Signature of science in Lotus leaf

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Abstract

The amazing and unbelievable self-cleaning property of Lotus leaf is widely cited in various books, dialects and different sections of our culture including Bhagavad Gita. Modern scientific research agrees to this remarkable property of the Lotus leaf. This amazing natural phenomenon promotes scientists to think of self-cleaning coatings on smart cloth, automobiles, optical devices, window glasses, solar panels and many more. The present discussion also admits that the nature has given birth to science that helps us understand natural phenomena.

Key words- Lotus effect, superhydrophobic surface, angle of contact, force of adhesion, nanoparticle.

Introduction

The 10th verse in Chapter-5 of Bhagavad Gita says :

ब्रह्मण्याधाय कर्माणि सङ्गं त्यक्त्वा करोति य: |
लिप्यते न स पापेन पद्मपत्रमिवाम्भसा || 10||

Brahmaṇyādhāya karmāṇi saṅgaṁ tyaktvā karoti yaḥ
Lipyate na sa pāpena padma-patram ivāmbhasā

The lines teach us the fact that he who acts placing all actions in the eternal Brahman, giving up attachment, is unaffected by sin like the Lotus by water. A Lotus leaf grows in water but it is never moistened by water. In the similar fashion, the person is untouched by sin like the Lotus leaf that comes out dry from inside the water. This amazing and unbelievable property of lotus leaf is widely cited in the various books, dialects and different sections of our culture including the Bhagvad Gita. The non-sticky clean surface of lotus leaf has been widely studied by researchers. In fact there exists science behind the amazingly non-sticky surface of Lotus leaf. The structure of the amazing surface has been analysed scientifically. The researchers have tried to mimic the morphology of the leaf to comprehend the magical property. Ultimately, they have succeeded to manufacture superhydrophobic surface by mimicking the magical surface morphology of the Lotus leaf.

Illustration

A Lotus leaf grows in water and mud, but it is never moistened by the water or mud. Apart from the Lotus leaf, there are a number of natural water-repellent leaves. But the Lotus leaf is recognised by the Bhagavad Gita as the leaf with the highest cleanliness. Today's research also agrees to this remarkable property of the Lotus leaf. The Lotus plant in modern research has been considered to have excellent water non-wettability. That is why the lotus plant is recognised as the "*King Plant*" among its entire category [**1**].

There exists interesting scientific theory behind non-wettability of the Lotus leaf. The wetting capacity of a liquid numerically depends upon its contact angle with the solid surface. The contact angle is defined as the angle subtended between a tangent drawn to the curved liquid surface at the point of contact and the solid surface present inside that liquid. The contact angle is different for different pairs of solid and liquid. We observe that water wets clean glass. The angle of contact between glass surface and water surface is around zero to 8°. The mercury cannot wet glass surface and its angle of contact is around 135°. Therefore, a liquid with numerically small angle of contact can wet a solid surface. The superhydrophobic surface of Lotus leaf possesses extremely high contact angle with water and it is greater than 150°. Thus, the angular magnitude agrees to the superhydrophobic nature of the leaf.

The magical surface of the Lotus leaf has been broadly investigated by the modern researchers and extensively applied on variety of substrates for potential self-cleaning. Although many kinds of superhydrophobic surfaces mimicking the lotus leaf's structure have also been studied, the lotus leaf has been proved to be the best natural superhydrophobic surface. It also provides comprehensive discussion on modern research carried out in the field of artificial superhydrophobic surfaces. The self-cleaning property in the field of modern research refers to the "Lotus effect" [**2**, **3**].

Nature is the creator of science and scientists. It is the largest laboratory for research, which laboratory is freely available to all types of researchers. It helps biologist, physicist, chemist, mathematician, as well as engineer in their field of higher study. Nature is fantastic and always ready to teach us without hesitation. About 460 crore years back our Earth was a ball of hot gases with no living creature. Nature developed living nanostructures around 350 crore years back as the result of evolution. The materials and devices in nano-scale have been developed today by precisely imitating the chemical components, surface structures and magical properties present in natural systems [**4**-**6**], although the 'perfect mimicry' is not possible. Nature has a good number of plants leaves whose surfaces exhibit excellent water-repellent properties [**7**-**9**]. However, the Lotus leaf among them has been popularly regarded as a *symbol of purity* in our culture for over 2,000 years due to its ability to remain clean.

The Lotus leaf remains clean even in dirty-muddy ponds. The phenomena in which water drops on the leaf-surface bead up like shiny balls are worth watching. The droplets cannot wet the surface, but quickly roll off along with dirt. The science behind such phenomena is related to the force of cohesion and adhesion. The force of attraction between similar molecules is known as force of cohesion, whereas, the force of attraction between dissimilar molecules is known as force of adhesion. The force of adhesion between the water droplet and dust particle is greater than the force of adhesion between the leaf surface and dust particle. That is why the water droplet can collect and carry the dust particles from the surface of leaf, and hence the surface remains clean.

Two German botanists, W. Barthlott and C. Neinhuis, in 1997 have illustrated the unique dual scale micro/nanostructure of the Lotus leaves with the help of a scanning electron microscope (SEM). They have also studied the chemical material present on the leaf [**2**]. The study of unusual surface wettability of leaf can be realised by controlling the surface geometrical microstructure and low surface energy of the surface. The research on such an amazing property leads to implementation of self-cleaning coatings on automobiles, optical devices, window glasses and solar panels. The technique enables us to manufacture anti-fogging coatings, anti-corrosive coatings and anti-icing surface. In the present scenario, the Lotus leaf-like micro/nanoscale binary structure is well accepted in developing superhydrophobic surfaces [**10**, **11**].

The application of nanotechnology to manufacture *smart cloth* is no doubt an imitation of unusual superhydrophobic surfaces. The way we keep our clothes clean, unsoiled and bright is expensive and time consuming. It needs soap, detergent, washing powder, washing machine and hot water. That too there is chance of colour fading during wash. Therefore, sophisticated washing materials are required for deep cleaning without colour fading. All these problems can be solved by adopting self-cleaning superhydrophobic surface of the clothes. The provision of nano-coating on the clothes can keep the clothes clean without wash. It is because the dust and dirt particles are much bigger than the nanoparticles.

Conclusion

The notion of Lotus effect and superhydrophobic surface is originated from nature, especially from the Lotus leaf. In fact, nature has given birth to science, although science helps us understand natural phenomena. Innumerable phenomena occur in the universe every moment. But we are capable of sensing and understanding a few of them. Scientists are truly unable to explain each and every phenomenon taking place in nature. New theories are formulated and coming into picture in order to explain both the touched and untouched problems. Research community should welcome new theories formulated for explaining various natural phenomena. Of course, a theory is subjected to be modified or even rejected if it fails to explain the phenomena consistently and logically.

Reference

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