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Hydrophobic surfaces found in nature

Serhat Akinci*[1], Filiz Karaömerlioğlu[1,2]

[1]*Mersin University, Nanotechnology and Advanced Materials, Türkiye, serhatakinci1903@gmail.com*
[2]*Mersin University, Engineering Faculty, Electrical Electronics Engineering, Türkiye, filizkrm@mersin.edu.tr*

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Abstract

With the 21st century technology, we have more knowledge about the structures found in nature. With technological developments, we discover many structures and features that are already presents in our nature and that we have not been able to explore in such detail before. With more powerful microscopes and studies, nano-scale engineering and nanotechnology studies are gaining momentum. Hydrophobia, which is one of these nanotechnological studies, has emerged by examining the structures found in nature on a smaller scale. This type of structure, which is found in the leaves of some flower species, on the feet of some insect species and even on the wings of butterflies, attracts a lot of attention. The structures and methods designed and inspired by these types will contribute to the solution of problems in many sectors and fields. The number of studies in the field of nanotechnology, which is seen as the technology of the future, is increasing day by day. With the new studies and the accumulated literature knowledge, hydrophobia studies are getting more and more exciting every day.

Introduction

With today's technological developments, our awareness of nature and structures in nature is increasing. With more sensitive microscopes and technological devices, these structures are better understood and their properties are determined more clearly. These discovered features aim to meet unlimited needs with limited resources and to find more environmentally friendly engineering solutions. Nanotechnology, which has opened the door to many studies by being named in our recent history, with the control of shape and size at the nanoscale; deals with the design, characterization, manufacture and development of structures, tools and systems.

Nanotechnology is the development of functional materials, devices and systems for the purpose of understanding and controlling physical, chemical and biological phenomena at the nanometer scale; In general terms, it is defined as the processing, creation and manipulation of various tools, materials and structures at the molecular level. Superhydrophobicity, which is one of the nanotechnological studies, is the subject of many studies today.

Material and Method

Hydrophobic and Hydrophilic Surfaces

In Greek, “hydro” means “water”, “phobos” means “fear” and “philia” means “friendship”. In this context, hydrophobic; avoid of water (repels water); On the other hand, hydrophilic means friends with water (holding water). Superhydrophobic and superhydrophilic mean that it does not hold water and retains a lot of water. These surfaces are named according to the contact angle they make with water. These angle values determine how much water it holds or how much it pushes [1].

Natural Hydrophobic Surfaces

One of the best-known examples we can give from nature to superhydrophobic surfaces is the lotus flower (Fig. 1.). The leaves of the lotus flower are always clean and free of dust. These leaves are covered with small nodules 5-10 micrometers in diameter, located 10-15 micrometers apart. The water on these surfaces in nature forms small beads with a high contact angle of more than 150° and when the surfaces are tilted slightly, they quickly roll away, removing dust-like contaminant. This interesting event spurred extensive research to make artificial superhydrophobic surfaces and use them for a variety of applications [2]. In addition to these, the entire surface is covered with a hydrophobic layer with a diameter of 1 nanometer. This rough structure on the surface is called the "Lotus Effect". When water droplets come into contact with the leaf surface, they form a contact angle of close to 170 degrees due to both the hydrophobic coating and the surface roughness [3].

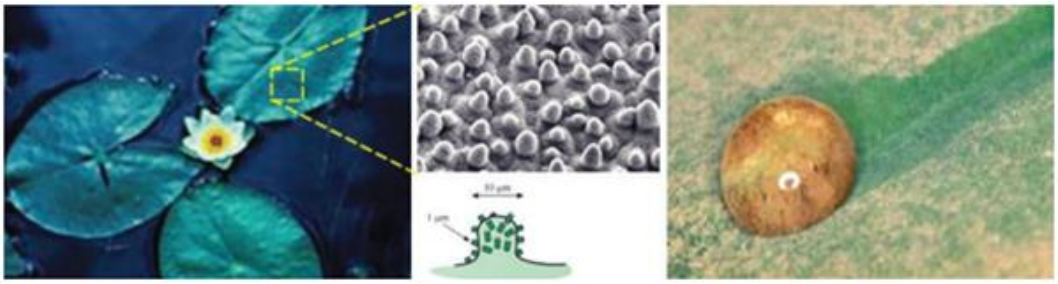

Figure 1. Lotus flower leaf [1]

Superhydrophobic surfaces are also present in many poultry. The wing structure of the Morpho Aega butterfly is superhydrophobic and has the ability to easily clean itself in aqueous environments [4]. The wings of some butterflies, on the other hand, have nanostructures that repel water, as well as nanophotonic lattices that reflect or scatter light falling on them. Thanks to these regular weaves (nanophotonic crystal), the butterfly's wing looks colorful [1].

