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► **To cite this version:**

Florence Biguenet, Safi Melki, Dominique Dupuis. On the Relevance to Test the Robustness of Textile Hydrophobic Properties. The Fiber Society 2016 Spring Conference Textile Innovations–Opportunities and Challenges, May 2016, Mulhouse, France. hal-03011065

HAL Id: hal-03011065

<https://hal.science/hal-03011065v1>

Submitted on 17 Nov 2020

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On the Relevance to Test the Robustness of Textile Hydrophobic Properties

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OBJECTIVE

Controlling wetting behavior has recently attracted a great attention due to the wide applications in technologies (medical, printing, cleaning processes...). This study examines the influence of textile structures on the hydrophobicity but also on the robustness of this property. A laboratory test method to evaluate this robustness is proposed.

INTRODUCTION

Wetting properties depend on a combination of surface chemistry and surface roughness. Many studies have been performed on the effects of model textured surfaces on the hydrophobicity [1][2][3]. Fewer have explored the wetting behavior of surfaces with non-perfect pattern structures as textile surfaces [4]. Such surfaces combine different roughness scale levels related to the yarns, the fibers and sometimes to nanofibers or nanoparticles grafted on the primary structure [5]. Additionally, the different elements constituting a fabric are highly deformable.

The main characteristic of the wetting properties of non planar surfaces is the apparent contact angle. Another important characteristic is the contact angle hysteresis which is the difference between the advancing and the receding contact angle. This hysteresis is related to the pinning of the drop when the solid surface is tilted. It is proportional to the force required to start a drop moving on a surface. The present discussion focuses on the necessity to introduce another characteristic parameter to express the robustness of the hydrophobic property of rough surfaces and especially here textile surfaces.

Some hydrophobic fibrous structures were prepared to prospect for the influence of textile structures on the natural and forced wetting properties.

APPROACH

All samples were submitted to the same sizing treatment in order to obtain hydrophobic surfaces. Two main classes of fabrics are considered: classical fabrics and flocked ones.

For the classical fabrics, different arrangement of the yarns and different geometries of the yarns are considered. The warp is made of cotton yarns. The weft is made of cotton, cotton/PET blend or PET yarns. PET yarns are continuous multifilament yarns while cotton and cotton/PET yarns are made of staple fibers which induces some pilosity. In order to modify the roughness at the yarn scale, two different

weaves have been chosen: satin weave (SW) and plain weave (PW).

Flocked textiles are composed of a cotton substrate (canvas fabric) on which the viscose hairs of various diameters and lengths are stuck.

To measure the robustness of the hydrophobic property, a laboratory tester has been designed and produced. It allows measuring the contact angle of a water droplet before and after compression on the surface.

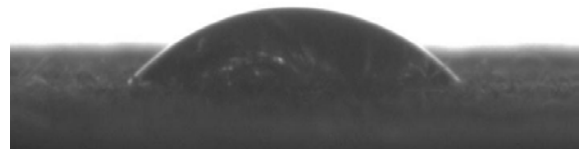
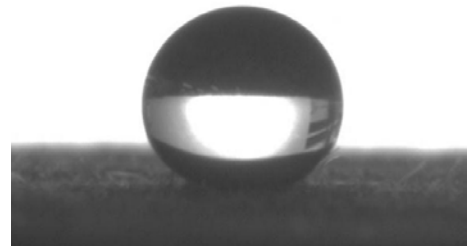


Fig. 1: Example of a drop before and after compression

RESULTS AND DISCUSSION

The classical fabrics are characterized by several scales of roughness corresponding respectively to the crosslinks of the yarns (weaving), the yarn structure and the fibers geometry. Our woven samples, exhibiting approximately the same natural contact angle (125° to 130°), show significant different forced wetting behavior. The fibers geometry and the weaving structure seems to complementary influence the contact angle hysteresis and the robustness of the hydrophobic property. The sateen weave clearly displays the influence of the type of weft yarn on the hysteresis and the robustness of the hydrophobic property. Indeed, the contact area of the liquid drop with these yarns is more important than in the case of plain weave.

The pile fabrics are characterized by a greater contact angle (142° to 147°) and ability for the drop to roll on it.

Nevertheless, when an external pressure is applied to the drop, the pile samples lose their hydrophobicity with contact angles being able to decrease up to 50°. The drop is, at rest, in a Cassie state and undergoes a wetting transition to the Wenzel state after compression. But the problem is more complicated than for model surfaces since the hairs are deformable and bend during the compression which significantly modifies the initial structure. As observed for the woven samples, the pile samples, of approximately the same static wetting properties, appear to resist differently to compression.

CONCLUSION

The measure of the static wetting properties (natural contact angle, hysteresis, roll-off angle) is not sufficient to characterize the wetting dynamic behavior of a textile surface. Such measurements have to be completed by a study on the influence of an external stress. Here, a laboratory test method is proposed to evaluate the robustness of hydrophobicity. This property can be characterized by the smaller pressure required to induce the lost of hydrophobicity.

KEYWORDS

Contact Angle, Hydrophobicity, Contact Angle Hysteresis, Forced Wetting, Wetting Transition.

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