Summary and Explanation of Slide 2 on SURFACE WETTING

Summary

This slide discusses bacterial biofilms, which are composed of bacteria and secreted biopolymers. Biofilms can form on various surfaces such as pipes, catheters, teeth, and even be consumed as a delicacy. They are notably resistant to erosion.

Explanations

Concepts and Terms

Biofilm: A biofilm is a structured community of bacteria encased in a self-produced matrix of biopolymers that attach to surfaces.
Surfaces:

- *On pipes*: Biofilms can form inside pipes, potentially causing blockages and corrosion.
- *On catheters*: Biofilms on medical devices like catheters can lead to infections.
- *On teeth*: Dental biofilms, commonly known as plaque, lead to tooth decay and gum disease.
- *As a delicacy*: Some cultures consume biofilms, like the Japanese food "natto," which consists of biofilm made by the fermentation of soybeans.

Resistance to Erosion: Biofilms are robust and can efficiently resist mechanical and chemical erosion, making them challenging to remove from surfaces.

Diagrams and Data

Diagram

- The diagram illustrates how biofilms form inside a pipe with descriptions in German:
  - *Trinkwasser (Drinking water)*: Indicates the fluid that passes through the pipe.
  - *Planktonische Bakterien (Planktonic Bacteria)*: Free-floating bacteria that can attach to surfaces.
  - *Biofilme (Biofilm)*: The formed biofilm layer.
  - *Freisetzung (Release)*: Potential release of bacteria from the biofilm.

Notes:

- Biofilms pose significant challenges in medical, industrial, and dental contexts due to their resistance to conventional cleaning methods and antimicrobial treatments.
- Understanding biofilms is crucial for developing strategies to prevent their formation and manage their impacts effectively.

Summary and Explanation of Slide 4 on SURFACE WETTING

Summary

The slide discusses how biofilms created by various bacteria can exhibit superhydrophobic properties.

Explanations

Concepts and Terms

Biofilms: A complex aggregation of microorganisms marked by the excretion of a protective and adhesive matrix.
Superhydrophobic: Surfaces that extremely repel water, causing water to form beads or droplets that do not spread out.

Relevant Information

Bacillus subtilis 3610

- A soil bacterium, shows superhydrophobic properties evidenced by water droplets beading on its biofilm.

Bacillus subtilis B1

- Found in oil fields, displaying superhydrophobic characteristics similar to Bacillus subtilis 3610.

Bacillus subtilis natto

- Associated with Japanese soy beans, it also forms superhydrophobic biofilms.

Pseudomonas putida

- This soil bacterium's biofilm similarly repels water.

Burkholderia thailandensis

- Another soil bacterium, forming biofilms that exhibit the superhydrophobic effect.

Notes:

- The images provide visual proof of superhydrophobicity, as evidenced by the water droplets maintaining a near-spherical shape on the biofilms.
- Understanding superhydrophobicity in biofilms has implications for medical, industrial, and environmental applications, such as preventing biofouling and developing self-cleaning surfaces.

Summary and Explanation of Slide 5 on SURFACE WETTING

Summary

The slide demonstrates the behavior of *Bacillus subtilis* grown on different agar media variants and explains the concept of contact angles to describe surface wetting.

Explanations

Concepts and Terms

***Bacillus subtilis* on Different Media**:
LB Agar: Standard growth medium.
LBGM Agar: Growth medium with additional components (detail unspecified).
MSgg Agar: Another variant with different composition (detail unspecified).
Contact Angle (CA):
Hydrophilic (CA $< 90°$): Surfaces that are easily wetted by water (low contact angle).
Hydrophobic (CA $> 90°$): Surfaces that repel water (high contact angle).
Superhydrophobic (CA $> 120°$): Extremely water-repelling surfaces (very high contact angle).

Diagrams and Data

Contact Angle Measurement

- Illustrated with water droplets on different surfaces.
- CA is the angle between the surface and the tangent where the droplet meets the surface.
- Illustrates how different contact angles affect the droplet shape.

Notes

- **Contact Angle Significance**: It is a crucial parameter in studying surface wetting and is affected by surface energy and texture.
- Different growth conditions for *Bacillus subtilis* can alter the surface properties, impacting how water interacts with the surface. This illustrates practical implications in microbiology and materials science.

Summary and Explanation of Slide 6 on SURFACE WETTING

Summary

The slide discusses *Contact Angle Hysteresis*, which is the difference between the advancing and receding contact angles of a liquid droplet on a surface. It demonstrates this concept through images and diagrams showing the behavior of droplets on different surfaces.

Explanations

Concepts and Terms

Contact Angle Hysteresis: The difference between the advancing angle (θ_a) and the receding angle (θ_r) of a droplet on a surface. It indicates how a droplet moves or sticks to the surface.
Advancing Angle (θ_a): The angle formed at the front (advancing edge) of the moving droplet.
Receding Angle (θ_r): The angle formed at the rear (receding edge) of the moving droplet.

Diagrams and Data

Images on the Left

- *LBGM agar*: The tilting of the surface causes the drop to roll off, indicating a low hysteresis.

- *MSgg agar*: The tilting of the surface causes the drop to stick, indicating a high hysteresis.

Diagrams on the Right

- *Tilting the Surface*: Shows how the advancing (θ_a) and receding (θ_r) angles change when the surface is tilted.

- *Changing the Droplet Volume*: Shows how adding or removing liquid changes the advancing and receding angles.

Notes

- **Application**: Understanding contact angle hysteresis is important in designing surfaces that are either hydrophilic (water-attracting) or hydrophobic (water-repelling). It impacts areas like coatings, materials science, and fluid mechanics.
- **Measuring Technique**: Contact angle hysteresis can be measured using techniques like tilting the surface or changing the droplet volume.

Summary and Explanation of Slide 7 on SURFACE WETTING

Summary

The slide discusses contact angle hysteresis, demonstrated through tilting experiments on two different agar surfaces (LBGM and MSgg) and illustrated with a graph showing advancing and receding contact angles as a function of droplet volume.

Explanations

Concepts and Terms

Contact Angle Hysteresis: *It refers to the difference between the advancing and receding contact angles of a liquid droplet on a surface.*
Importance: Indicates how a droplet interacts with a surface, influencing properties like adhesion and mobility.
Advancing and Receding Angles:
Advancing Angle (θa): The contact angle when the droplet expands on a surface.
Receding Angle (θr): The contact angle when the droplet contracts on a surface.

Diagrams and Data

Images of Agar Surfaces

- **LBGM Agar**: The image shows that tilting causes the droplet to roll off, indicating a non-sticky surface.

- **MSgg Agar**: The image shows that tilting causes the droplet to stick, indicating a sticky surface.

Graph

- **X-Axis**: Droplet Volume (μL)
- **Y-Axis**: Contact Angle (degrees)
- **Data Points**:
  - *LBGM Advancing (Green Circle)*
  - *LBGM Receding (Green Square)*
  - *MSgg Advancing (Red Diamond)*
  - *MSgg Receding (Red Triangle)*
- **Interpretation**: LBGM agar shows a smaller hysteresis compared to MSgg agar, demonstrating lesser resistance to droplet movement on LBGM.

Notes:

- The smaller hysteresis on LBGM indicates less difference between advancing and receding angles, making the surface less adhesive to the droplet.
- Understanding contact angle hysteresis is crucial for applications in coating technologies, material science, and biological surfaces.

Summary and Explanation of Slide 8 on SURFACE WETTING

Summary

The slide compares the surface wetting properties of lotus leaves and rose petals.

Explanations

Concepts and Terms

Lotus Plant: Lotus leaves exhibit a superhydrophobic surface, meaning water droplets bead up and roll off, carrying away dirt and contaminants. This self-cleaning property is known as the *lotus effect*.
Rose Flower: Rose petals, while also repelling water, have a different mechanism. The structure of rose petal surfaces allows water droplets to stick to the petals even though the surface is hydrophobic. This effect is known as the *petal effect*.

Notes

- **Superhydrophobic Surface:** A surface that extremely repels water, making it bead up and roll off.
- **Lotus Effect:** Characteristic of superhydrophobic surfaces that lead to self-cleaning capabilities.
- **Petal Effect:** A type of wetting where water droplets adhere to the surface due to specific surface structures despite being hydrophobic.

Understanding these effects is crucial in applications ranging from waterproof coatings to self-cleaning materials.

Summary and Explanation of Slide 9 on SURFACE WETTING

Summary

The slide compares the surface structures of lotus leaves and rose petals, highlighting the differences in their surface roughness and topology.

Explanation

Lotus-effect

The micrograph of the lotus leaf shows a rough surface with microscopic protrusions.

Rose petal effect

The micrograph of the rose petal shows a different rough surface with a distinct, more structured pattern.

Key Concepts

Surface Topology: The surface structure of both lotus leaves and rose petals has intricate features at the micro- and nanoscale. This complexity can influence how each surface interacts with water and other substances.
Roughness Features: The roughness of these surfaces contributes to their unique properties, such as water repellency in the case of the lotus leaf.

Notes

- The lotus-effect often results in superhydrophobicity, causing water droplets to roll off the surface.
- The rose petal effect can lead to a different interaction with water, such as increased adhesion.

Summary and Explanation of Slide 11 on SURFACE WETTING

Summary

The slide provides a detailed explanation of the hydrophobic properties of lotus leaves, illustrating how their microstructure contributes to their ability to repel water. It also compares these properties to those of another plant, *Salvinia molesta*.

