RBPT: Superhydrophobicity for energy efficiency (BITS F416) 09/02/2018

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Problem and Context

Context

Solar energy is one of the most preferred renewable energy sources for electricity in India and other parts of the world. Solar energy is extracted by converting the light from the sun to electricity with the help of solar cell panels made out of semiconducting materials. Depending on the power requirement several such modules has to be connected together and placed in an open area where sun light is available in plenty. In India, one can find several such installations in Gujarat and Rajasthan. One of the main issues that severely affects the performance of these modules is the dust accumulated on the panel. In particular, the dust accumulated on the surface of the panel reduces the photovoltaic efficiency resulting in power loss. To minimize such power losses panels are regularly cleaned with water manually. This is a laborious process if the panels are spread across a large area and also manual cleaning need not be good enough. In such situations, nanoscience could offer a solution based on the self-cleaning mechanism of surfaces which are superhydrophobic.

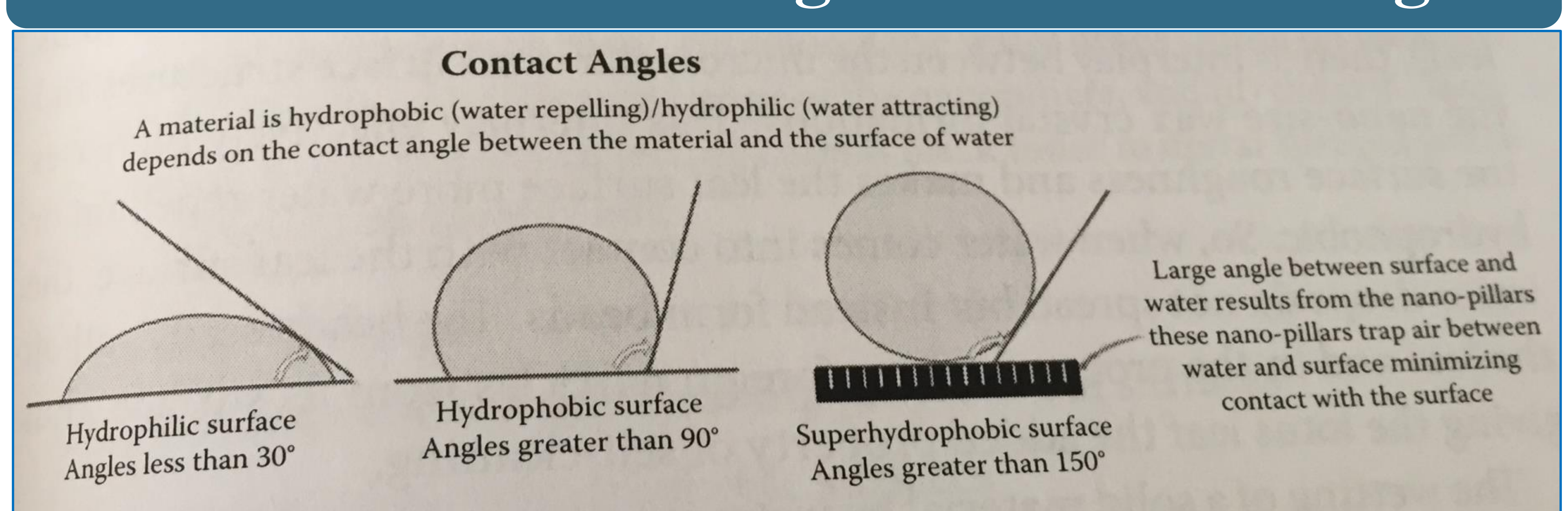
Problem

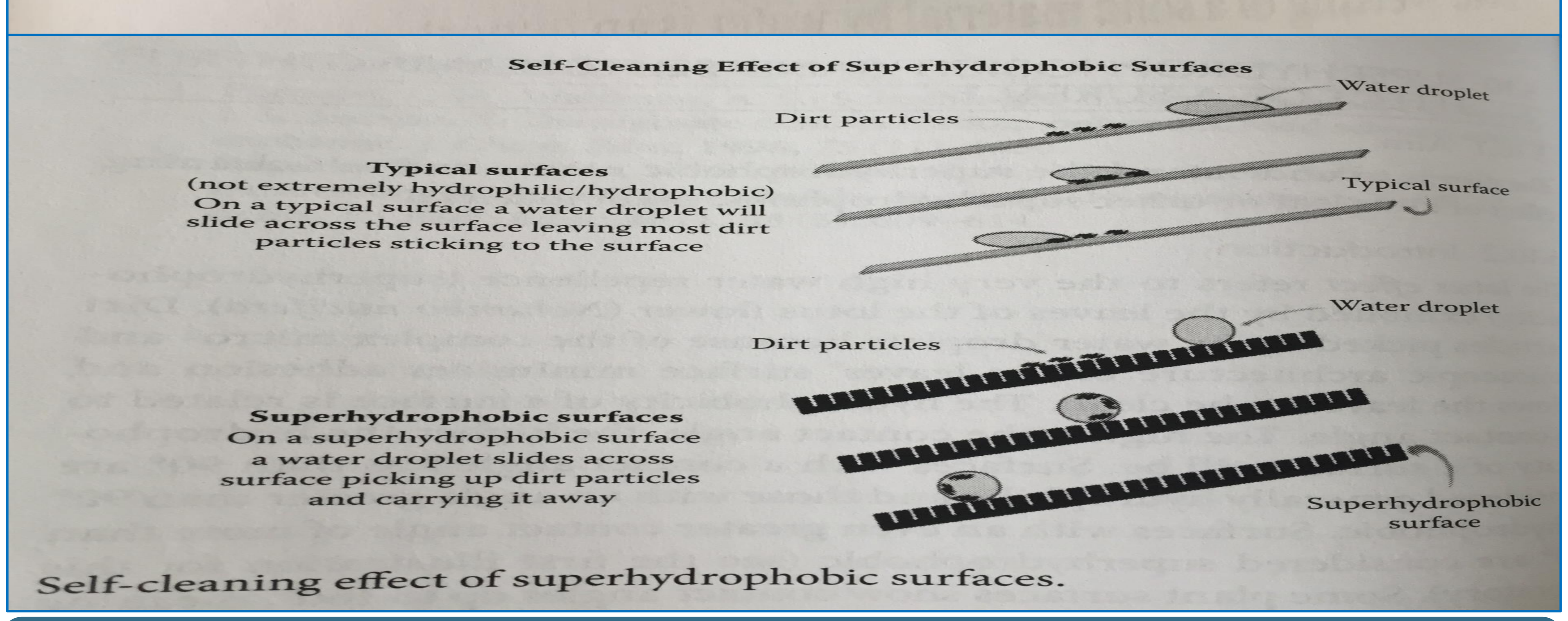
Each team has to investigate at least ten natural surfaces (leaves of plants and tress) you can find in and around BPHC campus and report about their hydrophillic and hydrophobic properties. The team which finds the BEST superhydrophobic surface WINS. Each team will also make a small proposal on how they will use the newly discovered superhydrophobic surface to clean the solar panels and therefore SAVE ENERGY.

Introduction: Superhydrophobicity, Self – cleaning and lotus effect

1. The hydrophobicity of a surface is defined with respect to contact angle
2. The higher the contact angle, the higher the hydrophobicity of a surface
3. Surfaces with contact angle less than 90^0 are mostly hydrophillic and those with contact angles more than 150^0 are considered superhydrophobic
4. Lotus effect is the high water repellence (superhydrophobicity) exhibited by the leaves of the lotus flower (Nelumbo nucifera).
5. The lotus leaves have intricate micro- and nanoscopic architecture that prevent dust accumulation and the surface remains clean.

Illustration of contact angle and self-cleaning





Procedure

1. Cut small rectangular sections from the leaf and add glue. Place cut samples on the flat surface of the microscope slide.