Figure 2. Gerridae: Ptilomera tigrine [5]

Insects in the family called Water Runners (Gerridae) can move by holding on to the water surface thanks to their water-repellent leg structures [5, 7]. The desert beetle, called "Stenocara gracilipes", absorbs the water it needs thanks to its back tissue, which consists of hydrophobic and wax-free hydrophilic regions covered with wax. can be supplied by the loaded winds. This ridge structure allows water droplets with a diameter of several tens of micrometers in the fog to accumulate on the hydrophobic regions, and the water mass reaching a certain size flows towards the hydrophilic regions and is absorbed by these regions [8]. Although superhydrophobic surfaces can be produced by many different methods inspired by the low-energy biological surfaces with micro and nano structure of these living species, it is seen that these man-made surfaces cannot maintain their water-repellent property for a long time in outdoor conditions. The problem of developing water-repellent surfaces resistant to outdoor conditions will continue to be the subject of research and discussion in the coming years.

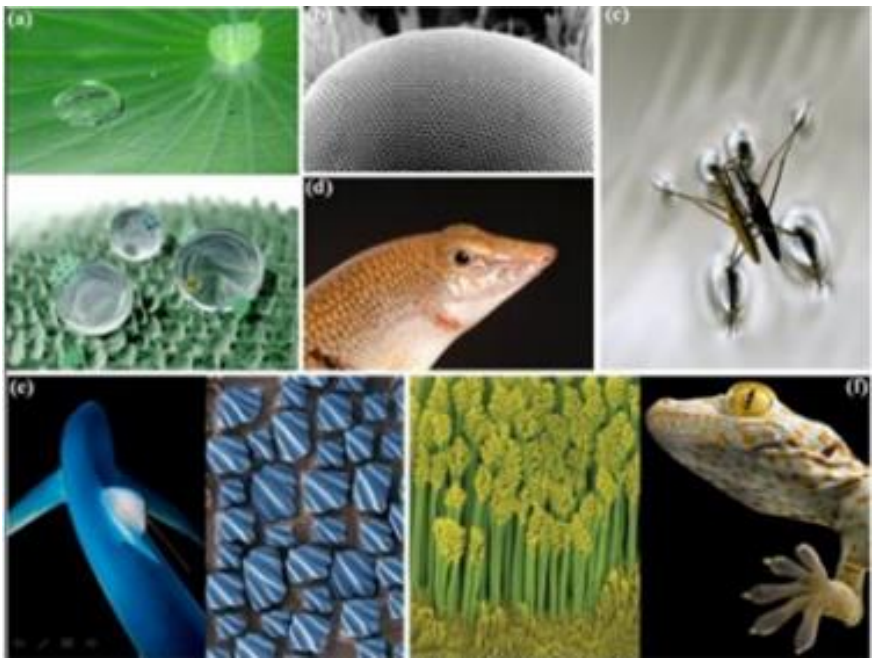

Figure 3. Some examples of hydrophobic and hydrophilic structures from nature. (a) lotus leaf, (b) moth's eye, (c) water scraper, (d) sand skin, (e) shark skin, (f) gecko [2]

Conclusion

Superhydrophobia, which is one of the working groups in the field of nanotechnology, is inspired by many structures existing in nature and offers solutions to problems in many sectors today. These solutions will revolutionize the textile, automotive industry, defense industry, construction, pharmaceutical industry and new treatment methods. Frictionless surfaces created by nanotechnology will eliminate the problem of changing engine oil in vehicles. Dirt-repellent fabrics may be able to put washing machines out of use. With the new studies and the accumulated literature knowledge, the studies of superhydrophobia arouse more and more excitement every day.

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