Explanations

Concepts and Terms

Hydrophobicity: The property of repelling water. Lotus leaves are a classic example, as they have surfaces that cause water to bead up and roll off.
Microstructure: The detailed structure of the surface of the lotus leaf, magnified to show hair-like wax crystalloids and papillose epidermal cells, contributing to the water-air interface.
Water-Air Interface: The boundary where water and air meet on the leaf surface, essential for creating the hydrophobic effect.
Epidermal Cells: The outer cells of the lotus leaf that have papillose (nipple-like) structures, enhancing water repellence.
Similar: Salvinia molesta: Comparison to another plant that has similar water-repellent properties but achieved through a different form of microstructure.

Diagrams and Data

Microstructure of Lotus Leaf

- The left image shows a water droplet on a lotus leaf.
- The magnified image (50 µm scale) reveals the detailed surface texture composed of tiny bumps, contributing to water repellence.

Cross-sectional diagram

- Illustrates the interaction between the hair-like wax crystalloids and the water-air interface, which creates the hydrophobic effect.

Salvinia molesta Images

- The right images show the surface of *Salvinia molesta* with its own unique microstructures, with (b) displaying a magnified view (500 µm scale) and (c) a schematic representation of how the structure traps air.

Notes:

- **Effect of Ethanol**: When lotus leaves are treated with ethanol, they lose their hydrophobic properties. This can be because ethanol can dissolve or disrupt the waxy coatings and microscopic structures on the leaves, which are crucial for maintaining the hydrophobic surface.
- **Microstructure Role**: The detailed microstructure of the lotus leaf is paramount to its hydrophobic properties. Any alteration or damage to this structure can significantly impact its ability to repel water.
- **Applications**: Understanding these natural hydrophobic surfaces can inspire technological innovations in materials science for creating water-repellent surfaces in various industries.

Summary and Explanation of Slide 12 on SURFACE WETTING

Summary

This slide discusses physical wetting models, specifically the Young and Wenzel equations, which describe how the contact angle (θ) is affected by surface smoothness and roughness, respectively.

Explanations

Concepts and Terms

Young Equation
Contact Angle (θ_0): The angle formed at the contact point of a liquid on a smooth solid surface.
Surface Tension Values (γ):
- γ_{SA}: Surface tension between solid and air.
- γ_{SL}: Surface tension between solid and liquid.
- γ_{LA}: Surface tension between liquid and air.

Equation: $\cos\theta_0 = \frac{\gamma_{SA}-\gamma_{SL}}{\gamma_{LA}}$
Diagram Explanation: Shows the contact angles and the forces acting at the contact line of a liquid droplet on a smooth surface.

Wenzel Equation
Rough Surface Effects: Describes how the contact angle changes on rough surfaces.
Surface Roughness (R_f): Defined as actual surface area to projected surface area ratio.
Equation: $\cos\theta = R_f \cos\theta_0$

Diagram Explanation: Illustrates a liquid droplet on a rough surface, showing the increased contact angle due to surface roughness.

Notes:

- *Young's Model* is accurate for ideal, smooth surfaces, while the *Wenzel Model* accounts for the enhanced wetting behavior on rough surfaces.
- These models are fundamental for understanding the wetting properties of materials, which are crucial in various applications like coatings, printing, and biological systems.

Summary and Explanation of Slide 13 on SURFACE WETTING

Summary

The slide discusses the Cassie-Baxter model for physical wetting, which applies when air is trapped between a rough solid surface and the liquid.

Explanations

Concepts and Terms

Cassie-Baxter Model: Describes the situation where air pockets are trapped beneath a liquid on a rough surface, leading to partial solid-liquid contact.
f_{SL}: Fraction of the solid-liquid interface area.
Cassie-Baxter Equation:

$$\cos\theta = R_f f_{SL} \cos\theta_0 - 1 + f_{SL}$$

- θ: Apparent contact angle.
- θ_0: Young's contact angle (intrinsic contact angle on a flat surface).
- R_f: Roughness factor of the solid-liquid interface.

Diagram

The diagram illustrates air pockets trapped between a liquid and a rough solid surface, typical of the Cassie-Baxter state.

Notes:

- Achieving trapped air on the microscale can involve micro- and nano-roughness (hierarchical surfaces).
- The model helps in understanding the behavior of liquids on textured surfaces, which is crucial for designing superhydrophobic materials.

Summary and Explanation of Slide 14 on SURFACE WETTING

Summary

The slide explains a physical wetting model called the *impregnated Cassie state*, where liquid fills the holes between surface roughness features. A relevant equation for this state is provided to calculate the contact angle.

Explanations

Concepts and Terms

Impregnated Cassie State: This is a wetting condition where the liquid penetrates the cavities in the rough surface, creating a composite interface of solid-liquid and liquid-air.
Equation for Contact Angle:

- $\cos\theta = 1 + f_{SL}(\cos\theta_0 - 1)$
- θ: Contact angle of the droplet on the rough surface.
- f_{SL}: Fraction of the surface that is in the solid-liquid contact.
- θ_0: Intrinsic contact angle on a flat surface of the same material.

Diagrams and Data

Diagram Description

- The diagram at the bottom visually illustrates the impregnated Cassie state, showing liquid filling in between the roughness features on the surface.

Notes:

- The formation of the impregnated Cassie state affects the contact angle due to the interaction of the liquid with the increased surface area from the roughness.
- Understanding this model is crucial for applications involving hydrophobic or hydrophilic surfaces.

Summary and Explanation of Slide 15 on SURFACE WETTING

Summary

The slide discusses physical wetting models, specifically comparing the Cassie-Baxter and Wenzel states. It highlights that two different wetting regimes can be observed in nature: the Cassie-Baxter state on lotus leaves and the impregnated Cassie state on rose petals.

Explanations

Concepts and Terms

Wenzel State: This wetting model occurs when a liquid thoroughly wets the textured surface, filling the grooves and valleys. The liquid droplet adheres strongly to the surface.
Cassie-Baxter State: In this model, the liquid droplet sits on top of the surface textures with air pockets underneath. This state leads to minimized contact area between the liquid and solid surface, often resulting in superhydrophobicity.
Lotus Leaf: The diagram demonstrates the Cassie-Baxter state with two parameters:
- *Peak-to-Base height*: The vertical height of the texture.
- *Pitch value*: The horizontal distance between peaks.

Cassie Impregnating or Petal State: Also known as the impregnated Cassie state, the droplet partially penetrates the surface textures while maintaining air gaps. This is observed in rose petals which makes them hydrophilic.

Notes

- **Cassie-Baxter State**: Results in superhydrophobic behavior, causing water droplets to bead up and roll off easily.
- **Wenzel State**: Results in higher adhesion between the surface and liquid, making it harder for the droplet to move.

Understanding these wetting models is crucial for applications in designing surfaces with specific wetting properties, such as self-cleaning, anti-fouling, and water-repellent surfaces.

Summary and Explanation of Slide 16 on SURFACE WETTING

Summary

This slide discusses staining results of hydrophobic biofilms, displayed through both 2D microscopy images and 3D surface plots.

Explanation

Hydrophobic Biofilms

These are clusters of microorganisms that adhere to surfaces and exhibit water-repellent properties.
Staining Results: Staining helps to visualize the structure and distribution of biofilms. The red regions in the images likely indicate areas where the biofilm is present.

Microscopy Images

Top row: *2D images show different patterns of biofilm coverage at a scale of 250 μm.*
The varying shades and intensity of red in these images indicate differences in biofilm thickness or density.

3D Surface Plots

Bottom row: *These plots give a 3D representation of biofilm architecture.*
Axes denote spatial dimensions (depth and width in μm), and color variation

represents different features of the biofilm structure such as height and density.

Notes

- Understand how hydrophobicity influences biofilm formation and structure.
- Consider the importance of visualizing biofilms in different dimensions to fully appreciate their complexity and heterogeneity.

Summary and Explanation of Slide 17 on SURFACE WETTING

Summary

This slide presents 3D visualizations of hydrophobic biofilms exposed to different wetting conditions (Before Wetting, During Wetting, and After Wetting) and grown under three different media conditions (LB, LB^+ (LBplus), and MSgg).

Explanations

Concepts and Terms

Hydrophobic Biofilms: Biofilms that repel water, influencing how they interact with wetting conditions
Visualizations: The slide shows a set of 3D plots illustrating the structure of biofilms before, during, and after wetting
LB (Luria-Bertani):

- Before Wetting: Biofilm structure appears dispersed.
- During Wetting: Biofilm becomes more sparse.
- After Wetting: Biofilm structure consolidates and flattens.

LBplus:

- Before Wetting: Biofilm further refined and structured.
- During Wetting: Significant disruption with larger gaps formed.

- After Wetting: Biofilm reconstitutes but shows distinct differences compared to the initial state.

MSgg:

- Before Wetting: Densely packed biofilm.
- During Wetting: Biofilm starts dispersing but still relatively dense.
- After Wetting: Biofilm displays a mixed structure of patches and gaps.

Notes:

- The slide poses a conceptual question: ”Where could this interface come from?” suggesting an exploration into the origin and formation dynamics of the observed interface in the middle of the LBplus biofilm during wetting.
- Biofilm response to wetting varies significantly based on the growth medium, indicating that the composition of the medium affects the biofilm structure's stability and reaction to water.

Summary and Explanation of Slide 18 on SURFACE WETTING

Summary

The slide provides microscopic images of biofilm structures at smaller scales for different samples (LB, LBGM, MSgg). Each sample is shown at two different magnifications (100 μm and 5 μm).