2. Add 50 μL of dye colored water to each cut leaf. Take pictures of the slide using digital camera and estimate the contact angle of the water droplets for each sample. Photos should be taken at the eye level.
3. In order to understand self-cleaning of the leaves sprinkle black carbon toner on the leaf. Add water droplets at 50 μL intervals for 5 mL and film it.
4. Extract the sequential frames to see the self-cleaning effect.

Assessment

1. Every team has to create a poster and display it in front of selected faculties. The poster presentation is also open to the BPHC community.
2. This project carries a 20% weightage of the total marks for the nanoscience course.

Learning Outcomes

1. Concept of wetting and surface tension
2. The idea of hydrophlic and hydrophobic surfaces through experimentation
3. Demonstration of self – cleaning properties of surfaces
4. Creation of superhydrophobic surfaces
5. Will learn the usage of advanced equipment like Atomic Force Microscope and Confocal microscope

Student Activities

1. Collect samples of leaves from the campus and the neighbourhood.
2. Clean the leaves with triple distilled water and follow the procedure to place them in microscopic slides.
3. Estimate the contact angles using digital photos and infer whether the leaf is hydrophobic or hydrophllic.
4. Perform self-cleaning experiments using black carbon toner.
5. If you have discovered a superhydrophobic surface investigate the surface of the leaf using AFM and confocal microscopy and jot down the reasons for the superhydrophobic properties of the leaf.
6. Continue your investigations till you find the WINNING hydrophobic surface.

Instructor Activities

1. Explain as well as demonstarte how the leaf has to be preparaed on the microscopic slide for the testing of contact angle.
2. Explain and demonstarte how the contact angle could be measured using digital camera.
3. Explain the working principle of AFM and confocal microscope. Help the students to interpret the images obtained from AFM and confocal microscope.
4. Identify and provide a place for students to conduct the experiments.
5. Meet the teams once in a week to monitor the progress as well as to provide useful suggestions and hints for the success of the project.
6. Provide research articles from the literature on superhydrophobicity that will help students better in their investigations.

Rewards

1. BEST three posters will get an AWARD
2. If a team discovers a new superhydrophobic material in the process which could also be useful for any potential applications a PATENT could be filed.
3. A start-up can emerge from the project.

Acknowledgements

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