Evaluation of Fresh Water Fouling Films Formed During Germicidal-Ultraviolet Water Purification

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ABSTRACT

Research in progress concerns the assessment of biological fouling on quartz sleeves used to protect ultraviolet (UV) lamps in a water purification unit. The equipment is in use at the Great Lakes Center located in Buffalo, NY where it is provided with water from the Black Rock Canal entering into Lake Erie. Exposure to natural water systems causes fouling buildup of organic, mineral, and biological components on the sleeves hindering the throughput of the UV rays and decreasing the integrity of the purification system. Biological fouling of a surface is preceded by the adsorption of a proteinaceous layer and the formation of a "conditioning film", whose adhesive and retention properties are dictated by the critical surface tension (CST) of the material's surface and reduced when the CST is between 20-30 mN/m. Coatings, intended to modify the surface of the quartz sleeves to within this range, are being investigated for differences in fouling rate, composition, adhesion and retention strength and stability after UV exposure.

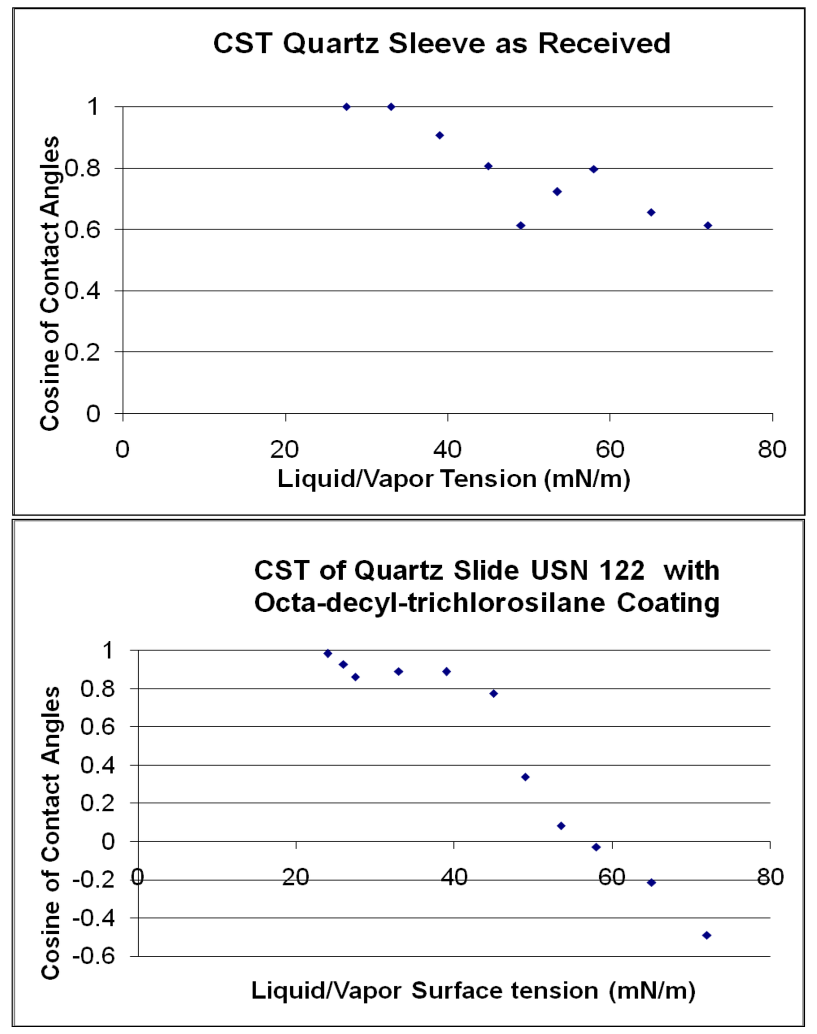
INTRODUCTION

Deposition of micro and macro-organisms on material surfaces in contact with biological fluids, such as freshwater, seawater, blood, and milk, is a problem continually plaguing industries which rely upon direct interaction of the material at the solid-liquid interface. Biological fouling of quartz sleeves in UV water purification systems is directly responsible for the decrease in performance and usability of these sleeves over a period of time. The fouling formation becomes hardened to the quartz making it difficult and, perhaps, impossible to mechanically remove from the surface without affecting the integrity of the sleeves. In order to examine this problem more closely, surface analysis and fouling deposition analysis were done on quartz sleeves used in UV purification units, quartz slides, and the quartz-surrogate substrata of germanium prisms. The information gained through these evaluations will help to determine whether the proposed solutions to the fouling problem are actually effective in doing so.