Explanations

Concepts and Terms

Biofilm: A biofilm is a complex aggregation of microorganisms growing on a solid substrate. Its structure can vary significantly depending on the environmental conditions and the types of microorganisms present.
Microscopic Images:

- *LB (Left Column):* Shows a less dense, more porous structure. The images indicate a biofilm with holes and spaces at both the 100 μm and 5 μm scales.
- *LBGM (Middle Column):* Exhibits a more compact and less porous structure in comparison to the LB sample. The close-up (5 μm) reveals tightly packed, smooth surface microorganisms.
- *MSgg (Right Column):* Displays a dense, heterogeneous structure. At the 5 μm scale, the images show a rough, highly structured biofilm surface.

Notes

- **Relevance to Surface Wetting:** Understanding the microstructure of biofilms is essential in studying surface wetting because the texture and porosity of a surface affect how liquids spread, adhere, and penetrate.
- **Scale Bars:** The presence of the scale bars (100 μm and 5 μm) help in understanding the magnitude and intricacy of the biofilm structures.

These microscopic examinations help in designing surfaces that can either promote or inhibit the formation of biofilms, relevant in fields like medical engineering, water treatment, and food safety.

Summary and Explanation of Slide 19 on SURFACE WETTING

Summary

The slide discusses the relationship between topography and wetting, focusing on metrological ISO-parameters used to measure surface roughness and developed surface area.

Explanations

Concepts and Terms

Root Mean Square Roughness (Sq): This is a measure of the surface texture, indicating how rough the surface is on average. It is calculated using the formula:

$$Sq = \sqrt{\frac{1}{A}\int_A (z - \bar{z})^2 dA}$$

Developed Surface Area (Sdr): This represents the relative increase in surface area due to the surface texture. It is calculated using the formula:

$$Sdr = \frac{1}{A}\left[\int_A \sqrt{1 + \left(\frac{\partial z(x,y)}{\partial x}\right)^2 + \left(\frac{\partial z(x,y)}{\partial y}\right)^2} - 1\right] dxdy$$

Additional Roughness Parameters:

- *Sp*: Maximum peak height.
- *Sv*: Maximum valley depth.

- *Sz*: Maximum height of the surface.
- *Sal*: Autocorrelation length.
- *Sdq*: Root mean square gradient.

Diagrams and Data

3D Surface Topography Maps

- These illustrate the physical surface features for different samples indicated as LB, LBGGM, and MSGG, with corresponding increases in developed surface area percentages (148% and 719% respectively).

Comparative Values

- Comparative values for surface roughness and topographic parameters across different surfaces (LB, LBGGM, MSGG) are provided in tabular form.

Notes:

- Higher values of Sq and Sdr indicate a rougher surface with a more significant increase in developed surface area.
- Understanding these parameters helps in analyzing how surface texture affects wetting properties.

Summary and Explanation of Slide 20 on SURFACE WETTING

Summary

The slide presents a comparison of biofilms generated by different *Bacillus subtilis* variants, illustrated with pictures and box plots.

Explanations

Concepts and Terms

Biofilms: Structured communities of microorganisms encapsulated within a self-produced polymeric matrix and adherent to an inert or living surface.
***Bacillus subtilis* Variants**: The slide highlights three variants:

- *B. subtilis* 3610
- *B. subtilis* natto
- *B. subtilis* B-1

Diagrams and Data

Images

- Left: Example of *B. subtilis* 3610 on a root sample.
- Middle: *B. subtilis* natto in fermented food (Natto).
- Right: *B. subtilis* B-1 associated with oil extraction.

Box Plots

- The box plots depict the Surface-to-Dry-Weight Ratio (Sdr) of biofilms for each variant in three different growth media: LB, LBGM, and MSgg.
- *B. subtilis* 3610: Shows Sdr values for LB (blue), LBGM (green), and MSgg (red) with significant differences denoted by $*$.
- *B. subtilis* natto: Similarly, the Sdr values are shown for the different media with significant differences marked.
- *B. subtilis* B-1: Displays Sdr values for LB, LBGM, and MSgg, indicating variations in biofilm properties depending on the growth medium.

Notes:

- The asterisk ($*$) signifies significant statistical differences in Sdr values among the different growth media for each *B. subtilis* variant.
- Understanding these differences can help in optimizing the use of these biofilms in agriculture, food, and industrial applications.

Additional Information

LB (Luria-Bertani): A nutrient-rich medium used for the growth of bacteria.
LBGM (LB Glucose Manganese): A modified LB medium with additional glucose and manganese.
MSgg: A specialized medium promoting biofilm formation.

Understanding the influence of growth conditions on biofilm formation can provide insights into their practical applications and biological significance.

Summary and Explanation of Slide 21 on SURFACE WETTING

Summary

The slide presents a roughness/wetting phase diagram for biofilms, highlighting differences in surface wetting characteristics of various bacterial species.

Explanations

Concepts and Terms

Contact Angle (°): This is plotted on the X-axis and measures how a liquid droplet interacts with a surface. Smaller angles (0-90°) indicate more *hydrophilic* (water-attracting) surfaces, while larger angles (greater than 90°) signify more *hydrophobic* (water-repelling) surfaces.
Sdr (%): This is plotted on the Y-axis and represents the surface roughness. Higher values indicate rougher surfaces.
Bacterial Species Symbols:

- ? B. subtilis 3610
- ? B. subtilis B1
- ? B. subtilis natto
- ? P. putida
- ? B. thailandensis

Hydrophilic: The cluster at lower contact angles and lower surface roughness values.
Lotus-like: Denotes surfaces that are superhydrophobic (high contact angle, high roughness), mimicking the lotus leaf effect.
Rose-like: Indicates high contact angle but relatively more roughness, similar to rose petal wettability.

Diagrams and Data

Contact Angle and Sdr:

- Contact angle measures surface hydrophilicity.
- Sdr represents surface roughness.

Bacterial Species and Wetting Characteristics:

- Various bacterial species show different symbols on the diagram.
- Wettability categories include hydrophilic, lotus-like, and rose-like.

Notes:

- This diagram helps in understanding how different bacterial species form biofilms with varying degrees of surface textures and wettability.
- The lotus-like and rose-like descriptions reflect bio-mimetic surfaces exhibiting unique wetting behaviors, which can have practical applications in material science and biotechnology.

Understanding these relationships is crucial for applications that require specific surface interactions, such as in coatings, medical devices, and biofilm management in industrial settings.

Summary and Explanation of Slide 22 on SURFACE WETTING

Summary

The slide compares the surface wetting properties of rose-like biofilms to actual rose petals.

Explanations

Concepts and Terms

Surface Roughness (sdr %): The diagram (b) compares the surface roughness of different surfaces, including biofilm grown on LB, LBGM, and MSgg media, and actual red and orange rose petals.
3D Surface Topography (a): The images showcase the 3D surface topography of red and orange rose petals, indicating that they have a microscopic structure influencing their wetting properties.
Biofilm: A thin, slimy film of bacteria that adheres to a surface.

Diagrams and Data

3D Surface Images (a)

- These images visually represent the microscopic structure of red and orange rose petals, showcasing a rough texture likely contributing to their water-repellent properties.

Box Plot (b)

- This graph shows the surface roughness (sdr %) of biofilm and rose petal surfaces indicating:
  - LB, LBGM, and MSgg columns represent biofilm grown on different media.
  - Red and Orange rose columns represent actual rose petals.
  - The surface roughness of rose petals is higher than that of biofilms grown in LB but comparable to LBGM and MSgg.

Notes:

- Surface roughness impacts how water interacts with surfaces; higher roughness often leads to hydrophobic (water-repellent) behavior.
- Understanding the comparison between biofilm and natural surfaces like rose petals can inspire bio-mimetic material design with specific wetting properties.

Summary and Explanation of Slide 23 on SURFACE WETTING

Summary

The slide showcases engineered hydrophobic surfaces by illustrating wax replicas of micro- and nanopatterned silicon wafer templates.

Explanations

Concepts and Terms

Hydrophobic surfaces: Surfaces designed to repel water.
Micro- and nanopatterned silicon wafer templates: These are silicon wafers engineered at microscopic (*micro*) and nanoscopic (*nano*) scales to create specific surface patterns.
Pitch: The distance between the centers of adjacent features on a surface. Here, pitches of 23 μm and 105 μm are mentioned.
Nanofeatures: Extremely small, nanoscale features that influence the surface properties.

Diagrams

Top images:

- Different micro-patterned surfaces with pitches (distances between features) of 23 μm and 105 μm, respectively.

Bottom images:

- The surface with shallow nanofeatures.
- The surface with higher nanofeatures.

Notes

- **Surface wetting**: These structures influence how water interacts with the surface, contributing to the hydrophobic properties.
- **Applications**: Such hydrophobic surfaces have applications in various fields, including waterproof coatings and self-cleaning materials.

Summary and Explanation of Slide 24 on SURFACE WETTING

Summary

The slide discusses how changing the topography of surfaces can alter their hydrophobic properties based on their microstructure pitch distance.

