Dynamic Hydrophobicity of Silicone Resin/VGCF Composite Sheet with Ultrasonic Vibration

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1. Introduction

Lotus leaf has fine irregularities on the surface. The lotus leaf has unique property of holding water on its surface without penetrating inside the leaf. This phenomenon is technically termed Lotus Effect or super-hydrophobicity. If the solid surface has high water repellency as a lotus leaf, then the water drops adhering to the solid surface are going to slip in a small angle. Super-hydrophobic surfaces are used not only for resisting water and fog condensation, but also for preventing contamination. At present, Water repellent material like a lotus leaf have been used in various fields such as building materials, transport equipment, to the fiber surface treatment and components in electronics devices. There is needed to develop various devices with super-hydrophobic surface.

For example, water drops adhering to the solid surface are slipped by adding a water repellent on the body of the car. At the same time, water drops do the adsorption of the dust that adhering on the body surface. The water drops roll away and prevents dirt. Furthermore, by adding a water repellent to the electronic device such as mobile phones, it will prevent water drops enter to the device.

Super-hydrophobic surface can be produced using various methods such as sol-gel processing and chemical vapor deposition method[1,2]. By these methods, it is difficult to produce hydrophobic surface in large-scale at low cost. And several studies on super-hydrophobic sheets by micro imprint methods were reported[3,4]. But even if adding a water repellent to the solid surface, the water drops do not slip when water repellency is weak or solid surface is slight slope. In practice, it is required that water drops can slip on the solid surface. And there are reports proved that the water drops become slippery by adding a vibration about 100Hz to the lotus leaf[5]. If it is add more frequency vibrations to the solid surface, the effect of the water slip become larger in a short time. However, there are no reports proved that if adding ultrasonic vibration frequency of 20 kHz or more, it going to improve the water slip.

In this paper we report a study on super-hydrophobic surface by ultrasonic vibration. This research purpose is improving the water slip by adding ultrasonic vibration to the solid surface. First silicone sheet was prepared. This experiment was conducted by provide following conditions for the water drops on the sheet surface to investigate what are these conditions affect water slip.

1) Change in the carbon nanotube composite amount
2) Change in the tilting angle of the sheet surface

2. Experiment

The Vapor grown carbon fibers (VGCFs)[6,7] were obtained from Showa Denko K.K Japan Company with diameters of 150 nm and lengths of 10–20 μm with highly crystalline carbon fiber synthesized by the gas-phase method. The silicone resin (Shin-Etsu silicone KE-111 grade) used in this work and supplied by Shin-Etsu Chemical Co., Ltd. respectively.

The silicone /VGCF composite sheets were produced by following processes:

1) A thermosetting silicone resin is selected as matrix material for plastic sheets.

2) VGCF 1wt% provide a good mechanical reinforcement potential to the plastic sheets[8,9].

3) The jig has vibrated sympathetically (Fig. 1).

4) The frequency of the vibration is 28 kHz.

5) The effect of ultra-sonic vibration on dynamic hydrophobicity is measured in droplet tests used contact angle and surface tension instruments (first ten angstromes).

3. Results and discussions

According to the droplet tests, tilting angles of water flowing on the silicone /VGCF sheet with and without ultra-sonic vibration were observed (Fig. 2). The tilting angle which water started flowing on the silicone sheets with ultra-sonic vibration (right figure) was about 10° and without vibration (left figure) was about 20°.

The moving distance of water droplet on the surfaces of the Silicone/VGCF sheets are shown by Fig. 3. The open circles shows the moving distance of water droplet on Silicone sheet and the filled circles shows the moving distance of water droplet on Silicone/VGCF sheets.

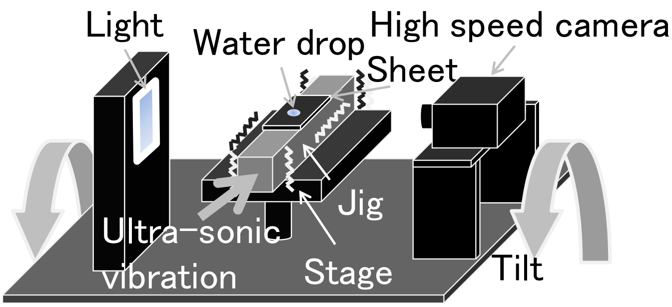

Figure 1 Apparatus of water droplet test with ultra-sonic vibration.

