotton substrate showed an increasing of contact angle of above 90º as the concentration of the TiO_2 increases. As it known in theory that a surface with a contact angle of 0º to 30º has hydrophilic property whereas a surface with contact angle 90º and more is super-hydrophobic. The application of sol-TiO_2 finish and hydrophobic finish with TiO_2 nanoparticles on the textile material surface show an improvement in surface properties of the textiles making the surface more rough because of the layer on the surface of the material. This improves the wettability properties of the textile material, and thus increases the contact angle of the material. This are the finding observed in this research work, as it is observed from the graphs obtained for comparing the contact angle with this TiO_2 concentration of different textile materials. The overall observations for the contact angle measurement was that TiO_2 nanoparticles have an effect on the surface textile material as applied finishing methods, and that its effect increases the surface wettability of the textile material. The degree of increase depends on the important property of materials that is controlled by the chemical composition and the geometry of the surface.

The result of a contact angle between liquid, air and a solid state surface with the structure of a solid state surface is given by the contact of the liquid with a jagged surface. [1]

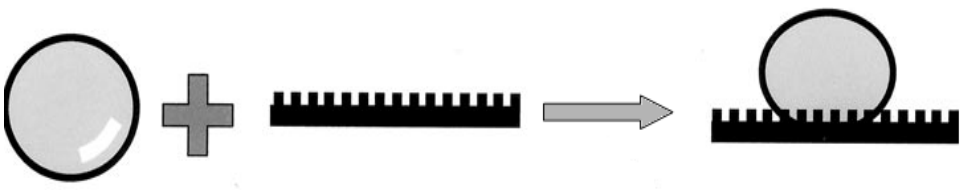

Figure 1. Behavior of a drop of liquid on a jagged surface [1]

2. Experimental part

The main goals of the experimental part was to observe the hydrophobic effect of different TiO_2 powders on textile material when using different treatment methods such as Sol-gel method and the hydrophobic treatment. The TiO_2 powder utilized during the experiment were labeled according to their trade names [091009/1, 181109/2].

Materials used for the experiment were

- glass microfiber
  Areal density was 75g.m^{-2}. Average diameter of fibres is about 1 µm.
- Cotton (30x12 ČSN 80 0101)

2.1 Sol description

Preparation of sol based TMSPM the basis for the preparation of sol was TMSPM ((3 - (trimethoxysilylpropylmethacrylate)

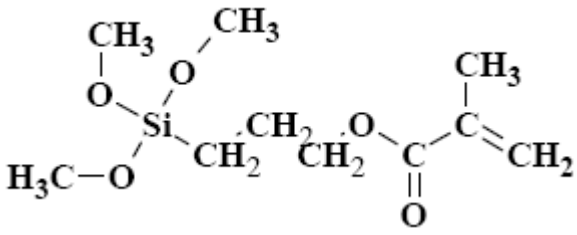

Figure 2. Chemical formula TMSPM

The principle consisted of sol dissolution TMSPM Mid required amount of IPA and the dissolution of other ingredients (water, HCl, BPO) in the second half of the required amount of IPA. Then the two solutions were mixed under vigorous stirring. Resulting sol was heated in boiling under reflux for 30 minutes after which the sol was cooled. Part of the final sol was diluted with IPA in the ratio 1:4. Sol was identified as AC4.

The application conditions of the sol gel with the TiO_2 powder on 100% cotton fabric

- sol gel solution 20ml;
- TiO_2 weights 0.01g, 0.02g, 0.05g and 0.1g;
- Time of sample exposition to the sol gel/TiO_2 powder dispersion 1minute;
- drying at room temperature 20°C for 5 minutes
- The samples were then placed in a 85°C dryer for fixation process for 3 hours

2.3 Hydrophobic Treatment

The hydrophobic solution was prepared for the hydrophobic treatment of textiles. The application was done on 2 different fibres (Cotton, Glass).

