SUPERHYDROPHOBIC AND OIL-REPELLENT SURFACES WITH NANOTECHNOLOGY

M. M. M. G. P. G. Mantilaka

Board of studies in Chemical Sciences

Products with oil-repellent (oleophobic) and water-repellant (hydrophobic) surfaces have become very attractive and popular in recent years. Therefore, many industrialists and researchers are working on fabrication and manufacture of products with hydrophobic and oleophobic surface finishes. Some of these products are papers [1], electronic devices including hard disks [2], optical devices [3], pipelines [4], glass products [5] and various textiles [5-7]. These surfaces are resistant to stain because dirt particles are usually dispersed or dissolved in liquids and the surfaces repel the liquid. As a result, dirt particles cannot be attached to the surfaces. Therefore, the products containing hydrophobic and oleophobic surfaces are always clean. Surfaces with extreme hydrophobicity are known as superhydrophobic surfaces. The concept of superhydrophobicity is taken from natural water-repellency of lotus leaf and hence, it is known as lotus effect.

The contact angle between the hydrophobic surface and the water drop on the surface is measured in order to determine the hydrophobicity of materials. The water-contact angle for hydrophobic materials must be over 90° and for super-hydrophobic materials, the water-contact angle should be greater than 150° [8]. The relationship between contact angle (θ) and forces acting on water drop is given in Equation 1 [9]. The parameters described in Equation 1 are graphically shown in Fig. 1.

$$Y_{SG} = Y_{SL} + Y_{LG} \cos\theta \quad \ldots(1)$$

Where, γ_{SG} = interfacial tension between the solid and gas; γ_{SL} = interfacial tension between the solid, liquid; γ_{LG} = interfacial tension between the liquid and gas

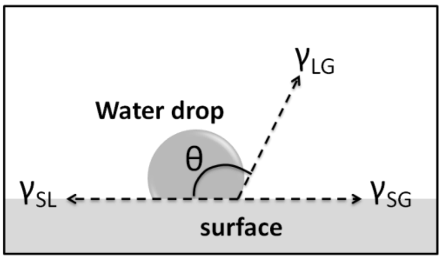

Figure 1: The relationship between each parameter given by Equation 1

The surface free energy of the substrate should be lower than the surface tension of the water in order to introduce hydrophobicity to the substrate. Pure water has a high surface tension about 72 mN/m. Therefore, surface free energy of the surface must be lowered to 24-30 mN/m for the fabrication of hydrophobic surface. In the case of oleophobicity, the surface free energy of the substrate should be lower than 20 mN/m since the surface tension of oils is usually 20-30 mN/m [10]. Surfaces with both oleophobic and superhydrophobic properties are more important [10, 11]. Therefore, nano-architectured surface coatings with low surface free energies are fabricated on surfaces in order to prepare superhydrophobic and oleophobic surface finishes. Some of commonly used coating materials are fatty acids, polyhedral oligomeric silsesquioxane (POSS), polysiloxanes with various functional groups and fluorochemical repellents [3]. An example for nano-architecture surface is shown in Fig. 2. Herein, inorganic nanorods such as zinc oxide and titanium dioxide have been grown on the surface of the product and then, above mentioned liquid repellent molecules have been allowed to self-assemble on nanorods. The intermediate inorganic material of nanorods should have an ability to bind with both surface of product and the liquid repellent molecules. Therefore, nano-architectured superhydrophobic and oleophobic surfaces will cause a significant impact on industrial and economic development.

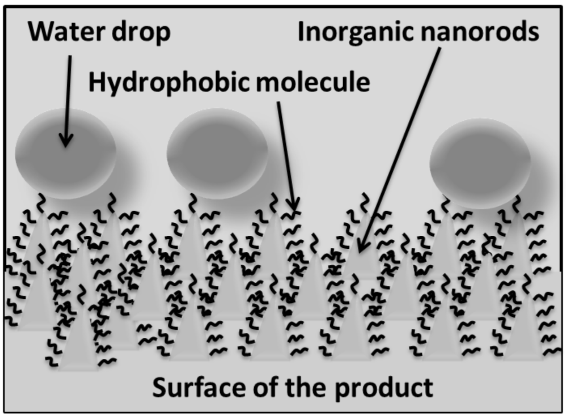

Figure 2: Example nano-architecture of superhydrophobic surface

References

1. Fukuda, S., Chaussy, D., Belgacem, M.N., *Appl. Surf. Sci.* 2013, *277*, 57– 66.
2. Yoshimura, Y., Aono, T., Ikeda, Y., Endou, Y., Tokisue, H., Kouno, A., *Surf. Coat. Technol.* 2001, *141*, 202-7.
3. Kessman, A.J., Huckaby, D.K.P., Snyder, C.R., Kukurek, S.N., Cairns, D.R., *Wear* 2009, *267*, 614–18.
4. Guo, Y. Li, W., Zhu, L., Wang, Z., Liu, H., *Appl. Surf. Sci.* 2012, *259*, 356–61.
5. Cˇ erne, L., Simoncˇicˇ, B., Zˇ eljko, M., *Appl. Surf. Sci.* 2008, *254*, 6467–77.
6. Artus, G.R.J., Zimmermann, J., Reifler, F.A., Brewer, S.A., Seeger, S., *Appl. Surf. Sci.* 2012, *258*, 3835–40.
7. Zhou, X., Zhang, Z., Xu, X., Men, X., Zhu, X., *Appl. Surf. Sci.*, 2013, *276*, 571–7.
8. Ding, B., Ogawa, T., Kim, J., Fujimoto, K., Shiratori, S. *Thin Solid Films* 2008, *516*, 2495–501.
9. Young, T. *Phil. Trans. R. Soc. Lond.* 1805, *95*, 65–87.
10. Gao, Y., He, C., Huang, Y., Qing, F.L., *Polymer* 2010, *51*, 5997-6004.
11. Huang, J.Q., Meng, W.D., Qing, F.L., J. Fluorine Chem. 2007, *128*, 1469–77.