Atomic Engineering on Water Wetting: Life-Like Superhydrophobicity and Temperature Control

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Surface wetting is one of the most significant natural processes on Earth, for the support of terrestrial life. It is also a highly influential material characteristic of many modern engineering designs. It was generally believed that macroscopic wetting phenomena were insensitive to the atomic scale features of the surface. With this project, we demonstrate, via a novel nanoparticle composite material,that wetting properties can be drastically tuned by atomic scale structural changes, leading to anomalous wetting behaviors. We propose a new mechanism, based on “molecular self-supply,” to achieve superb wetting properties and have thus designed a graphene-based multi-layered composite material with superhydrophobic behaviors. Mimicking the "Lotus Effect" in a new way, this new matarial not only allows superhydrophilicity and superhydrophobicity to be electrically reversed instantaneously, but this material also enables biomimetic possibilities such as self-repairing and sustained body-temperature control via water evaporation controlled by bias voltage modulation. Using this method, the evaporation rate of a single water droplet can be enhanced up to 50% more than its natural state, thereby allowing for sharp temperature changes, as significant as10-30% from ambient temperature. This novel technology offers a wide array of superlatives to various industries, including low costs ($0.01/cm2), biocompatibility, low maintenance due to self-repair, and low profile. This innovative concept will lead to numerous commercial applications in self-cleaning windows/walls, and other surfaces which require precise temperature maintenance such as artificial skin for robotics, sensors/ detectors in natural environments, aerospace equipment, and a multitude of other industries.