https://doi.org/10.1557/mrs.2011.47 Published online by Cambridge University Press

Bio Focus

Bacterial biofilm demonstrates nonwetting behavior

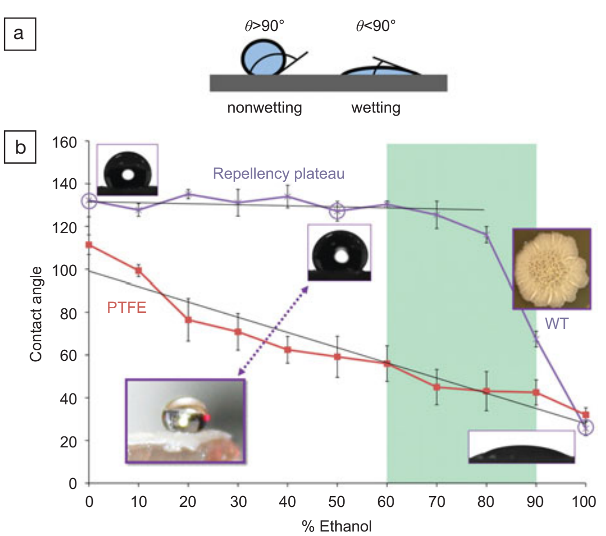
The performance of heat exchangers, ventilation systems, ship hulls, and medical implants are often compromised by biofilms. Biofilms are communities of microorganisms that form on solid or fluid interfaces and are designed to protect the individual cells, such as bacteria, from the environment. Protection largely comes from the extracellular matrix (ECM) that is secreted by the cells. The ECM hinders diffusion of molecules through the biofilm, which limits the effectiveness of antimicrobials and can lead to drug resistance. The resulting pernicious nature of biofilms is commonly associated with the complex chemistry of the ECM. However, researchers at Harvard University have recently demonstrated that the chemistry and topography of biofilms of the bacteria *Bacillus subtilis* exhibit nonwetting behavior, which provides an additional defense mechanism.

As reported in the January 18th issue of the *Proceedings of the National Academy of Sciences* (DOI: 10.1073/pnas.1011033108; p. 995), A.K. Epstein, B. Pokroy, A. Seminara, and J. Aizenberg measured the contact angle of a series of water/ethanol solutions on biofilms of *B. subtilis*. Surprisingly, the biofilm maintained a constant contact angle (~135°) up to a concentration of 80% ethanol. Hydrophobic materials such as Teflon® exhibit a linear decrease in contact angle with ethanol concentration and even 20% ethanol solution wets its surface. This is significant because it demonstrates that liquid does not reach the bulk of the biofilm and no chemical change occurs in the biofilm exposed to 60–70% ethanol—a range commonly thought to be disinfectant.

To further describe the fluid-repellent nature of the biofilm, the researchers examined the influence of topography. These biofilms naturally have an undulating surface at the 10s–100s μm scale. Confocal microscopy showed that drops containing a fluorescent dye stained only on the top layer of the biofilm and did not penetrate into the grooves of the surface. This demonstrates that the biofilm exhibited Cassie–Baxter wetting, a state which traps gas within the topography and is common for many superhydrophobic surfaces. However, epoxy replicates of the surface did not reproduce the contact angle behavior of the biofilm. This shows that a combination of the topography and a dynamic chemistry of the ECM are responsible for liquid repellency.

The researchers demonstrated that water repellency on the macroscopic scale may provide bacteria an additional defense mechanism to antimicrobial agents. The researchers are careful to note that this strain of bacteria is commonly found in soil, so biofilms that are constantly submerged in water will likely exhibit different behavior. Yet this research demonstrates that some sterilization techniques, such as soaking in disinfectant, may not be effective for certain types of bacteria.

Scott Cooper



(a) Schematic of contact angles on nonwetting (θ > 90°) and wetting (θ < 90°) surfaces. (b) Contact angle of the wild-type (WT) biofilm of *B. subtilis* for a series of water/ethanol solutions. The contact angle remains relatively constant at ~135° up to a concentration of 80% ethanol. Polytetrafluoroethylene (PTFE) demonstrates an incremental decrease in contact angle with the concentration of ethanol (surface tension of the liquid). The green region denoting 60–90% ethanol is commonly regarded as antimicrobial for free-swimming bacteria. *Source: PNAS* **108** (3)(2011) DOI: 10.1073/pnas.1011033108; p. 995. © 2011 National Academy of Sciences.

Mid-infrared Fe:ZnSe laser achieves output energy scaling at room temperature

The development of a compact mid-infrared (mid-IR) laser operating over a 2–10 μm spectral range has been a challenge for several decades. This range contains the atmospheric transparency window that allows for easy passage of radiation to the earth's surface. Many important atmospheric constituents have absorption lines in the 2–10 μm "molecular fingerprint" region. Mid-IR lasers are thus suitable candidates for applications in space optical communications, as well as in remote sensing, trace gas analysis, laser surgery, and medical diagnosis. Lasers based on II–VI compounds doped with transition metals (such as Fe-doped binary and ternary chalcogenides) with a gain bandwidth of up to 50% of the central wavelength constitute a viable route for broadly tunable mid-IR coherent sources. They can provide very high power levels with good beam quality, but realizing these in practice has been a challenge. While some sources have been developed, the output energy levels have been unacceptably low. N.-S. Myoung, S.B. Mirov, and colleagues from the University of Alabama at Birmingham have now achieved energy scaling in a 4.3 μm Fe:ZnSe mid-IR laser at room temperature by optimizing the fabrica-

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