Tailormade Surfaces for the Generation of Novel Bioinspired Materials

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For the often astounding properties of biological systems, which allow living organisms to survive under frequently quite hostile conditions, it is essential for such biosystems to control their interactions with the contacting environments. For example the surfaces of leaves must be freed from water droplets or dust to avoid damage by the sun or to mitigate soiling. Bones that slide against each other in natural joints must exhibit low frictional properties to reduce wear or the bodies of animals must be protected against hypothermia when exposed to cold water. However, the toolbox with which nature controls such interactions, for example with the aim adjusting the adhesion of two materials, reducing or increasing the friction of two objects sliding against each other and controlling the wetting of surfaces by contacting liquids is quite limited. While the generation of artificial, strongly water repellent materials is usually based on fluorinated compounds, biosystems do not have complex factories to generate such fluorinated organic compounds and polymers, but they must rely on the use of simple waxes and liquids, i.e. compounds having long alkyl chains, for example to induce low water roll-off angles. The spectacular wetting properties, as observed, for example, at the well know superhydrophobic properties of lotus leaves, are not the result from the use of an extremely water-repellent surface chemistry, but from a sophisticated combination of surface chemistry and surface topography.

In our presentation we describe how inspiration from such biological systems is used to generate novel metamaterials, i.e. materials where the properties are achieved through a combination of surface chemistry and topography. To obtain such combinations, we describe the development of novel chemical tools based on C,H insertion reactions that enable the attachment of tailor-made polymer molecules to surfaces with complex topographies and combine the generation of micro- and nanostructures with such surface chemistries. As examples for applications of such bioinspired systems we will discuss processes to generate hairy surfaces or materials systems designed to mimic artificial cilia or the surfaces of a Stenocara beetle. It also describes how systems containing fragile nanostructures can draw inspiration from snakes or lizards to create objects where superhydrophobic properties can be restored after strong mechanical damage.