Lahore College for Women University Lahore

Lecture:13

Course: Nanotechnology & Nanostructures

Instructor: Dr. Zohra Kayani

Overview

- Fundamental Approaches for Cleaning and Antimicrobial Actions

1. Hydrophobic Surface
2. Hydrophilic Surface
3. Photocatalytic Surface

- Applications for various types of Surfaces

a) Self-Cleaning Materials
b) Easy-cleaning Materials
c) Antimicrobial Materials
d) Anti-fogging, Anti-reflection Materials

Fundamental Approaches for Cleaning and Antimicrobial Actions

- An antimicrobial is a substance that either kills or inhibits the growth of microrganisms.
- Nanomaterials (coatings, paints, or films) are used for self-cleaning, antimicrobial, fungicidal, and related applications
- Three primary technologies are being employed in these areas to make self-cleaning materials:

1. Hydrophobic (water-repelling) surfaces
2. Hydrophilic (water-attracting) surfaces
3. Photocatalytic surfaces

First Approach (Hydrophobic surface)

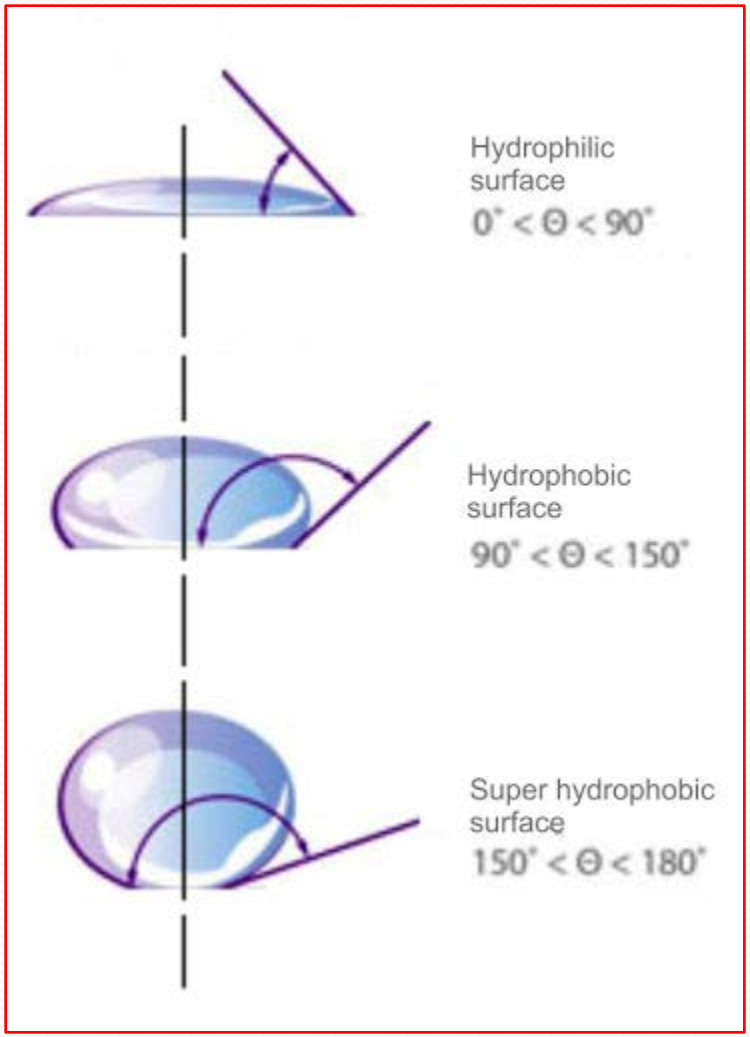
- The lotus flower has been a symbol of purity. Using SEM, it was found that the surfaces were also not smooth. The self-cleaning activity of the lotus flower is a result of hydrophobic action. On superhydrophobic leaf surfaces, water droplets form spherical droplets that roll off easily, removing dirt particles as well.