METHODS & MATERIALS

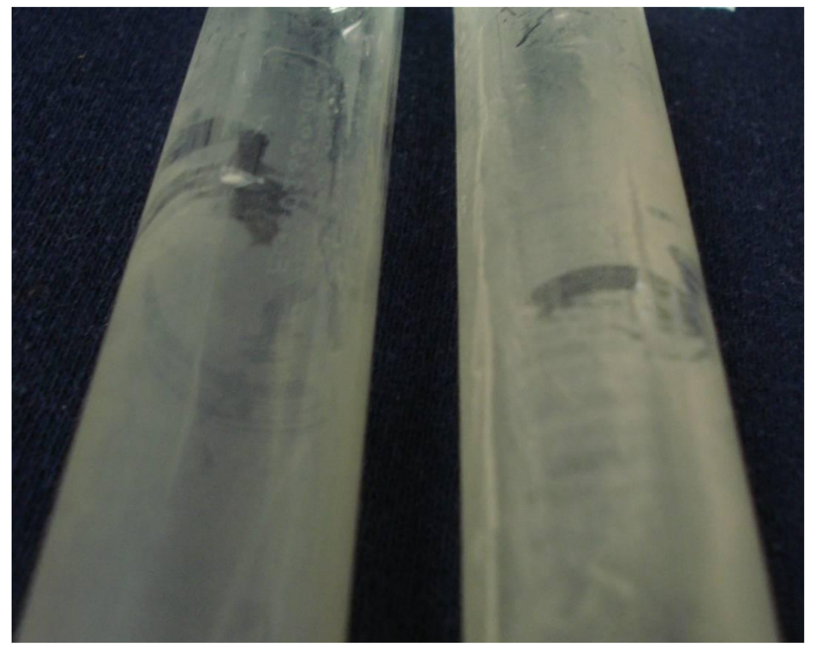
Contact angle analysis was used to determine the critical surface tension of the three different substrata in various stages: as received, after coated in a test coating and polished, and after being fouled: through use in the UV purification unit (quartz sleeves), through use in flow cells (germanium prisms) and through use in a manifold/UV lamp set-up (quartz slides.) Infrared spectroscopy was utilized to investigate the composition of the water, coatings and fouling depositions via germanium prisms. Fouling removal has and continues to be studied using two methods: a brush shear test to determine the mechanical shear force necessary for fouling removal, and a hydro-shear test to determine whether removal is possible, within the means available, through hydro-dynamic shear forces alone.

