How Windshields Can Be Made Superhydrophobic to Improve Driver Visibility During Rainy Weather

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For decades, the scientific community has been fascinated by the 'self-cleaning' effect, a phenomenon in which water droplets roll easily off a surface. This effect arises due to a property of the surface called superhydrophobicity and is related to the water droplets having a surface contact angle of over 140°. It depends largely on the surface having a rough structure, since the contact angle depends mostly on the fraction of the droplet that is actually touching the solid (Bico and others 1999). A lower area of contact between the droplet and surface means a lower amount of attraction between the two, contributing greatly to this 'self-cleaning' effect.

Creating a superhydrophobic windshield is more complex than simply manufacturing superhydrophobic glass. Superhydrophobic materials would not normally be feasible for use as windows, because such rough surfaces "often suffer from strong scattering or diffraction effects" (Chang and others 2007). This property would decrease the amount of visible light entering the car and make it difficult for drivers to see, especially at night. To make a functional superhydrophobic window, one would have to integrate both superhydrophobic and anti-reflective properties.

One successful method of combining these properties was developed by Bravo and colleagues (2007). Their approach involves depositing three main multi-layered blocks on a glass substrate, through immersion of this substrate in different aqueous solutions. These blocks essentially comprise many bilayers of the polymer poly(allylamine hydrochloride) (PAH) and 20 nanometer (nm) and 50 nm silica nanoparticles, with the bottom five bilayers containing poly(sodium 4-styrenesulfonate) (SPS) to form an adhesive layer. The films are then calcinated and imbued with trichloro(1H,1H,2H,2H-perfluorooctyl) silane by chemical vapour deposition. The top three bilayers of the film contain only smaller silica nanoparticles (20 nm), and are essential in obtaining a low contact angle hysteresis, allowing water droplets to slide freely with minimal surface tilt. Calcination of the film improves its adhesion to glass and decreases its thickness, refractive index, and roughness.

In the experiment conducted by Bravo and his colleagues (2007), around 90% optical transmission was achieved in the visible spectrum. At certain wavelengths, the film even enhanced transmission for the glass substrate, due to the low refractive index of the body layer. Interestingly, this low refractive index is a result of the nanoporous nature of the film, which causes the film to exhibit superhydrophilic qualities prior to treatment with semifluorosilane.

This technique is of enormous value to any glass manufacturing company, especially those whose glass would be exposed to rainfall such as makers of vehicle windshields. In a study of driver performance under simulated rain conditions conducted by the University of Michigan, a hydrophobic windshield coating decreased average driver response time by more than one second and improved visual acuity during night time conditions to nearly that of daytime rain conditions with the untreated glass (Sayer 1997). This suggests that the widespread use of superhydrophobic windshields has the potential to significantly reduce car crash frequency, since visual acuity and response time are such significant factors in these accidents.

Innovations in nanoscience such as the development of superhydrophobic glass will forward the cause of nanotechnology in society. "People tend to react to nanotechnology according to their value systems" (Hornyak and others 2008) and safety is always a concern among the public.

References

Chang YC, Mei GH, Chang TW, Wang TJ, Lin DZ, Lee CK. 2007. Design and Fabrication of a Nanostructured Surface Combining Antireflective and Enhanced-Hydrophobic Effects. *Nanotechnology* [serial online]; 18(28):1-5. Available: http://www.iop.org/EJ/toc/0957-4484/18/28 via the INTERNET. Accessed 2008 Nov 17.

Bico J, Marzolin C, Quéré D. 1999. Pearl drops. *Europhys*

Lett [serial online]; 47(2):220-226. Available: http:/www.iop.org/EJ/abstract/-link=8486861/0295-5075/47/2/220 via the INTERNET. Accessed 2008 Nov 17.

Bravo J, Zhai L, Wu Z, Cohen RE, Rubner MF. 2007. Transparent Superhydrophobic Films Based on Silica Nanoparticles. *Langmuir* [serial online]; 23(13):7293-7298. Available: http://pubs.acs.org/doi/full/10.1021/la070159q via the INTERNET. Accessed 2008 Nov 17.

Sayer JR, Mefford ML, Flannagan MJ, Sivak M, and Kojima S. 1997. *The Influence of Hydrophobic Windshield Coating on Driver Visual Performance. Technical Report No. UMTRI-97-31* [monograph online]. Ann Arbour, MI: University of Michigan Transportation Research Institute. Available: http://hdl.handle.net/2027.42/49362 via the INTERNET. Accessed 2008 Nov 17.

Hornyak GL, Dutta J, Tibbals HF, Rao AK. 2008. *Introduction to Nanoscience*. Boca Raton: CRC Press.