Lotus Effect

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Lotus leaf (\textit{Nelumbo nucifera}) has become the epitome of natural superhydrophobic surfaces and has long been considered as a sacred symbol of purity for thousand years in oriental culture due to its impressive self-cleaning feature, where leaves remain unsmudged even being immersed into muddy water. Water contact angle on lotus leaf is reported above 160° with few degrees of roll-off angle. Therefore, \textit{lotus effect} is sometimes a synonym for superhydrophobicity or self-cleaning nowadays. Although the effect has long been noticed for several generations, a systematically detailed investigation was not carried out until 1997 where more than 200 water-repellent plants were studied via scanning electron microscopy (Neinhuis and Barthlott 1997). The study reveals the secret of lotus leaf, which, not surprisingly, attributes to its combination of surface roughness and chemical substances. Hydrophobicity and self-cleaning of lotus leaf are believed as a mechanism to resist harmful microorganism bounding to the leaf surface, since water is usually required for the germination.

The lotus leaf is covered by small protrusions (Fig. 1a) called papillae with their average diameter and height about 10 µm. The papillae are further covered by an additional layer of epicuticular waxes, generated from epidermal cells (Fig. 1b). These wax crystals are presented in submicron size and in crystalline tubules with water contact angles of about 95–110°, which is considered hydrophobic. The epicuticular waxes play a practically important role as they are not only to provide hydrophobicity but to generate an additional roughness in a smaller length of scale other than micron-sized bumps. The absence of wax crystals, i.e., dropping hot water onto the leaf, will totally eliminate the superhydrophobicity (Liu et al. 2009). The kind of hierarchical roughness on superhydrophobic surfaces seems to play a crucial role, but the detailed mechanism is not yet completely clear. A general benefit suggested is to repel both macro- and microscope water droplets (Nosonovsky and Bhushan 2007). Surfaces with only one scale of roughness repelled macroscopic droplets fairly well, while the condensation may easily form microscopic droplets between the grooves of the surface structure.

Cross-References

- Young Equation
Lotus Effect, Fig. 1  SEM micrographs of lotus leaf showing its relatively rough surface covered by small micron-sized protrusions (a) and submicron-sized wax crystals (b) (Hsu 2010)

References