RESULTS

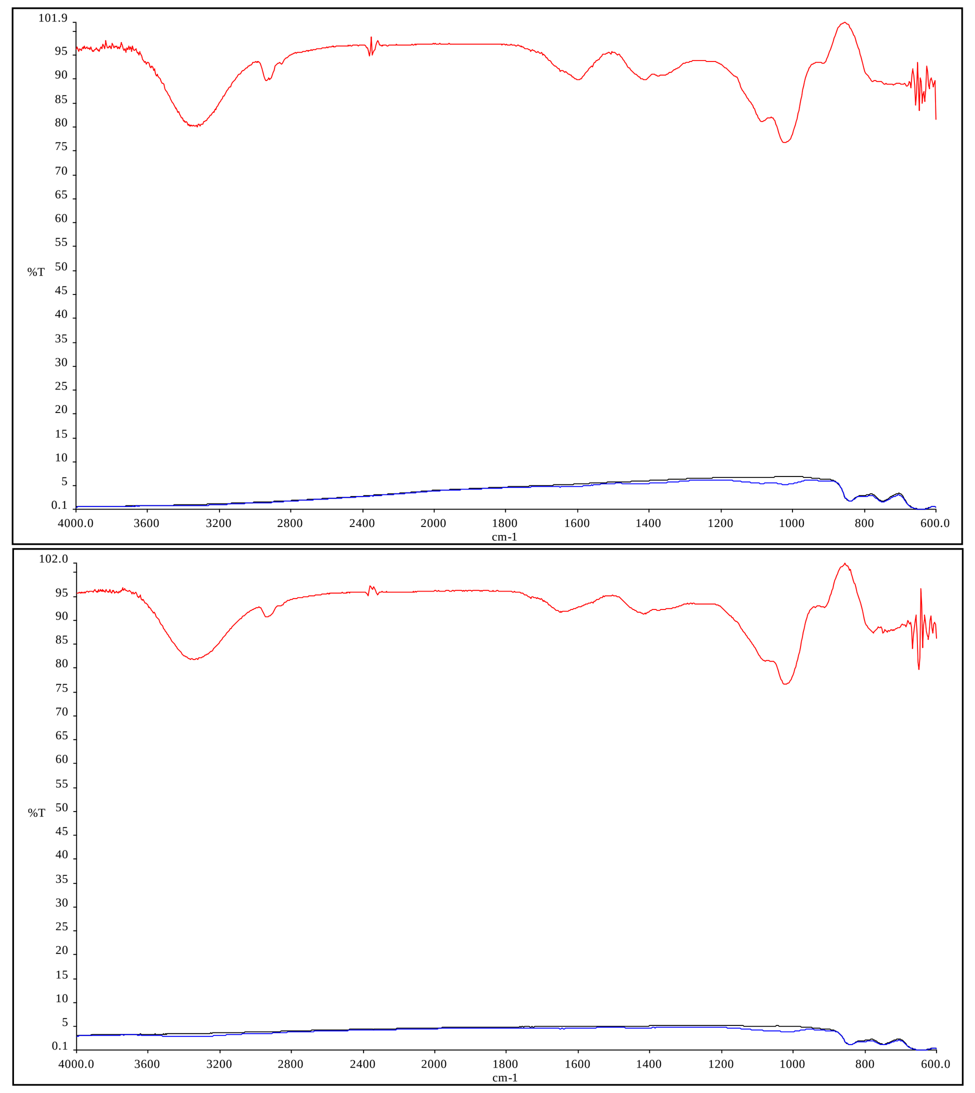


Change in critical surface tension on the quartz surfaces is seen by the different intercepts at the 1 x-axis.

☐Shear brush test designed to determine mechanical shear necessary to remove fouling from sleeves of different initial critical surface tensions. Set #7 sleeve A, uncoated, on the left required 25 strokes and sleeve B, ODS coated required 20.



After 6 weeks in the UV water purification unit, Sleeve Set #7 showed differences in fouling between the ODS-coated and as-received quartz sleeves. Sleeve A, uncoated, is on the left, and Sleeve B, ODS coated is on the right.



Fouling transfers from Set #5, have very similar infrared spectra showing the presence of hydroxyls, amines, methylene, amides, carbonates, and carbohydrates or silicates. Sleeve A, uncoated, is at the top and Sleeve B, ODS-coated is at the bottom.

CONCLUSIONS

Modification of the quartz sleeves' surfaces from outside to within the "easy-release" range of critical surface tension can be accomplished by coating them in octa-decyl-tricholorosilane(ODS.) Although the sleeves were placed into the UV purification unit with different critical surface tensions, fouling for both the coated and uncoated sleeves occurred within 48 hours. However, the fouling on the ODS-coated sleeves appeared more raised than that of the as-received sleeves, which may indicate a difference in the fouling retention between the coated and un-coated sleeves or an adverse reaction between the coating and the UV exposure. Additional testing will need to be done to determine whether the ODS coating is altered and/or degraded by the UV exposure within the purification units. Consistencies between the infrared spectra of the distilled water transfers and the water characterization are a good indication that although surface chemistries may be different, exposures to the same aqueous environment produce similar fouling compositions.

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