The gray Xs and the black Xs show the moving distance of water droplet on Silicone sheet and Silicone/VGCF sheets with ultra-sonic vibration. The moving distance was increased for VGCF composite and for ultra-sonic vibration. The moving distance of water droplet on the surfaces of the Silicone/VGCF sheets are shown by Fig. 4. The gray circles, the filled circles and the open circles show the moving distance of water droplet on 5°, 15°, 45° tilting Silicone sheet respectively. The gray Xs, the black Xs and the white Xs show the moving distance of water droplet on 5°, 15°, 45° tilting Silicone sheet with ultra-sonic vibration respectively. The moving distance was increased for tilting angles and for ultra-sonic vibration. The Silicone/VGCF sheets with ultra-sonic vibration had improved hydrophobic surface. It is because that surface energy is changed by ultra-sonic vibration.

4. Conclusions

In this study, a process was developed for making super hydrophobic surfaces using ultrasonic vibration. According to experimental results, it was found out by using ultrasonic vibration, increase inclination angle and the composite of the CNT can improve the water slip.

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6. References

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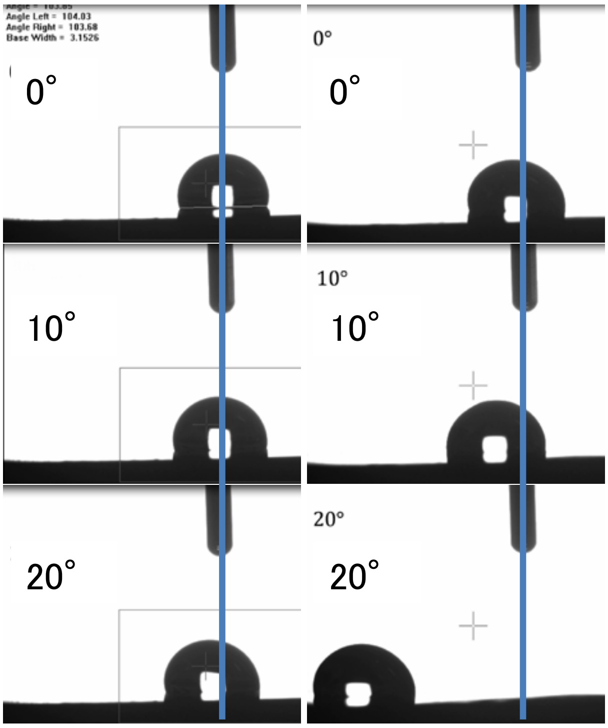

Figure 2 Waterdrop flow behavior, on silicone sheet surface without vibration (left figure) and with ultra-sonic vibration (right figure).

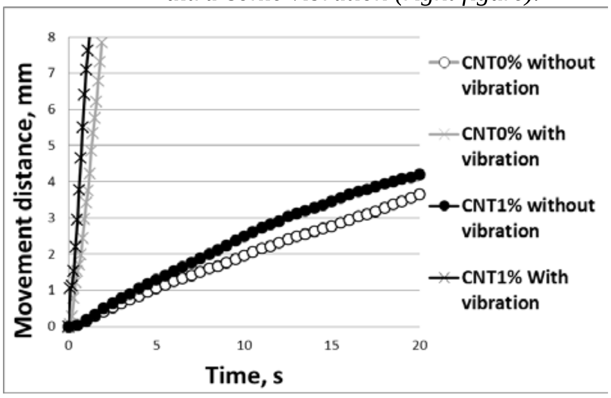

Figure 3 Moving distance of water droplet on silicone /VGCF sheet surface without vibration and with ultra-sonic vibration.

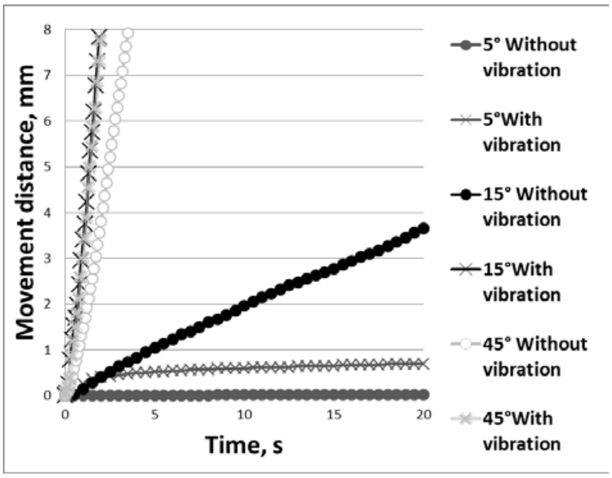

Figure 4 Moving distance of water droplet on silicone /VGCF sheet surface by several tilting angles.