Project STOP: Preventing the transmission of pathogens

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The EU-funded project STOP aims to develop long-lasting, sprayable, antimicrobial and antiviral nanocoatings for highly frequented surfaces, combining inorganic nanoparticles, antimicrobial peptides and laser-induced surface structuring [1]. These coatings are designed to minimize resistance development, reduce infections, healthcare costs, and disinfectant-related pollution, and improve pandemic preparedness. Fraunhofer IKTS in Forchheim contributes to the project by conducting detailed surface characterization of systematically varied nanocoatings using advanced microscopy and spectroscopy techniques.

Figure 1 shows a scanning electron microscopy (SEM) image of a typical sprayable nanocomposite coating on a stainless-steel substrate, featuring metal-based TiO_2 nanoparticles dispersed in a Darvan matrix, chemically identified by Raman spectroscopy (Fig. 2). The TiO_2-Darvan mixture ensures a stable suspension, improved adhesion, mechanical stability, and enhanced antimicrobial properties, all essential for real-life conditions. Later in the project, helium ion microscopy (HIM) with charge compensation will be used to visualize bacteria and viruses on various surfaces, to assess the efficacy of different coatings. HIM provides high-quality imaging of biological samples with minimal sample damage and charging.

Laser patterning of surfaces to induce nanoscale roughness (so-called laser-induced periodic surface structures – LIPSS [1])

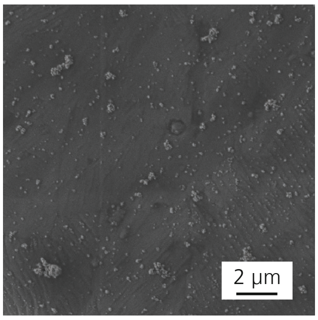

Fig. 1: SEM image of a TiO_2-Darvan sprayable antimicrobial coating on a stainless-steel surface.

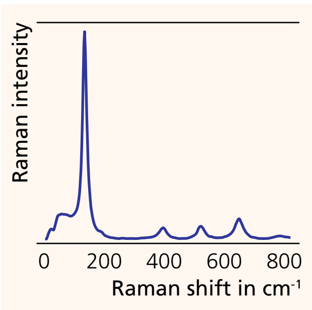

Fig. 2: Chemical identification of TiO_2 nanoparticles by Raman spectroscopy.

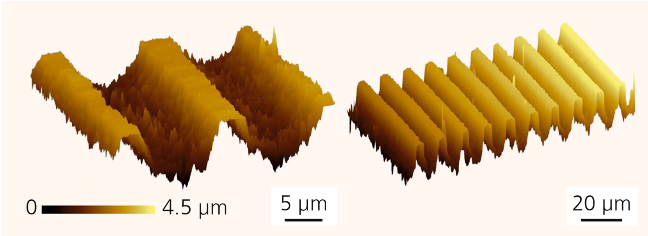

Fig. 3: Left: AFM image of a laser-patterned glass substrate with LIPSS to prevent bacterial and viral attachment. Right: Large-area optical profilometry of the same sample.

is an effective approach to prevent bacterial and viral attachment by physically disrupting the pathogens and/or increasing hydrophobicity. Atomic force microscopy (AFM) and optical profilometry can be used to analyze the topography of lasered surfaces. While AFM captures the finest nanoscale details of surface roughness over smaller areas, optical profilometry provides faster measurements over larger areas but with lower lateral resolution compared with AFM.

Figure 3 shows 3D AFM (left) and 3D optical profilometry (right) images measured on a typical lasered glass substrate. These techniques provide nano- to macroscale roughness data, with the latter being important for statistically relevant correlations with pathogen colonization on large highly frequented surfaces, such as those found in hospitals.

In the project STOP, Fraunhofer IKTS uses nanoGPS technology to relocalize the same region of interest across different instruments [2]. This enables the acquisition of morphology, topography, and compositional data on the same objects (nanoparticles, bacteria, viruses) and the integration of this data into a correlative-analytical workflow using customized machine learning algorithms.

Services and cooperation offered

- Nanocoating and laser surface modification
- Correlative, multiscale microscopy and spectroscopy
- Machine learning for analyzing complex datasets

Literature

[1] L. Sotelo et al., Adv. Mater. Technol. 8, 2201802 (2023).
[2] A Kraus et al., Cells 12, 1245 (2023).

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