Superamphiphobic Surfaces by Using Biomimetic Catechol Containing Fluorinated Polymer and Halloysite Clay Nanotubes

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Accumulation of ice on material surfaces is a widespread problem that causes high costs and safety accidents. For example, icing can adversely affect aircraft, ships, cars, electric cables, and wind turbines. The deposition of ice on surfaces leads to higher energy consumption and lower energy output. For wind turbines, cold climates often provide the best wind resource, but ice on turbines can reduce electricity production by up to 20%. Ice buildup can also cause unbalanced spinning of the rotor, leading to mechanical failure. Anti-icing fluids are usually applied to aircrafts to protect against freezing precipitation. However, the coating material must be regularly renewed due to the short holdover time, thus is not suitable for permanent use. Superhydrophobic surfaces provide another promising solution to the challenge of ice formation, because water droplets easily slide off the surfaces before they freeze. While contaminated water could possibly adhere to superhydrophobic surfaces, since surface tension of water generally changes upon contamination, e.g., acid rain. To overcome this problem, superamphiphobic surfaces, which are applicable for liquids over a wide range of surface tension, are preferred.

Compared with superhydrophobic surfaces, the fabrication of superamphiphobic surfaces remains a great challenge. This is because low surface tension liquids, such as various oils, tend to easily wet and spread on most solid surfaces rather than ball up. Successful attempts to prepare superamphiphobic surfaces include introducing several special microstructures, such as nanofilaments, nanowire forests, flowerlike clusters, overhang structures, and re-entrant surface curvatures. Although promising excellent amphiphobic performance, the fabrication of those structures is usually limited to particular substrates, thus essentially offering very little in the way of real utility.

Herein, we report a superamphiphobic surface based on halloysite nanotube (HNT), which is a naturally occurring clay type. Owing to the needle like morphology of individual HNT, the agglomerates can form pincushion structure with connected air pockets. Therefore, HNT can be potentially used for the fabrication of superamphiphobic coatings. Inspired by the high sticking ability of mussel adhesive proteins, a copolymer of 2-(perfluorooctyl)ethylacrylate and dopamine acrylate was synthesized through radical polymerization to modify HNT surface. Upon dropping on a substrate, the surface modified HNTs form a micro/nano hierarchical structure and show an excellent superamphiphobicity with good mechanical durability.