Explanation

Concepts and Terms

Engineered Hydrophobic Surfaces: Designed to repel water through specific topographical features
Lotus Effect: Water droplets bead up and roll off easily
Rose Petal Effect: Water droplets stick even when tilted
Pitch Distance: The distance between peaks in the surface's microstructure
Microstructure: Small surface features affecting properties
Cassie State: Air pockets trapped beneath a water droplet, leading to high hydrophobicity
Wenzel State: Water fully penetrates the surface texture, leading to increased adhesion

Diagrams and Data

Images of Water Droplets

- Shows water droplets on surfaces with different pitches (23 μm and 105 μm)

Schematic Diagrams

- Illustrates different pitches and their effect on hydrophobicity (Cassie state for 23 μm pitch and Wenzel state for 105 μm pitch)

Graph

- Relationship between nanostructure mass and microstructure pitch distance, highlighting a transition point around 105 μm

Notes

- Scale bar in images indicates 0.5 mm, showing droplet size
- Bhushan and Nosonovsky's work emphasizes the practical application of modifying surface textures to control wetting properties

Summary and Explanation of Slide 25 on SURFACE WETTING

Summary

The slide discusses how biofilm wetting can vary spatially depending on nutrient availability.

Explanations

Concepts and Terms

Biofilm Wetting: Refers to how biofilms interact with water, impacting their formation and the distribution of liquid on their surface.
Spatial Heterogeneity: Indicates variations in biofilm wetting across different areas.
Nutrient Availability:

- **High Nutrient Conditions**: The biofilm shows lotus-like wetting characteristics, where water droplets bead up, indicating hydrophobic surface properties.
- **Limited Nutrient Conditions**: The biofilm forms a hydrophilic center, which is conducive to spore formation.

Diagrams and Data

Two Types of Agar Plates (LBGM and MSgg)

- The images show different types of agar used for biofilm growth. The LBGM agar indicates high nutrient content, while the MSgg agar indicates limited nutrient content.

Water Droplets on Surfaces

- Under high nutrient conditions, the surface shows lotus-like wetting with droplets forming beads.
- Under limited nutrient conditions, the central part of the biofilm becomes hydrophilic, promoting spore formation.

Notes:

- The question at the bottom (*"What could this be good for?"*) suggests exploring potential applications or benefits of understanding and manipulating biofilm wetting properties, such as in medical or industrial contexts.

Summary and Explanation of Slide 26 on SURFACE WETTING

Summary

This slide discusses structures with heterogeneous wetting strategies, highlighting two examples: Lupin regalis and the desert beetle.

Explanations

Concepts and Terms

Lupin regalis strategy:
Superhydrophobic: Extremely water-repellent property.
Rose-like plant tips: The geometry resembles a rose, aiding in water collection.
Hydrophilic stem: Water-attracting parts where the collected droplets roll towards.

Desert beetle strategy:
Hydrophilic bumps: Areas that attract water.
Superhydrophobic waxy wings: Extremely water-repellent parts of the beetle's body.
Droplets rolling to mouth: A mechanism to collect water efficiently.

Notes:

- Heterogeneous wetting combines both hydrophobic (repelling water) and hydrophilic (attracting water) characteristics to control water movement.
- Understanding these natural strategies can inspire the design of artificial materials and systems for managing water.

Summary and Explanation of Slide 27 on SURFACE WETTING

Summary

The slide discusses the wetting properties of the desert cactus *Opuntia microdasys*, highlighting its heterogeneous wetting structures.

Explanations

Relevant Concepts

Heterogeneous Wetting: Refers to surfaces having both hydrophilic (water-attracting) and hydrophobic (water-repellent) regions.
Opuntia microdasys: A desert cactus exhibiting heterogeneous wetting characteristics which aid in fog collection.

Details

1. **Image Descriptions**:

- *(a)*: A general view of the cactus showing spines.
- *(b)*: Top view magnified to show detail.
- *(c)*: Side view of the spines showing the organization of barbs.

2. **Specific Features**:

- **Belt-structured trichomes**: These are hydrophilic regions that attract water.

- **Gradient grooves**: Represent a transition in the surface structure.

- **Oriented barbs**: Hydrophobic regions that repel water.

3. **Purpose**: The specific structural arrangement aids in the collection of fog, a vital moisture source for the cactus.

Notes

- **Hydrophilic Regions**: Marked in blue.
- **Hydrophobic Regions**: Marked in yellow.

The combination of these regions enables efficient water collection from the fog, crucial for the plant's survival in arid environments. This natural design inspires biomimetic applications for water collection technologies.

Summary and Explanation of Slide 28 on SURFACE WETTING

Summary

The slide discusses the basics and strategies of technical fog collection and provides illustrations and diagrams to show how fog particles can be captured for use.

Explanations

Concepts and Terms

Fog Particle Characteristics: The slide describes fog particles as having varying mass and size, which impacts their behavior in the atmosphere. It also raises questions about the safety and content of the particulates, such as sand and pollutants.
Fog Collection Strategy: A net-based strategy is shown, which captures fog particles as the wind blows through. The importance of minimizing *fog waste* is highlighted, suggesting that the design should focus on maximizing particle capture efficiency.
Fog Particle Paths:

- *Hydrophilic (Attracts Water):* These paths are designed to attract and collect water from fog.
- *Hydrophobic (Sheds Water):* These paths are designed to repel and shed water.

- The slide indicates that an efficient collector should incorporate both hydrophilic and hydrophobic elements.
- It also notes that if the net is too impermeable, the wind will bypass it, reducing efficiency.

Diagrams and Data

Illustrations

- *Net Close-Up:* Demonstrates the capture of water droplets on a fog collection net.
- *Fog Collection Set-Up:* Shows a practical deployment of fog nets with water collection containers.
- *Cooling Tower Schematic:* Suggests an application where fog and humid air are directed into a cooling tower, potentially for water harvesting or cooling purposes.

Diagram of Fog Collection System

- Depicts the setup of a net in an environment where fog is prevalent, showing how particulate fog is collected from the wind.

Notes:

- Efficient fog collection requires balancing hydrophilic and hydrophobic properties in the net material.
- Designing an optimal fog-collecting mesh is crucial to maximize water capture and minimize wind deflection.

Summary and Explanation of Slide 29 on SURFACE WETTING

Summary

This slide explains the anti-fogging properties of fly compound eyes and provides detailed images of their surface structures.

Explanations

Concepts and Terms

Anti-fogging Surfaces: The compound eyes of flies can remain water-free even in a fogging test chamber, indicating their anti-fogging properties.
SEM Images: Scanning Electron Microscope (SEM) images show the fine structure of the fly's compound eye. These images illustrate that the facets of the eyes are closely packed and exhibit a nanostructure.
Nanostructures: The structure on the fly's eyes has regular nanostructures with diameters around 100 nm, contributing to their anti-fogging property.

Diagrams and Data

Figures a-e:

- **a:** Fly covered with water droplets.
- **b:** Diagram of the fly's eye anatomy (cornea lens, cone, rhabdom, nervus).
- **c, d, e:** Close-ups and SEM images showing the hexagonal packing and nanostructures.

Notes:

- **Nanostructures Role:** The small size and regular pattern of the nanostructures prevent water accumulation, providing anti-fogging capabilities.
- **Practical Application:** Understanding these natural designs can inspire the development of anti-fogging materials in various industries like optics, automotive, and textiles.

Summary and Explanation of Slide 30 on SURFACE WETTING

Summary

The slide discusses the development of anti-fogging surfaces using ZnO nanoparticles. These nanoparticles, when synthesized at the correct temperature, form a surface with hexagon-shaped crystals that prevent fogging by creating a superhydrophobic surface.

Explanations

Concepts and Terms

ZnO Nanoparticles: Zinc Oxide nanoparticles
Superhydrophobic Surface: A surface that extremely repels water
Fogging: The formation of a thin layer of water droplets on a surface

Mechanisms and Applications

Hexagon-Shaped Crystals: The ZnO nanoparticles, when properly synthesized, form densely packed hexagon-shaped crystals. This specific structure helps in making the surface superhydrophobic.
Anti-fogging Mechanism: When applied to a surface, these ZnO nanoparticles create a layer that can prevent water droplets from coalescing and forming a foggy layer. This is demonstrated through visual tests where bare glass and glass with the bio-inspired coating were exposed to fog in different conditions.

Diagrams and Data

Image a (Before Testing)

- Comparison of bare glass vs. bio-inspired coating

Image b (Fog on Horizontal Place and Tilting Plate)

- Shows the difference between treated and untreated surfaces when exposed to fog

Image c and d (Fogging - horizontal and 10° tilting)

- Close-up view indicating the anti-fogging efficiency of the bio-inspired coating in horizontal and tilted orientations

SEM Image

- Shows the hexagon-shaped crystals of ZnO nanoparticles at nano-scale

Notes

- The ZnO nanoparticle coating can be an effective solution for industries where clear visibility is essential, such as in windshields, optical devices, and various coatings.
- Understanding the synthesis and application of these nanoparticles is crucial for developing advanced anti-fogging surfaces.

(Source: Sun et al., Small (2014))

Summary and Explanation of Slide 31 on SURFACE WETTING

Summary

The slide emphasizes that biofilms can resist wetting with alcohols, and highlights their hydrophobic nature, especially compared to PTFE (teflon).

Explanations

Concepts and Terms

Biofilms: These are complex aggregations of microorganisms marked by the excretion of a protective and adhesive matrix.
Hydrophobicity: This term refers to the tendency of a material to repel water. The slide suggests that biofilms are more hydrophobic than PTFE (teflon).
Contact Angle: A measurement used to quantify the wettability of a surface. Higher contact angles indicate more hydrophobic (less wettable) surfaces.

Diagrams and Data

Graph

- *X-Axis*: Represents the percentage of ethanol.
- *Y-Axis*: Shows the contact angle in degrees.
- The graph compares the contact angles of PTFE and biofilms (WT) across varying ethanol concentrations.