Chemicals used for the preparation of the hydrophobic treatment solution

- 30g/l Lukofix T40D
- 20g/l Katalyzator C48
- 10ml/l Acetic acid (CH_3COOH)

Experimental procedure:

- About 30ml of the prepared hydrophobic treatment solution was mixed with different TiO_2 powders at various concentration : 0.1g/l, 0.5g/l, 1g/l, 5g/l, 10g/l, 20g/l
- The mixing of TiO_2 powder was done by the Ultrasound machine under the following settings; AM-30%, time- 2minutes, Energy -3.570KJ

3. Results and discussion

3.1 Contact angle measurement results - the Sol Gel method results

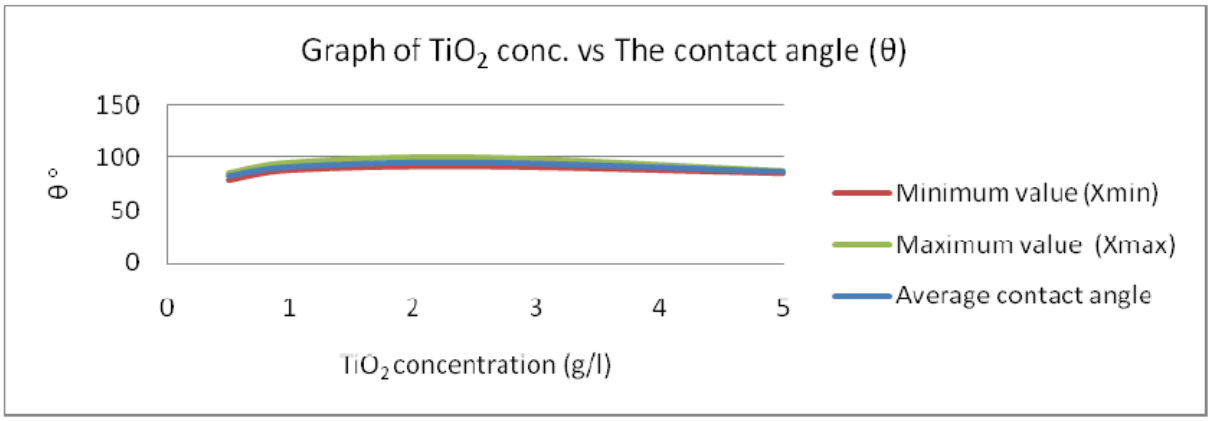

Figure 3. The graph showing the relation between the contact angle with sol-TiO_2 treated cotton surface for TiO_2-091009/1

The surface wettability was assessed by contact measured for sol-TiO_2 cotton treatment, showing the relationship between the sol-TiO_2 concentrations with the contact angle. In figure 3 the 0 concentration of the sol-TiO_2 on the cotton sample was not measurable due to the complete absorption of water by the cotton substrate. The graph distribution above shows the contact angle increasing at the low sol-TiO_2 concentration and decreasing towards the higher concentration.

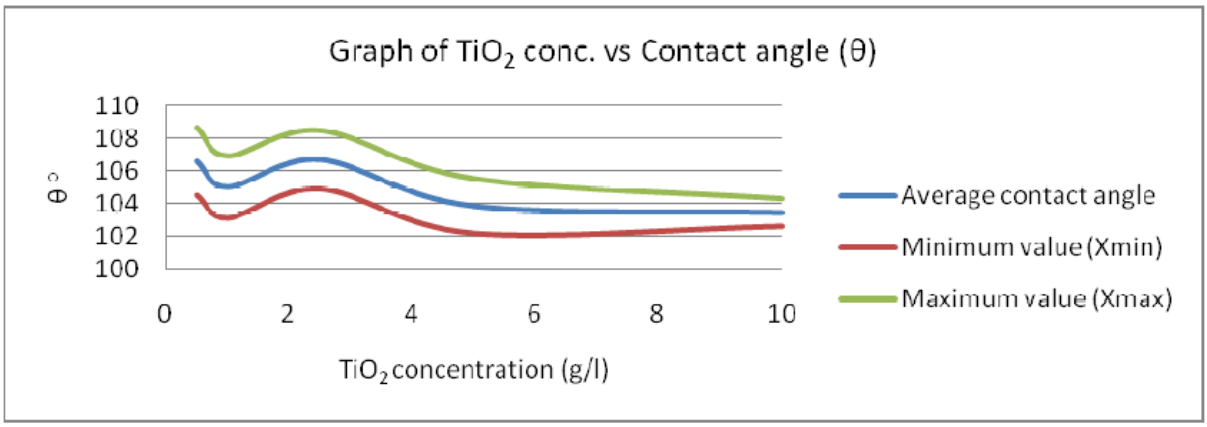

Figure 4. The graph showing the relation between the contact angle with sol-TiO_2 treated cotton surface for TiO_2-181109/2

With the use of TiO_2-181109/2 powder the contact angle distribution with the sol-TiO_2 concentration started with a decrease at 1g/l concentration, then an increase at 2.5g/l concentration and further decline to a constant distribution till high concentration.

