Engineering antimicrobial surfaces using MoS_2 and WS_2 nanowalls

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The development of novel antimicrobial coatings is important, as implant associated infections are difficult to treat. As the use of antibiotics is always temporally restricted, especially in implant-associated infections, surface-based, non-antibiotic antimicrobial strategies are of great demand. Transition metal dichalcogenides (TMDs), such as MoS_2 and WS_2 have recently attracted broad interest in both fundamental and applied research owing to their unique chemical and physical properties. While widely explored for applications in energy storage and catalysis, these materials are also emerging as promising antimicrobial agents. Among their different morphologies, vertically aligned TMD nanowalls are especially attractive for antimicrobial applications, due to their extremely high roughness and hydrophobicity. In this study, we synthesize MoS_2 and WS_2 nanowalls directly on titanium substrates – Ti6Al4V a widely used titanium alloy for orthopedic bone implants – using metal–organic chemical vapor deposition (MOCVD) [1]. By systematically tuning the growth conditions we achieved morphologies with variable wall lengths and densities. The resulting structures are characterized using X-ray photoelectron spectroscopy (XPS), Raman spectroscopy, atomic force microscopy (AFM), scanning electron microscopy (SEM) and water contact angle measurements. To study the antimicrobial properties of the coatings, the samples were inoculated with GFP-labelled *Staphylococcus aureus*. After incubation, bacterial adhesion was assessed by fluorescence microscopy and SEM, enabling direct visualization and quantification of bacterial colonization on the different TMD morphologies. Morphological parameters and the bacterial attachment are quantitatively extracted with the image-analysis platform JIPipe [2], enabling direct correlation between MOCVD conditions, nanowall architectures and antimicrobial activity. Our results demonstrate that titanium substrates functionalized with TMD nanowalls possess superior antimicrobial properties in comparison to the bare substrates.

References

[1] Z. Gan, R. Sadhukhan, C. Neumann, A. Turchanin, *Mater. Today Catal*. 6 (2024) 100060.
[2] R. Gerst, Z. Cseresnyés, M. T. Figge, *Nat. Methods* 20 (2023) 168–169.

Figures

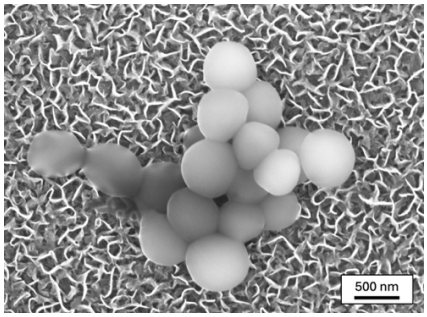

Figure 1: SEM image of *S. aureus* interaction with MoS_2 nanowalls. Surface attachment appears unfavorable, as cells form clusters rather than adhering to the substrate. Some bacteria display membrane damage, indicating compromised integrity.