- A higher contact angle implies greater hydrophobicity. The biofilms maintain a higher contact angle (repellency plateau) even as the ethanol concentration increases, demonstrating their pronounced hydrophobic nature.

Table

- Lists contact angles for different biofilms (LBGM and MSgg) when exposed to various alcohols (acetone, ethanol, isopropanol, and methanol).
- Both biofilm types exhibit high contact angles, further confirming their resistance to wetting by alcohols.

Images

- Show water droplets on surfaces, indicating high contact angles and thus high hydrophobicity.

Notes:

- Understanding how to manage the hydrophobic nature of biofilms is crucial for disinfection, especially in contexts where biofilm presence can result in contamination or health risks.
- *How to disinfect such biofilms?* suggests impending discussion on strategies for overcoming their resistance to cleaning agents.

Summary and Explanation of Slide 32 on SURFACE WETTING

Summary

The slide discusses altering the wetting properties of biofilms by treating lotus-like biofilms with an 80% ethanol solution for 10 minutes, which decreases their roughness and makes them more wettable.

Explanations

Concepts and Terms

Biofilms: These are clusters of microorganisms where cells stick to each other and often these cells adhere to a surface.
Wettability: This is the ability of a liquid to maintain contact with a solid surface, resulting from intermolecular interactions when the two are brought together.
Lotus-like Biofilms: A reference to the lotus effect where the surface is extremely hydrophobic (water-repellent).
Ethanol Solution: A treatment using 80% ethanol, which is a common disinfectant.
Roughness (Str): Refers to the texture of the biofilm surface, where lower roughness indicates a smoother surface.
Contact Angle (CA): The angle between the tangent to the liquid surface and the solid surface; a lower contact angle indicates increased wettability.

Diagrams and Data

Graph a

- Shows the roughness (Str) and contact angle (CA) before and after the ethanol treatment for different biofilm types (B. subtilis B-1, B. thailandensis, and P. putida).

- The reductions in roughness and contact angle after treatment indicate increased wettability.

Images b

- 3D representations of the surface topographies of the biofilms before and after treatment with ethanol.

- Showing the decrease in surface roughness visually.

Notes

- The ethanol treatment's reduction in surface roughness appears to be a key factor in enhancing the wettability of biofilms.
- This kind of surface modification could be crucial in various applications where controlling biofilm formation and behavior is necessary, such as in medical devices, industrial pipelines, and water treatment systems.

Summary and Explanation of Slide 33 on SURFACE WETTING

Summary

The slide discusses how altering the topographical properties of biofilms changes their wetting characteristics, demonstrating different levels of wetting through images and data.

Explanations

Concepts and Terms

Biofilms: A biofilm is a group of microorganisms in which cells stick to each other on a surface. These can adhere to surfaces in aquatic environments and wet surfaces.
Wetting Properties: Refers to how liquids interact with solid surfaces. The wetting properties are characterized by the contact angle between the liquid and the solid.
Lotus-like, Rose-like, Hydrophilic: These terms describe different levels of water repellency and wetting:

- **Lotus-like**: Highly hydrophobic, mimicking the properties of a lotus leaf.
- **Rose-like**: Moderately hydrophobic.
- **Hydrophilic**: High affinity for water, allowing it to spread more easily.

Diagrams and Data

Surface Topography Images:

- Show the 3D surface profiles of biofilms under different conditions (NaCl, KCl).
- **NaCl** treatment changes the biofilm properties to a more lotus-like or rose-like state with varying roughness.
- **KCl** treatment shifts the wetting behavior to a hydrophilic state.

Contact Angle Measurements:

- Charts and graphs show the contact angle, which indicates the degree of wetting.
- A high contact angle implies poor wetting (hydrophobic).
- A low contact angle implies good wetting (hydrophilic).

Data Explained

Volume (μL) vs. Contact Angle (°C):

- Plots the contact angle changes with the volume of the drop, giving a quantitative measure of the wetting behavior.

Surface Roughness Measurements (% ±):

- Indicate how the surface roughness changes with the different treatments, affecting the wetting behavior.

Notes:

- **Topographical alterations induced by NaCl and KCl**: These treatments significantly change the roughness and wettability of the biofilm surfaces, allowing for controlled manipulation of surface properties in practical applications.
- **Applications**: Understanding and controlling the wetting properties of biofilms can be critical in various industries, including medical device manufacturing, food processing, and water treatment.

These findings highlight the importance of surface engineering in modifying the wetting properties of biofilms for specific applications.

Summary and Explanation of Slide 34 on SURFACE WETTING

Summary

This slide discusses the increased vulnerability of biofilms post-pre-treatment when exposed to dripping water and antibiotic solutions.

Explanations

Challenge biofilms by

Dripping water: Illustrated by an experimental setup where water drips onto a biofilm.
Antibiotic solutions: Indicates the application of antibiotics to challenge biofilms.

Graphs

Eroded Area Over Time (Top Right Graph)

- Compares treated and untreated *B. subtilis* biofilms.
- Treated biofilms show higher erosion over time compared to untreated ones.

Percentage of Live/Dead Cells (Bottom Graph)

- Compares the effect of 10 min Ethanol, 18 h NaCl, and 18 h KCl treatments.
- Key Insights:

- For all treatments, green represents live cells, and red indicates dead cells.
- Treated biofilms (with antibiotics) have more dead cells (red) than untreated ones.
- Hydrophilic surfaces have the highest percentage of dead cells compared to hydrophobic lotus and rose surfaces.

Notes

- **Pre-treatment**: Refers to any modifications applied to biofilms before the main experiment, making them more vulnerable.
- **Hydrophilic vs. Hydrophobic Surfaces**: Hydrophilic surfaces (attract water) are more effective in biofilm eradication compared to hydrophobic surfaces (repel water).

Summary and Explanation of Slide 37 on SURFACE WETTING

Summary

The slide presents images of four different oils (Cinnamon oil, Clove oil, Paraffin oil, and Thyme oil) to discuss their wetting properties.

Explanations

Concepts and Terms

Surface Wetting: The degree to which a liquid maintains contact with a solid surface. Each oil demonstrates a different wetting behavior, evident from the shape of the droplet.
Contact Angle: This is the angle at which a liquid/vapor interface meets a solid surface. A larger contact angle indicates less wetting, while a smaller contact angle indicates more wetting. From the images:

- *Cinnamon oil and Clove oil* exhibit higher contact angles, suggesting these oils are less wetting.
- *Paraffin oil* has a significantly lower contact angle, indicating better wetting.
- *Thyme oil* appears to have a moderate contact angle, showing intermediate wetting behavior.

Notes

- The images help visualize the differing wetting properties of various oils, highlighting how different liquids interact with the same solid surface.
- Understanding these properties is crucial in applications like lubrication, coating, and cleaning where the interaction between liquid and solid surfaces plays a vital role.

Summary and Explanation of Slide 38 on SURFACE WETTING

Summary

The slide discusses artificial omniphobic surfaces achieved through the Cassie-Baxter state using micro-structured SiO_2 with mushroom-shaped pillars. It presents experimental results highlighting the contact angles of various liquids on these surfaces.

Relevant Concepts and Data Explanation

Micro-structured SiO_2 with Mushroom Pillars

Images B, C, D, E show the microscopic structures of these pillars. These structures create air pockets, enhancing liquid repellency.

Cassie-Baxter Model

It describes a state where liquid droplets rest on top of the structures, trapped by air pockets, minimizing liquid-solid contact and therefore enhancing hydrophobicity or omniphobicity.

Graphs and Data

Bottom Left Graph

- Illustrates apparent contact angles (θ^*) as a function of gas fraction (f_x) and solid fraction (f_s).

- θ_o (on smooth surface) = 130°, the contact angle with no micro-structure.
- Different Colored Lines: Represent transition from hydrophobic to superhydrophobic (blue-green), oleophobic to superoleophobic (red-orange), and highly wetted surfaces to superomniphobic (yellow-green).

Top Right Graph

- Shows the apparent contact angles of different liquids (hexane, acetic acid, ethanol/water, glycerol, water) on surfaces with different microstructures (e.g., reentrant SiO_2, vertical C_4F_8).
- Key: Symbols represent different surfaces, indicating high contact angles (reduced wetting) for omniphobic surfaces regardless of liquid surface tension.

Notes:

- **Omniphobic Surfaces**: Means surfaces that repel both water (hydrophobic) and oils (oleophobic), leading to a wide range of applications in self-cleaning materials, anti-fouling surfaces, and other fields requiring liquid repellency.
- This combination of micro-structure and material properties is critical in developing surfaces that exhibit such repellent behavior across multiple types of liquids.

Summary and Explanation of Slide 39 on SURFACE WETTING

Summary

The slide discusses *artificial omniphobic surfaces* utilizing the *Cassie-Baxter state* with improved design featuring **doubly reentrant cavities**. The advantage highlighted is the sustained non-wetting effect even if some nanostructures become damaged.

Explanations

Concepts and Terms

Artificial Omniphobic Surfaces: Engineered surfaces that repel various liquids, not just water.
Cassie-Baxter State: A state of wetting where the liquid rests on top of the surface textures, trapping air beneath, which minimizes the contact area between the liquid and the surface.
Doubly Reentrant Cavities: These are complex surface structures that enhance the non-wetting properties by creating more significant barriers for liquid penetration.