Surface tension factors for Hydrophobic surface

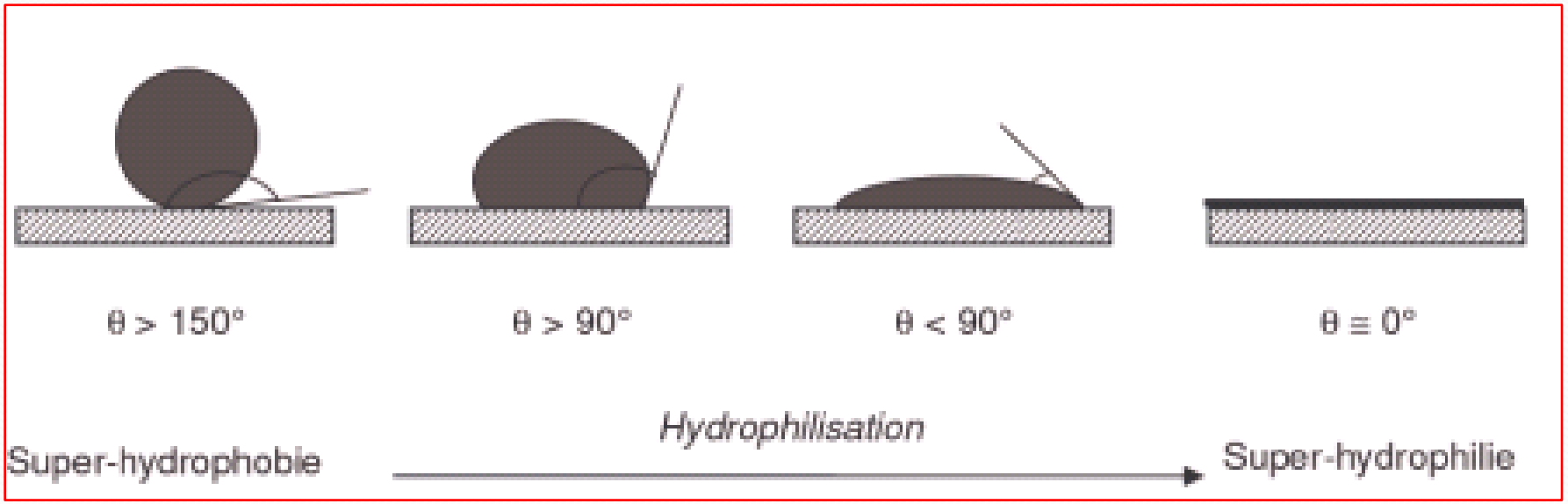
- Three primary surface tension factors, which influence the shape of a water droplet are:
- Liquid-to-vapor surface tensions
- Liquid-to-solid surface tensions
- Solid-to-vapor surface tensions

Contact Angle and surface tensions

- In self-cleaning surface, an important factor is the contact angle (θ) between the water drop and the surface. The relative magnitude of the tensions influences the value of the "contact angle" (θ).
- If θ < 90°, the surface is hydrophilic. If the surface tension of the solid surface is greater than that of the liquid, drops will spread and surface wetting will occur and hence, the contact area between the water droplet and the surface is maximized in hydrophilic surfaces.
- If θ ≥ 90°, the surface hydrophobic. If the surface tension of the solid surface is less than that of the liquid, the water droplet will be repelled and hence, the contact area between the water droplet and surface is minimized in hydrophobic surfaces.
- If θ ≥ 150°, the surfaces are termed as superhydrophobic (180° is the upper boundary).