3.2 Hydrophobic Treatment Results

Hydrophobic Treatment of Cotton with different TiO_2 powders

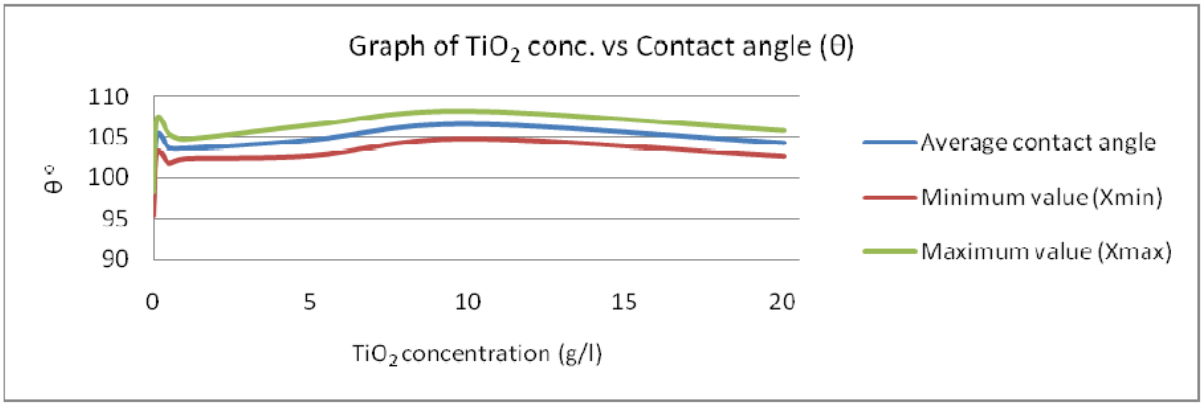

Figure 5. The graph of contact angle with hydrophobic-TiO_2 treated cotton surface for TiO_2-091009/1

The figure above shows the graph distribution of the contact angle,in which the wettability of the cotton surface is assessed on the hydrophobic-TiO_2 treated cotton surface. The TiO_2-091009/1 powder in hydrophobic treatment shows the contact angle increasing from the low TiO_2 concetration and to the maximum increase at 10g/l,then a decrease as the concentration decreases.

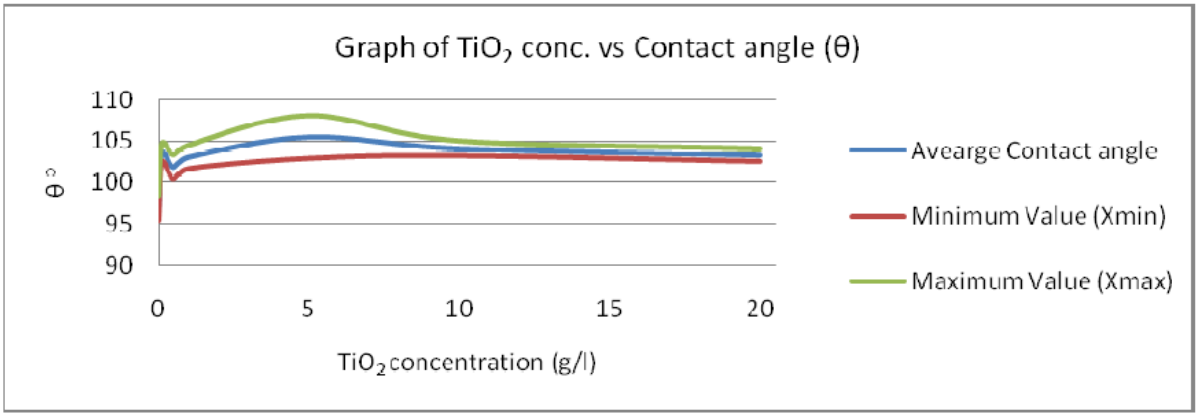

Figure 6. The graph of contact angle with hydrophobic-TiO_2 treated cotton surface for TiO_2 -81109/2

For the distribution in fig.6 the contact angle is showing its maximum distibution at concentration of 5g/l and the decrease to a constant distribution as the concentration increases.That is the contact angle is more or less the same for the concentartion of TiO_2 from 10g/l to 20g/l.