Diagram Explanation

Left Image

- Shows a schematic of the surface textures with vertically aligned structures that trap air, preventing water (H_2O) from penetrating and spreading.

Right Image

- Demonstrates the grid-like cavity structures that trap air, effectively maintaining the non-wetting effect.

Notes:

- The improved design with doubly reentrant cavities is crucial for maintaining functionality even if some structural integrity is compromised.
- This feature can enhance the durability and effectiveness of omniphobic surfaces in practical applications.

Summary and Explanation of Slide 40 on SURFACE WETTING

Summary

The slide explains the creation of superhydrophobic surfaces using additive manufacturing, specifically 3D printing. It outlines the transition from a plain, rather hydrophilic material to a superhydrophobic rose-like and lotus-like surface by adding a 3D-printed grid and nanoparticles, respectively.

Explanations

Concepts and Terms

Additive Manufacturing: *Plain Material (Hydrophilic)*: Initially, the material is hydrophilic, which means it has an affinity for water.
3D-Printed Grid (Superhydrophobic Rose-Like): Introducing a 3D-printed grid structure transforms the material to exhibit superhydrophobic properties, similar to the surface of a rose petal.
Nanoparticles Addition (Superhydrophobic Lotus-Like): Further addition of nanoparticles to the grid results in a superhydrophobic lotus-like surface, known for its excellent water-repelling properties.

Diagrams and Data

Contact Angles (static)

- A bar graph shows the static contact angles for different surfaces: PCL (Polycaprolactone), PCL-grid, and Nanoparticles.

- Increased contact angles indicate more hydrophobic characteristics.

3D-Printed Grid Image

- Visual representation of the grid's surface structure.

Microscope Image (20x)

- Close-up view of the grid structure, showing detailed interactions at a microscopic level.

Contact Angle Hysteresis

- Bar graph showing changes in contact angles (CA) hysteresis.
- Provides insights into the surface energy and wetting behavior transition with the addition of a grid and nanoparticles.

Notes

- **Contact Angle (CA)**: Measures the angle formed at the interface between the water droplet and the surface. A higher CA indicates greater hydrophobicity.
- **Contact Angle Hysteresis**: Evaluates the difference between the advancing and receding contact angles, indicating the surface's ability to resist water adhesion.
- **Relevance of Rose-like and Lotus-like Surfaces:** - *Rose-like*: High CA but sticky surface, where water droplets stick instead of rolling off. - *Lotus-like*: Extremely high CA and low hysteresis, resulting in water droplets rolling off easily.

This slide provides useful insights into how surface modifications using additive manufacturing can significantly alter wetting properties, making materials either more hydrophilic or superhydrophobic by structural changes and the incorporation of nanoparticles.

Summary and Explanation of Slide 41 on SURFACE WETTING

Summary

The slide discusses the creation of superhydrophobic surfaces using additive manufacturing with a 3D-printed grid incorporating nanoparticles.

Explanations

Concepts and Terms

Superhydrophobic Surfaces: Surfaces that extremely repel water, preventing it from spreading out and sticking.
Additive Manufacturing: A process of creating objects by adding material layer by layer, often referred to as 3D printing.
3D-Printed Grid: A structured, lattice-like framework created using a 3D printer.
Nanoparticles: Extremely small particles that can be added to materials to achieve specific properties, such as enhanced hydrophobicity.
Sdr (Developed Interfacial Area Ratio): A parameter that quantifies the surface roughness and area available for interaction between a solid surface and a liquid.

Diagrams and Data

Graph Explanation

- The graph shows the Sdr values for two conditions: background (without fibers) and fibers.

- **X-axis**: Represents different stages, including cleaned and several incubation stages (incubation1 through incubation6).
- **Y-axis**: Represents the Sdr values.
- The trend indicates that Sdr values increase for the fiber condition across the incubation stages, suggesting an enhanced interface area for fibers, which is crucial for superhydrophobicity. The background condition shows minimal increase in Sdr.

Notes:

- The increase in Sdr for fibers indicates the efficiency of the 3D-printed grid with nanoparticles in creating a superhydrophobic surface.
- The use of nanoparticles in the grid significantly enhances the surface properties, making it more effective for applications requiring water repellency.

Summary and Explanation of Slide 42 on SURFACE WETTING

Summary

The slide discusses the creation of *superhydrophobic surfaces* using *additive manufacturing* techniques, highlighting the combination of 3D-printed grids and nanoparticles.

Explanations

Concepts and Terms

Superhydrophobic Surfaces: These are surfaces that exhibit extreme water repellence, causing water droplets to bead up and roll off rather than spreading out.
Additive Manufacturing: A process commonly known as 3D printing, where material is added layer by layer to create objects.
3D-Printed Grid: A structure created using a 3D printer, which can be customized to have specific patterns and properties.
Nanoparticles: Tiny particles added to the 3D-printed grid to enhance the surface properties, in this case, to create the ultrahydrophobic effect.

Notes:

- Superhydrophobic surfaces are useful in various industries including self-cleaning materials, anti-fouling coatings, and water-resistant fabrics.
- This slide appears to show an example or sample of a superhydrophobic surface created with a 3D-printed grid and nanoparticles.

Summary and Explanation of Slide 44 on SURFACE WETTING

Summary

The slide discusses the issue of water invasion in civil engineering structures, particularly basements. It highlights common entry points for water and notes the challenge posed by freeze/thaw cycles, especially in Western Europe.

Explanation

Key Entry Points for Water

Window Wells: These can allow water to leak through if not properly sealed.
Tie Rods: Metal rods used in the construction of concrete walls may allow water to penetrate if corrosion occurs.
Mortar Joints: Gaps in brick or stone walls can enable water to seep through.
Foundation Wall Crack: Cracks in the foundation walls are common points of entry.
Over Top of Wall: Water can overflow the top of the wall, especially during heavy rain.
Floor Drains and Cracks: Any cracks in the floor or improper drainage can lead to water accumulation.
Water Line and Pipe Penetration: Points where pipes penetrate walls and floors can be vulnerable to leaks.
Floor & Wall Joint: The junction between floor and walls can be susceptible to water intrusion.

Additional Problem in Western Europe

Freeze/Thaw Cycles

- The diagram on the right side of the slide shows the temperature fluctuations involved in freeze/thaw cycles.
- This process can exacerbate water infiltration problems by causing materials to expand and contract, leading to further cracks and leaks.

Notes:

- Ensuring proper sealing and waterproofing at all identified entry points is crucial for preventing water intrusion.
- Regular maintenance and inspection can help mitigate the effects of freeze/thaw cycles on building structures.

Summary and Explanation of Slide 45 on SURFACE WETTING

Summary

The slide discusses traditional hydrophobization methods, specifically post-curing treatments of bridge pillars using silan-based chemicals.

Explanation

Concepts and Terms

Hydrophobization: This is a process that makes surfaces water-repellent.
Post-curing Treatment: A method applied after initial curing of materials, aimed at enhancing their characteristics.
Chemicals Used: Silan-based chemicals like alkoxysilanes, alkoxysiloxanes, and alkalisiliconates are commonly used for this purpose.

Disadvantages

Time-Consuming

- Applying these coatings is an additional and labor-intensive step.

Organic Solvents Leakage

- These solvents can leak from the material over time, reducing its effectiveness.

Spot Treatment Flaws

- If any area is missed during treatment, it can become susceptible to water invasion.

Notes

- These traditional methods are being critiqued for their impracticality and inefficiencies, possibly setting the stage for discussing better alternatives.

Summary and Explanation of Slide 46 on SURFACE WETTING

Summary

The slide explains the process of bulk-hydrophobization of mortar using biofilm from *Bacillus subtilis* 3610.

Explanations

Concepts and Terms

Hydrophobic: The term indicates a material's tendency to repel water.
Biofilm: A thin, slimy layer of bacteria that adheres to a surface.
Mortar: A mixture used in building construction that hardens to bind building blocks like bricks or stones.

Diagrams and Data

Harvesting Biofilm

- Biofilm grown on LB^plus agar is harvested using a sterile tool.

Generating a Biofilm Suspension

- The harvested biofilm is introduced into a liquid medium to create a suspension.

Using the Suspension as an Admixture for Mortar Generation

- The biofilm suspension is mixed with traditional mortar materials.

Sample Casting and Drying

- The resulting mixture is cast into samples and allowed to dry, creating a hydrophobic mortar.

Notes:

- The hydrophobic nature introduced by the biofilm helps in making the mortar repel water.
- This technique aims to enhance the durability and longevity of mortar by protecting it against moisture-related damage.

Summary and Explanation of Slide 48 on SURFACE WETTING

Summary

The slide explains the process of bulk-hydrophobization of mortar using *B. subtilis* 3610 biofilm. It outlines the steps to create hydrophobic hybrid mortar by incorporating biofilm into the mortar mix.

Explanations

Biofilm Growth

Grown on LB^plus agar: Produces hydrophobic biofilm
Grown on LB agar: Produces hydrophilic biofilm

Steps of Bulk-hydrophobization

Step 1: Harvesting biofilm

- Biofilm is scraped from the agar.

Step 2: Generating a biofilm suspension

- Biofilm is suspended in a liquid medium.

Step 3: Using the suspension as an admixture for mortar generation

- The biofilm suspension is added to mortar mix.

Step 4: Sample casting and drying

- The mortar is cast into shapes and dried.

Notes:

- The slide highlights the key difference in surface properties based on the agar used for cultivating the biofilm, showing hydrophobicity is retained in the hybrid mortar.
- Hydrophobic surfaces have a higher contact angle, as illustrated in the images beside the steps.
- This process demonstrates a practical application of biomaterials to modify surface wetting properties in construction materials.