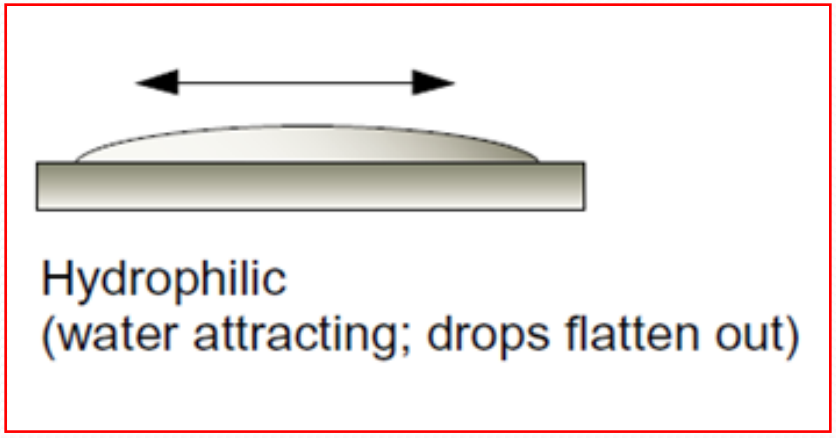


The value of contact angle and surface tension influence the shape of droplet



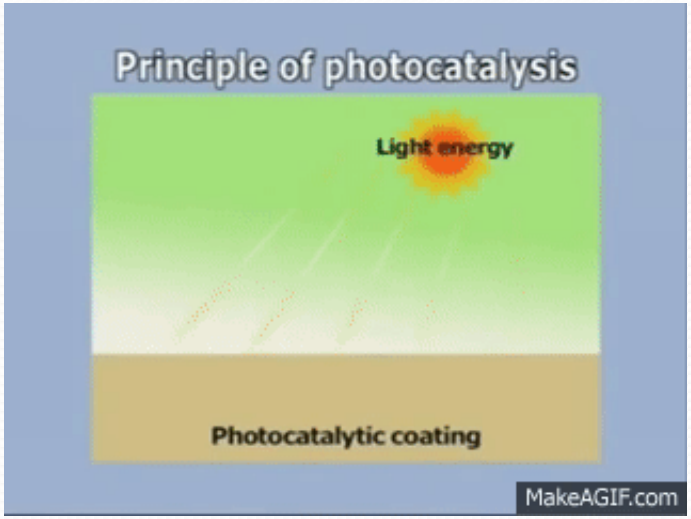
Second Approach (Hydrophilic Surface)

- The water attraction characteristic (hydrophilic surface) is used to develop a thin sheet like films of water that can be largely transparent and that aids in surface washing and cleaning. Hydrophilic surfaces also form the basis for some "anti fogging"applications.

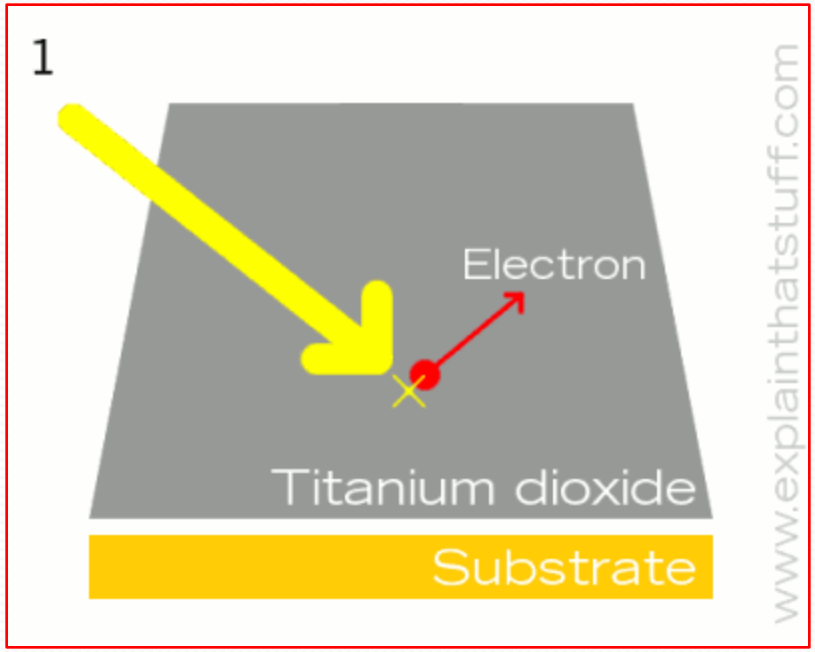


Third Approach (Photocatalytic Surface)

- Photocatalysis happens when certain materials are exposed to ultraviolet (UV) light present in normal sunlight.
- This approach includes self-cleaning antimicrobial actions and air purification. Exposure to UV radiation produces electron-hole pairs in the material. The charged particles chemically react with foreign substances on the surface. Hence, the foreign substances decompose through oxidation. Organic matter can be quickly decomposed. The decomposed material can then be washed away by normal rainfall or other means.



- **Examples:**
- Titanium dioxide (TiO_2)or zinc oxides (ZnO) are often used as photocatalytic materials. They are relatively inexpensive and respond well to UV light.



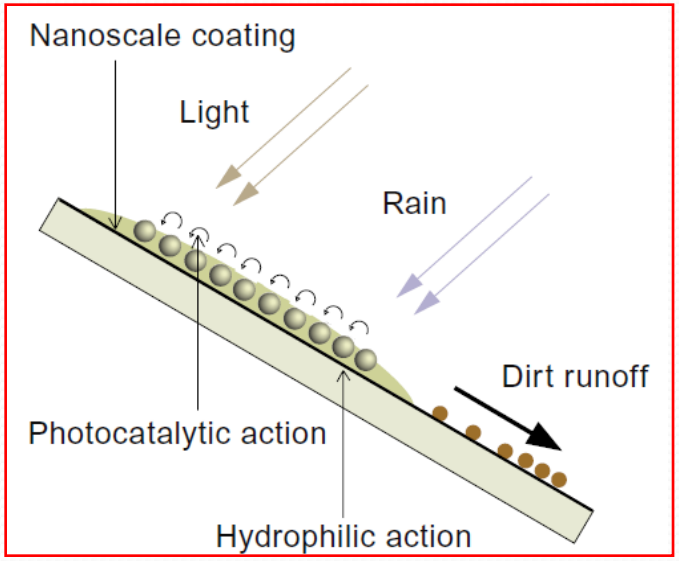
Applications for various types of Surfaces

