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Effect of microbial treatment on the prevention and removal of paraffin deposits on stainless steel surfaces

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HIGHLIGHTS

- The wettability of stainless steel can be changed to water-wet through bio-treatment.
- Adhesion work is used to evaluate the efficiency of the bacterial method.
- Cells can emulsify hydrocarbons by forming cell layers on the hydrocarbon surface.
- Microorganism can remove the paraffin deposits on the solid surfaces.

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ABSTRACT

In this study, biosurfactant-producing strain N2 and non-biosurfactant producing stain KB18 were used to investigate the effects of microbial treatment on the prevention and removal of paraffin deposits on stainless steel surfaces. Strain N2, with a biosurfactant production capacity, reduced the contact angle of stainless steel to 40.04°, and the corresponding adhesion work of aqueous phase was decreased by 26.5 mJ/m^2. By contrast, KB18 could only reduce the contact angle to 50.83°, with a corresponding 7.6 mJ/m^2 decrease in the aqueous phase work adhesion. The paraffin removal test showed that the paraffin removal efficiencies of strain N2 and KB18 were 79.0% and 61.2%, respectively. Interestingly, the N2 cells could attach on the surface of the oil droplets to inhibit droplets coalescence. These results indicate that biosurfactant-producing strains can alter the wettability of stainless steel and thus eliminate paraffin deposition.

1. Introduction

Paraffin is complex mixture containing n-alkane, iso-alkane, and cycloalkane. During the oil exploitation process, when the temperature is lower than the wax appearance temperature (WAT) in the pipeline, the paraffin in crude oil can precipitate and form particles. When crude oil exhibits a non-Newtonian state, particles may adhere to the surface of the pipeline and form blockages. This phenomenon occurs widely in oil exploitation and transportation systems, especially in the offshore oil industry, leading to pipeline blockages and increases in exploitation cost.

Mitigation methods for paraffin deposition generally include chemical and physical treatments. Chemical methods can inhibit the deposition process by lowering the WAT or cloud point to prevent paraffin from adhering to pipeline walls. However, inhibitors may be not suitable because of their limited commercial efficacy, which requires evaluation on a case-to-case basis (Aiyejina et al., 2011). Physical methods mainly include pigging and heat washing. Pigging is a mechanical way of launching a pipeline pig along the line to scrape deposited paraffin from the walls. However, the pigging method may not work because of mechanical problems or incorrect optimization (Fung et al., 2006). Heat washing can clean deposited paraffin from the surface of pipelines by high temperature but decreases in temperature precipitate and deposit paraffin on the pipeline yet again (Rana et al., 2010).

The microbial paraffin removal method is a technique that utilizes microbe-enhanced oil recovery technology. Compared with chemical and physical methods, microbial treatment has several advantages, including simple construction, long washing periods, low energy costs, and environment-friendliness (Sood and Lal, 2008). Rana et al. (2010) reported that the use of microbes could

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