Summary and Explanation of Slide 49 on SURFACE WETTING

Summary

This slide compares the surface characteristics of unmodified and hybrid mortar and explains the concept of the lotus effect.

Explanations

Concepts and Terms

Surface Microstructure: The slide presents scanning electron microscope (SEM) images at two different spots on the outer surface and cross-section of unmodified mortar and hybrid mortar.
Unmodified mortar (with 0% biochar and 0.5 water/cement ratio): Shows a rough and cracked structure.
Hybrid mortar (with 2% biochar and 0.5 water/cement ratio): Shows a more intricate and densely packed surface structure.
Micro-roughness: The 3D surface topography maps indicate that hybrid mortar has higher roughness compared to unmodified mortar.
Roughness parameters:

- *Unmodified mortar*: $Sq = 2.54 \pm 0.79$ µm, $Sdr = 49.5 \pm 23.9\%$
- *Hybrid mortar*: $Sq = 2.92 \pm 1.16$ µm, $Sdr = 126.6 \pm 64.4\%$

Lotus Effect: The images on the right illustrate the lotus effect, showing water droplets on a lotus leaf and the surface microstructure responsible for its superhydrophobicity.

The lower diagram: Symbolizes how surface roughness (due to micro/nanostructures) contributes to water repellency.

Notes

- **Sq (Root Mean Square Height of the Surface)**: Describes the roughness level, higher values indicate rougher surfaces.
- **Sdr (Developed Interfacial Area Ratio)**: Represents the increase in surface area due to roughness. Higher values indicate more complex surfaces.

This slide highlights the microstructural differences between unmodified and hybrid mortars and links these to the lotus effect, emphasizing how surface roughness and structure can influence material properties like wettability.

Summary and Explanation of Slide 50 on SURFACE WETTING

Summary

This slide presents information about how hybrid-mortar can suppress capillary water uptake. This concept is demonstrated in a TV report shown in the science magazine *Nano* on 3Sat in the fall of 2016.

Explanations

Concepts and Terms

Hybrid-Mortar: A type of mortar that has been chemically modified to enhance its properties, particularly in resisting water absorption.
Capillary Water Uptake: The process where water is drawn up into tiny spaces within materials due to capillary action. Reducing this process is crucial in construction materials to prevent water damage.

Explanation

Hybrid-mortar has properties that prevent water from being absorbed into the material via capillary action. This is particularly important in construction and building maintenance, as water infiltration can cause a variety of structural and durability issues.

Notes:

- The slide suggests practical application and efficacy of hybrid-mortar in a real-world setting, evidenced by the TV report in a scientific context.
- Viewing the TV report might provide additional insights into the practical implications and benefits of using hybrid-mortar in construction.

Summary and Explanation of Slide 51 on SURFACE WETTING

Summary

This slide presents data on how hybrid mortar suppresses capillary water uptake compared to unmodified mortar.

Explanations

Concepts and Terms

Hybrid Mortar: *Modified version of traditional mortar with additives to enhance its properties*
Capillary Water Uptake: *The process of water being absorbed into the pores of a material due to capillary action*

Diagrams and Data

Graph

- The graph shows the averaged dark-field signal over time for both unmodified (yellow curve) and hybrid (green curve) mortars.
- The unmodified mortar shows a higher and increasing dark-field signal, indicating more water uptake, while the hybrid mortar maintains a lower signal, indicating less water uptake.

Images

- The side-by-side images illustrate the visual difference in water absorption.
- Images of unmodified mortar (left side, yellow background) show noticeable darkening over time (from 5 seconds to 24 hours).
- In contrast, the hybrid mortar (right side, green background) exhibits much less darkening over the same time period.

Notes

- *Color Coding*: The slide uses a color-coding scheme where white/grey indicates dry areas and dark grey/black indicates wet areas.
- **Data Source**: Information derived from Grumbein et al., Advanced Materials (2016).

This slide supports the conclusion that hybrid mortars significantly reduce capillary water uptake compared to traditional unmodified mortars.

Summary and Explanation of Slide 52 on SURFACE WETTING

Summary

The slide discusses how altering the mortar composition affects its wetting properties, specifically by measuring the contact angle for various formulations.

Explanations

Concepts and Terms

Contact Angle: This is a measure of the wettability of a surface. A higher contact angle indicates lower wettability (more hydrophobic), and a lower contact angle indicates higher wettability (more hydrophilic).
Biofilm Addition: Different amounts of biofilm were added to the mortar ranging from 1.0% to 2.5%. The chart shows that increasing the biofilm content generally increases the contact angle, suggesting that these additives make the surface more hydrophobic.
Water-Cement Ratio (wc-ratio): Various water-cement ratios (0.5, 0.6, 0.7) were used in the tests. The graph indicates that these ratios do not influence the general trend; higher biofilm content consistently increases the contact angle irrespective of the wc-ratio.

Diagrams and Data

PTFE Reference

- The dashed blue line represents the contact angle of PTFE, a hydrophobic material, serving as a reference for comparison.

Saltwater Droplets

- The central segment of the chart shows comparative data using saltwater droplets instead of regular water, indicating similar trends with slight variations.

Lyophilized Biofilm

- Additional samples contain lyophilized (freeze-dried) biofilm in different percentages (2%, 5%, 10%), showing heightened contact angles compared to unmodified mortar.

Notes:

- Adding biofilm increases the hydrophobicity of mortar as seen by the increase in contact angles
- This effect is consistent across different water-cement ratios and using both regular and saltwater droplets

Summary and Explanation of Slide 53 on SURFACE WETTING

Summary

The slide discusses the practical execution of a lab concept by mixing water, cement powder, sand, and lyophilized biofilm to demonstrate surface wetting principles outside of a controlled lab environment.

Explanations

Components

Water: A critical component for initiating hydration and mixing in the concrete.
Cement Powder: Serves as the binding agent.
Sand: Provides structural stability and texture to the concrete mix.
Lyophilized Biofilm: A biofilm that has been freeze-dried to extend its shelf life and stability. Its inclusion suggests it plays a role in the surface wetting properties being studied.

Practical Setup

The combination of these materials illustrated with a concrete mixer hints at how the experiment might be scaled from lab conditions to real-world scenarios.

Notes

- Lyophilized biofilms are stable and retain their functional properties, which can be crucial for studying surface interactions in varying environmental conditions.
- The objective could be to observe how these combinations affect surface wetting and possibly influence the characteristics of the resulting concrete mix.

Make sure to understand the properties of each component and their interactions to fully grasp the implications for surface wetting outside the lab.

Summary and Explanation of Slide 54 on SURFACE WETTING

Summary

The slide evaluates the performance of a hybrid material in real-world conditions by measuring the contact angle of water on the material over time and under various environmental conditions.

Explanations

Concepts and Terms

Contact Angle [°]: This measures the wettability of a surface. A higher contact angle typically indicates a more hydrophobic (water-repellent) surface.
Conditions Tested:

- Reference (baseline)
- Water (H_2O)
- -20°C (cold conditions)
- 50°C (hot conditions)
- Na_2SO_4 (saline conditions)
- HCl (pH 4) (acidic conditions)
- Freeze/thaw cycles

Time Intervals: Measurements taken after 7 days, 14 days, and 28 days.
Results Interpretation: The bar graph shows contact angles for different treatments. Consistent contact angles across various conditions suggest good performance and stability of the hybrid material.

Notes:

- *Hybrid Mortar (BC2%)* compares to a reference to evaluate performance improvements.
- *Environmental Icons* represent the different conditions, aiding visual understanding.
- *Micrographs* show the visual appearance of the reference and hybrid material's surface after treatment.

This data helps in understanding the durability and effectiveness of the hybrid material in resisting wetting in various environments. This can be particularly relevant for construction materials and coatings.

Summary and Explanation of Slide 55 on SURFACE WETTING

Summary

The slide discusses methods for making materials stronger through long-term incubation in Na_2SO_4 solutions and examines the effects of adding silica fume (SF) to the materials.

Explanations

Concepts and Terms

Long-term Incubation in Na_2SO_4 Solutions: The slide shows the impact of Na_2SO_4 solutions on materials over time.
Graph (top left): Length change in materials over a storage period, indicating the deformation of different materials (HM BC2%, UM, UM BC2%, 6%SF).
Materials Evaluated:
HM (BC2%): A high-modulus material with BC2%.
UM: An unspecified material.
UM (BC2%, 6%SF): UM material with BC2% and 6% silica fume addition.
Silica Fume (SF): A fine, powdered form of silica used to enhance material properties.
Compressive Strength: Graph (bottom right): Comparison of compressive strength of different materials under various conditions (water, -20°C, 50°C, Na_2SO_4, HCl with pH 4). Indicates that materials with SF show improved strength in several conditions.

Diagrams and Data

Length Change Graph

- Shows storage time (days) vs. length change (mm)
- Demonstrates that materials with silica fume (yellow line) have better resistance to deformation compared to others

Compressive Strength Bar Graph

- Presents the compressive strength in N/mm^2 for different materials under various environmental conditions
- The orange bars represent materials with 6% SF, showing higher strength than those without SF (blue bars)

Notes:

- Adding silica fume (SF) to materials can significantly improve their resistance to deformation and increase their compressive strength under various conditions.
- This finding can be applied to enhance the durability and performance of construction materials and other applications requiring strong, resilient materials.