- Hydrophobicity, hydrophilicity, and photocatalysis form the basis of self-cleaning, easy-cleaning, and antimicrobial surfaces.
- The surfaces can form on glasses, tiles, enameled panels, and other hosts. They also can have overlapping actions in

a) **Self-Cleaning Materials**
b) **Easy-cleaning materials**
c) **Antimicrobial materials**
d) **Anti-fogging, Anti-reflection materials**

Self-Cleaning Materials

- An object or apparatus designed in such a way that it is able to clean itself automatically.
- **Self-cleaning glasses and tiles:** In glasses and tiles, coatings with thicknesses at the nanoscale that have particular photocatalytic and hydrophilic (water-attracting) properties.
- The photocatalytic material (thicknesses of the order of 15nm), titanium dioxide (TiO_2) that produces chemical reactions when subjected to (UV) light that help in oxidizing foreign substances and decomposing them.
- When the surface is subjected to rain or simple washing, due to hydrophilic action, water droplets hitting the surface of the coated glass attract each other, thus forming thin sheets. The decomposed (loosened) material can then be washed away by normal rainfall or other means.



- **Self-cleaning paints, textiles:** Paints are relatively thick coatings in comparison to the thin coatings on self-cleaning glass. Titanium Dioxide, Zinc Oxide, and other kinds of nanoparticles are used in paints to provide the photocatalytic action.
- In everyday textiles such, the surface tensions of the textile materials are quite high compared to those of water; hence wetting typically occurs. When these same textiles are treated with fluorocarbons, the surface tension of the textile will become less than that of water; hence a water-repellant action occurs.

- **Self-cleaning anti-pollutant concrete:** The photocatalytic nanoparticles (TiO_2) are directly mixed into the concrete or mortar at their surfaces and they provide the photocatalytic effect. Hydrophilic action from rains or washings then causes the impinging water to form into thin-sheet forms that carry away dirt particles. Alternative approaches are spraying concrete with a photocatalytic coating.
- These concrete reportedly also has capabilities for reducing pollutants such as nitric oxides in the air.

Easy-cleaning materials

- A number of products use hydrophobic properties associated with smooth surfaces. These materials are not fundamentally self-cleaning, but help prevent buildup of dirt or other organic molecules and are easy to keep clean. Reduced surface attractions to these molecules result from the smooth surfaces that exhibit lower surface energies.
- The surfaces of this type have extensive application potential anywhere cleanliness and hygiene are important, including kitchens and bathrooms or in medical or healthcare facilities or equipment.
- A major material design issue is assuring that common detergents used in cleaning do not cause degradation of these surfaces.

Antimicrobial materials

- Microbes are minute life forms that include bacteria, fungi, and protozoan parasites. Many microbes can cause disease or aid in its spread. Antimicrobial surfaces target disease-producing microorganismswith the aim of helping prevent the spread of germs injurious to health.
- These kinds of surfaces are important in the medical field as well as in every day circumstances of normal healthy living.

Different Approaches to make Antimicrobial surfaces using Nanomaterials

1) One approach is to use copper or silver nanoparticles embedded in some other matrix as a coating on many kinds of base materials are incorporated directly on the surfaces of the base materials.
2) Second approach is photocatalysis process.
3) The third approach is micro-encapsulation of biocides or fungicides. The micro-capsules are distributed on the surface of a material as a coating and then are designed to have a "timed release" capability.
4) Though some molds are positive while certain kinds of mold in buildings can cause extreme health problems to occupants. Many kinds of anti-mold (based on titanium dioxide) treatments are available on the market today.

Anti-fogging, Anti-reflection materials

- Many anti-fogging applications depend on the hydrophilic action of surfaces; the resulting spreading of water droplets becomes largely invisible.
- Nanoproducts with anti-reflection characteristics are widely used in architecture as well as in product design to reduce troublesome reflections. They are also used in optical devices to increase light transmission. Many of these optically related products also can block specific types of infrared, visible, or ultraviolet light wavelengths and thus be useful in a wide array of applications.

Thank You