Contribution ID: **95**

Type: **Poster Only**

Investigating Bacterial Behavior on Nanostructured TiO2 to Guide Antifouling Surface Engineering

Understanding bacterial adhesion on biomaterial surfaces is critical for developing anti-bacterial and/or antifouling surfaces. In this study, we investigate two clinically relevant bacterial strains—Escherichia coli ATCC 25922 and Staphylococcus aureus ATCC 49775—on titanium dioxide (TiO_2) nano structured and flat surfaces, and bare glass substrates. Our goal is to elucidate how nanoscale topography of the surface influence bacterial attachment and viability.

We fabricated TiO_2 nanostructures with varying nano-bump densities and interspacing and characterized their surface morphology using atomic force microscopy (AFM). Surface roughness parameters were quantified, and grain density analysis was performed using Gwyddion software. Water contact angle measurements were used to assess surface hydrophobicity and correlate it with bacterial adhesion trends.

To evaluate bacterial attachment, we employed fluorescence microscopy to quantify surface coverage over 24hr and distinguish between live and dead cells. Scanning electron microscopy (SEM) provided high-resolution visualization of bacterial morphology and adhesion patterns across different surfaces. Comparative analysis revealed that nanostructured TiO_2 surfaces significantly altered bacterial adhesion behavior relative to flat titanium and glass, with variations in adhesion energy linked to nano-bump density and wettability.

Our findings suggest that engineered nanoscale features on TiO_2 surfaces can modulate bacterial attachment due to the variation in nanostructure density and spacing on the surface. This work provides a foundation for predictive modeling of surface adhesion energy and offers insights into the design of next-generation antibacterial surfaces.

Topical Area

Emerging research and multimodal techniques

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