Summary and Explanation of Slide 56 on SURFACE WETTING

Summary

This slide discusses the pitcher plant (*Nepenthes*) and its surface wetting properties that enable it to trap insects.

Explanations

Concepts and Terms

Pitcher Plant (Nepenthes): A carnivorous plant that has a pitcher-like structure
Surface Wetting: The inner surface of the pitcher can become very slippery when wet, which helps the plant trap insects like ants
Insect Trapping Mechanism: Insects are attracted to the plant's sweet nectar, and once they venture inside the pitcher, the slippery surface causes them to fall into the trap where they are digested by the plant

Notes:

- The slippery surface in the pitcher plant is an excellent example of how surface wetting properties can be utilized for biological functions
- This functionality showcases how certain natural surfaces can alter their wettability to achieve a specific purpose, in this case, trapping prey efficiently

Summary and Explanation of Slide 57 on SURFACE WETTING

Summary

This slide illustrates the inner surface of a pitcher plant and emphasizes that it is rough, not smooth.

Explanations

Concepts and Terms

Image A: Displays a photo of the pitcher plant.
Image B, C, (d), (i): Electron microscope images showcasing the microstructure of the inner surface.

Diagrams and Data

Relevant terms

- **WP**: Likely refers to ”wax particles.”
- **C**: Could denote specific features like ”cells” or another structural aspect.

Rough surfaces

- Contribute to specific wetting properties which may trap prey or collect nutrients.

Notes:

- Understanding the surface texture helps explain the plant's water interaction and prey trapping mechanism, relevant to the study of surface wetting.

Summary and Explanation of Slide 58 on SURFACE WETTING

Summary

The slide explains how the surface wetting of the pitcher plant affects the ability of ants to climb its structure.

Explanations

Concepts and Terms

Dry Surface: On a dry surface, the friction is high, which allows ants to walk up and down easily.
Wet Surface: When the surface is wet, a lubricating film of water forms between the rough surface features of the plant, reducing friction. This causes ants to slide off the surface.

Notes:

- The pitcher plant uses surface wetting as a mechanism to trap prey.
- This principle of reduced friction due to surface wetting is relevant in various applications, including biomimicry designs and anti-slip technologies.

Summary and Explanation of Slide 59 on SURFACE WETTING

Summary

The slide presents the creation process of nanoscale slippery, lubricant-infused porous surfaces (SLIPS), explaining step-by-step how to form these coatings.

Explanations

Concepts and Terms

SLIPS (Slippery, Lubricant-Infused Porous Surfaces): These are surfaces designed to be extremely slippery by infusing a lubricant into a porous structure.
Layer-by-Layer (LbL) Process: A method involving the sequential deposition of various layers to build up the SLIPS coating.

Diagrams and Data

Figure Explanation

- *i.* Introduction of negative charges to the substrate.
- *ii.* Adsorption of positively charged polyelectrolytes onto the substrate.
- *iii.* Adsorption of negatively charged silica nanoparticles to the polyelectrolyte layer.
- *iv.* Formation of a hybrid thin film through further adsorption of polyelectrolyte and nanoparticles.

- *v.* Calcination process to produce a porous silica coating.
- *vi.* Covalent functionalization of the silica coating with fluorinated silanes.
- *vii.* Wicking a fluorinated lubricant into the porous structure.
- *viii.* Resulting in a non-adhesive and slippery surface facilitating the easy sliding of immiscible liquids.

Notes

- *Calcination*: A thermal treatment process applied to the inorganic materials. It alters the structure to produce a porous coating.
- *Fluorinated Silanes and Lubricants*: These provide the slippery characteristic due to their low surface energy and chemical nature.

Summary and Explanation of Slide 60 on SURFACE WETTING

Summary

The slide discusses the efficiency of artificial slippery surfaces and their properties with varying numbers of coating layers.

Explanations

Concepts and Terms

Artificial Slippery Surfaces: *The term refers to engineered surfaces that reduce friction and improve the sliding of liquids.*
Water Contact Angle (CA) Hysteresis: *Lower values for more coated layers indicate better slipperiness.*
Octane Contact Angle (CA) Hysteresis: *Higher number of coated layers generally increases hysteresis.*
Water Sliding Angle: *Lower angles with more coating layers signify better slipperiness.*
Octane Sliding Angle: *Similar trend to water sliding angle, confirming improved efficiency with more layers.*

Diagrams and Data

Graphs Analysis

- Four graphs analyze different properties related to the slippery coatings:

- Water Contact Angle (CA) Hysteresis: Lower values for more coated layers indicate better slipperiness.
- Octane Contact Angle (CA) Hysteresis: Higher number of coated layers generally increases hysteresis.
- Water Sliding Angle: Lower angles with more coating layers signify better slipperiness.
- Octane Sliding Angle: Similar trend to water sliding angle, confirming improved efficiency with more layers.

Transparency of Coating

- The line graph on the right shows the transmittance percentage of different layers of the coating over a spectrum of wavelengths.
- The coating maintains high transparency (over 90% transmittance) even with increased layers.

Notes:

- **Contact Angle Hysteresis**: It is the difference between the advancing and receding contact angles of a liquid on a surface, indicating how easily a liquid slides off the surface.
- **Sliding Angle**: The tilt angle at which the liquid starts to slide down the surface – a lower angle means better slipperiness.
- **Transmittance**: It measures how much light passes through the coating; higher transmittance values denote better transparency of the coating.

This slide highlights the superior performance and transparency of artificial slippery surfaces with increased coating layers.

Summary and Explanation of Slide 61 on SURFACE WETTING

Summary

The slide demonstrates the effect of artificial slippery surfaces (SLIPS) compared to untreated surfaces using honey on glass and crude oil on polypropylene.

Explanations

Artificial Slippery Surfaces (SLIPS)

SLIPS are engineered surfaces designed to repel liquids and reduce adhesion. Developed at Harvard, these surfaces are highly effective in making sticky liquids like honey and crude oil slide off effortlessly.

Experiment Comparison

Honey on Glass

- Top row: Honey on untreated glass.
- Bottom row: Honey on SLIPS-treated glass.
- Observation: Honey slides off more easily from the SLIPS-treated glass than the untreated one.

Crude Oil on Polypropylene

- Left: Crude oil on an untreated polypropylene surface.

- Right: Crude oil on a SLIPS-treated polypropylene surface.
- Observation: Crude oil adheres to the untreated surface but slides off the SLIPS-treated surface.

Notes:

- *Material Names:*
Lbl SLIPS: Lab-made SLIPS, which enhances surface slipperiness.
Untreated: Surfaces without any slippery coating.
- *Study Reference:*
The findings are from Sunny et al., published in Advanced Functional Materials in 2014. This study underlines the potential applications of SLIPS in various industries requiring non-stick and self-cleaning surfaces.

Summary and Explanation of Slide 62 on SURFACE WETTING

Summary

The slide illustrates the effect of SLIPS (Slippery Liquid-Infused Porous Surfaces) coating on a bronchoscope in preventing fouling and aiding in easier cleaning.

Explanations

Concepts and Terms

SLIPS Coating: A type of surface treatment designed to reduce adhesion of fouling materials by creating a liquid-infused, slippery surface.
Bronchoscope: A device inserted into the airways, usually through the nose or mouth, to provide a view of the trachea, bronchi, and lungs.
Fouling: Accumulation of unwanted material (e.g., mucus, blood) on the bronchoscope surface.

Diagrams and Data

Section A:

- Shows the visual comparison before and after submersion, and final images before withdrawal for both uncoated and liquid-infused coated bronchoscopes.
- *Uncoated*: Evident fouling and difficulty in acquiring a clear final image.

- *Liquid-Infused Coated*: Demonstrates minimal fouling and a clearer final image.

Section B:

- Provides a detailed comparison of the bronchoscope images before sample retrieval, time to foul, and time to clear between uncoated and liquid-infused coated bronchoscopes across three biopsies.
- *Uncoated*: Shows fouling times ranging from 3 to 4 seconds and average clearing time of 67 seconds.
- *Liquid-Infused Coated*: Shows significantly reduced fouling times (mostly no fouling or minimal) and average clearing time of 4 seconds.

Notes:

- **Importance**: The slide demonstrates the effectiveness of SLIPS coating in reducing fouling and improving the clarity of images during bronchoscopy procedures, which is crucial for medical diagnostics and treatment.

Summary and Explanation of Slide 63 on SURFACE WETTING

Summary

This slide showcases various commercial products using LiquiGlide, which utilizes SLIPS (Slippery Liquid-Infused Porous Surfaces) technology.

Explanations

Concepts and Terms

LiquiGlide: A company that creates liquid coatings to prevent sticky substances from adhering to surfaces.
SLIPS (Slippery Liquid-Infused Porous Surfaces): A technology that creates super-slick surfaces to impede substances from sticking.

Demonstrated Applications

Maple Syrup, Hair Gel, BBQ Sauce, Ranch Dressing, and Mayonnaise

- These products showcase the effectiveness of LiquiGlide in food industry containers, helping to pour out sticky substances without waste.

Nail Polish

- Demonstrates ease of dispensing, reducing residue and waste.

Lotion

- Highlights the utility in health and beauty products to ensure full usage of the product.

Ketchup

- Similarly demonstrates easy dispensing and reduced waste in condiment containers.

Wood Glue

- Shows the technology's application in industrial products to prevent clogging and ensure efficient usage.

Notes

- The URL at the bottom can be visited for more detailed information about LiquiGlide technology and other applications.