Hydrophobic Treatment of Glass Fibers with different TiO_2 powders

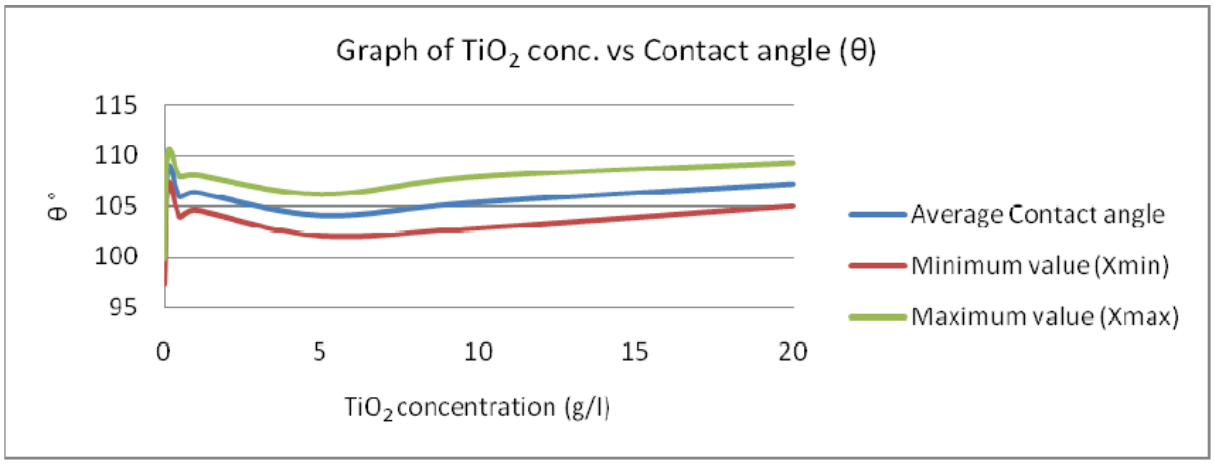

Figure 7. Description of the relation between the Contact angle and TiO_2 concentration for TiO_2-091009/1

In the results above the contact angle is high at 0.1g/l concentration and then decreases at 5g/l concentration. As it moves further to the increasing concentration the contact angle is constant.

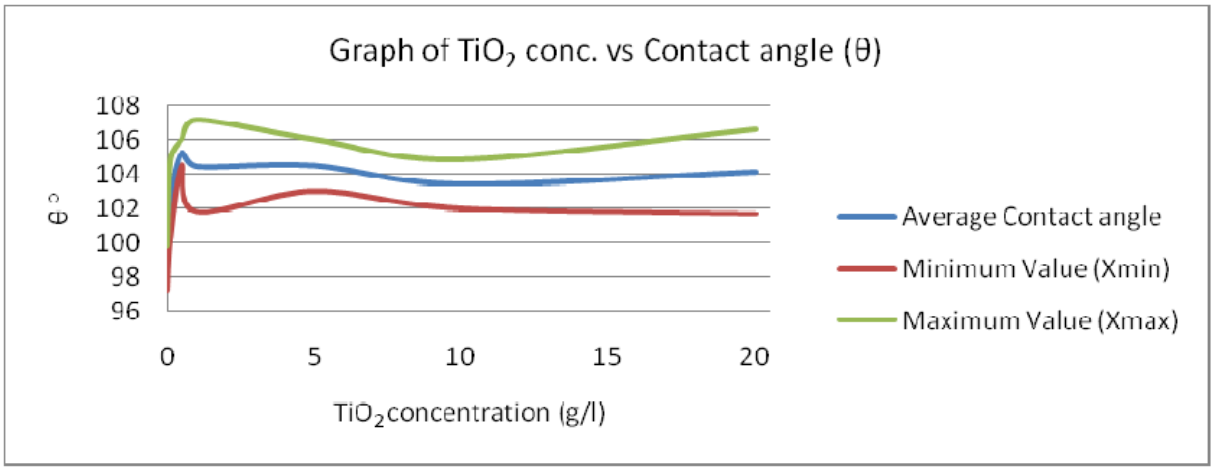

Figure 8. Description of the relation between the Contact angle and TiO2 concentration for TiO_2-81109/2

The finishing treatment by the use of the TiO_2 -81109/2 the highest contact angle value at concentration 1g/l and the a decrease towards concentration 5g/l.and then a little bit of an increase but still less that at concentration 1g/l.

4. Conclusion

Super hydrophobic textile materials have been successfully prepared. The incorporation of TiO_2 particles by Titania sol finishing can not only cause a dual-size surface roughnessfor enhancing the hydrophobicity. All graphs for contact angle measurement show an increasing in contact angle from the lower concentration of TiO_2 to higher concentration.

5. References

1. Wiener J., Dembický J., *Wetting of anisotropic surfaces*, **Fibres and Textiles**,4, 2005, 167

ACKNOWLEDGMENT

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