Nanostructured complex polymer films with long-lasting antimicrobial efficacy

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Development of long-lasting antimicrobial surfaces is critically important not only to prevent biofilm formation and limit contamination and transmission(1, 2), but also to reduce chemical usage and promote environmental sustainability(3-5). This project aims to understand the nanostructure of novel polymer coatings that underpin their newly discovered long-lasting antimicrobial efficacy, preventing the spread and growth of pathogens over a prolonged period of time. To this end, we have evaluated the components in a cleaning formulation developed by Wessex Chemical Factors, found to possess promising long-lasting antimicrobial properties against Gram-negative *Pseudomonas aeruginosa* and Gram-positive *Staphylococcus aureus* and yeasts 48 hours after a single spray application of the product on a surface.

The formulation actives comprise poly(dimethylsiloxane) (PDMS), a water-based silane emulsion, and biocides. To better understand the functional and structural role of each component within the produced film, we dip-coated them onto silicon wafers in a controlled manner and then analysed the film structure using X-ray reflectivity (XRR). The films were measured by X-ray reflectivity at beamline BM28 of the European Synchrotron Radiation Facility (ESRF) and at Diamond I07 (UK). The XRR Kiessig fringes (i.e. intensity oscillations) were observed on silica dip-coated in 1 wt% PDMS (WM 2,500 g mol^{-1} with a corresponding viscosity of 65 cSt; Curve 1, Fig.1), indicating a well-organized film structure with a thickness of 14.8 nm and a roughness of 0.49 nm. However, after rinsing with hexane, the oscillations diminished, and the thickness decreased to 1.48 nm, with a roughness of 0.16 nm (Curve 2, Fig. 1). Another component in the formulation is a silane-based compound (silane, 0.14 wt%). To evaluate its role, we evaluated the XRR profile before and after rinsing, showing that the films remain after rinsing (thickness of 1.7nm) (data not shown). In contrast, when silane was dip-coated first (Fig. 1A), the thickness decreased from 14.8 nm to 4.0 nm after rinsing, indicative of improved stability. A two-layer model (PDMS on silane) provided an excellent fit to the reflectivity data (Curve 4, Fig.1). Contact angle measurements confirmed the presence of a hydrophobic surface after rinsing with water and hexane (Fig. 1B). Furthermore, the antimicrobial tests demonstrated that the efficacy of the formulation was improved due to the presence of the polymeric platform. Such structural information will help to understand the function-structure relationship in long-lasting antimicrobial efficacy of the films and inform optimization of formulations.

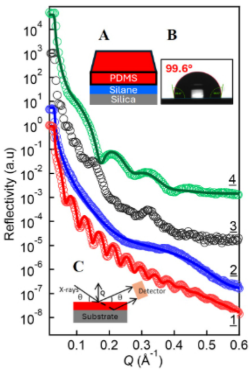

Figure 1. XRR data (symbols) and fittings (solid curves) of PDMS (1.0 wt%, 65 cSt) 1 pre-rinsed, 2 post-rinsed, and silane+PDMS, 3 pre-rinsed, and 4 post-rinsed. A) Schematic of XRR model, B) Contact angle of a water droplet on PDMS-silane coated silica, and C) Sketch of the XRR experimental setup.

References:

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