Robust Liquid-Repelling Nanofilament Coatings for Enhanced Oil Flow, Reduced Biofouling, Scaling and Corrosion within Oil Wells

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Abstract:

Corrosion and scaling have tremendous impact on oil well maintenance intervals. Liquid-repelling surfaces (LRS) have high potential to protect well pipe surfaces. Taking inspiration from the slippery surface of a pitcher plant (*nepenthes truncate*), LRS are designed to repel water by maintaining a liquid layer of oil within a nanostructure silicone network. We chose silica (SiO_2)-based nanofilaments (SiNF), which can be deposited out of a simple solution reaction and would be applicable for pipe surface coatings. SiNF surfaces are self- cleaning and are expected to protect pipes from scale formation, biofouling, and corrosion. By using SiNF coatings in wells, maintenance intervals can be prolonged and operational costs can be severely reduced. Our goal is to move SiNF coatings from its current academic context towards field-testing under realistic conditions. We characterized the growth of SiNFs on steel surfaces with scanning electron microscopy (SEM) and energy dispersive x-ray (EDX) spectroscopy. To test the stability of the SiNF coatings on steel surfaces, we have designed and constructed a flow reactor, which can mimic the pressure, temperature, and shear stress expected in an oil well. Using this reactor, we have been able to validate that the coating of clean steel pipe surfaces is stable under well pipe flow rate conditions of up to 10,000 barrels per day. We field-tested the SiNF coatings under realistic conditions to test its ability to reduce scale formation. The field-test was conducted over 3 hours and the uncoated surface developed 16.3 ± 1.5 mg (0.345 ± 0.032 % increase) of scale while the coated surface only had 4.0 ± 0.1 mg (0.085 ± 0.017 % increase) of scale, a reduction of 75%, compared to an uncoated surface.

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