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Investigation of microbial souring mechanisms and test of natural antibiotics for MIC prevention

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INTRODUCTION

Offshore oil production facilities are subjectable to internal piping corrosion, potentially leading to human and environmental risk, and significant economic losses. Microbiologically influenced corrosion (MIC) and souring (sulphide production by Sulfate-reducing prokaryotes) from bacteria (SRB) or archaea (SRA) occur due to water flooding during secondary oil recovery, where the seawater used can contain large amounts of sulfate (25-30 mM). MIC is often seen as localized pitting attack that is generally associated with the presence of microbial communities embedded in a matrix (often with bioinorganic matrixes) referred to as biofilms. Active phytochemicals including strong antimicrobials from halophytes will be applied in this study to combat MIC by inhibiting MIC microorganisms such as methanogens and SRP. A bioreactor system for biofilm production was setup and inoculated with Wadden Sea sediments to emulated onsite MIC.

MATERIALS AND METHODS

PHASE 1 Formation of biofilm: Three reactors were inoculated with sediments obtained from Wadden Sea and continuously circulated with Postgate media while maintained at 25°C. Each reactor has four stainless steel and four carbon steel coupon. The ATP, pH, and hydrogen sulphide levels were measured at regular intervals to monitor the microbiological activity in the reactors (results from which can be see in Fig.4). The experimental design is shown in Figure 2. Nitrogen was flushed through the reactor and substrate bottle to maintain anaerobic conditions.

Phase 2 Treatment of biofilms with halophyte extract: The three reactors will be tested with varying levels of halophyte extract. α reactor will serve as the control, β reactor will have continuous 10% extract mixed with Postgate media, and γ will be pulsed every 3rd day with 5,10,15,20, and 30% extract directly in the reactor mixed with Postgate media (running for a total of 15 days). Upon completion of this phase, the coupons will be analyzed for DNA using next generation sequencing (NGS), 3D scanning of pitting corrosion, and analyzed for ATP of biofilm from coupon surface. Additionally the media will analyzed by high performance liquid chromatography (HPLC) to determine metabolic products.

Figure 1: Mechanism of Microbiologically Influenced Corrosion [1]

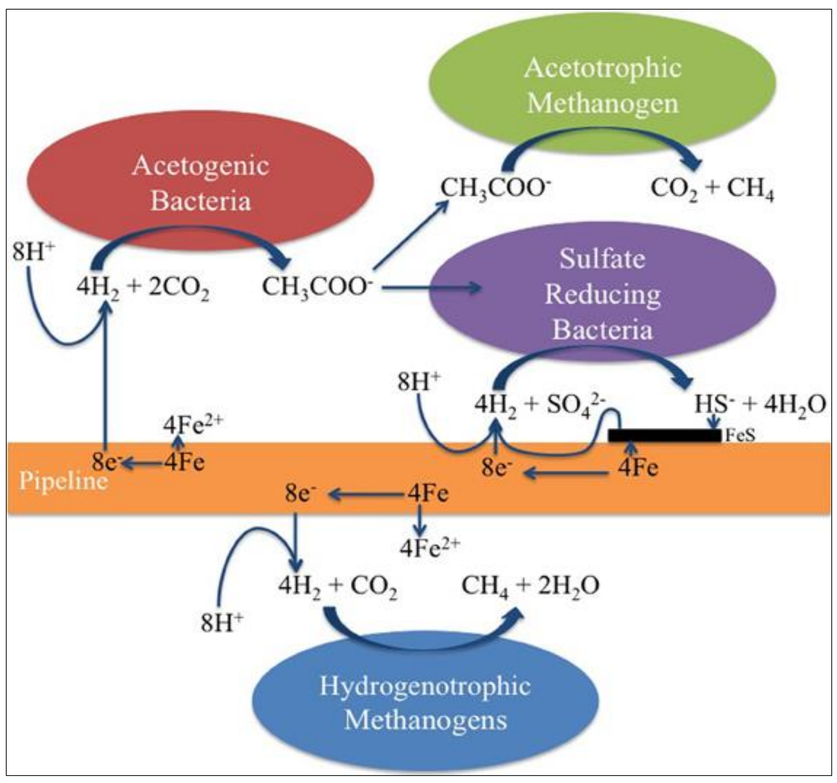


Figure 2: Bioreactor Schematic

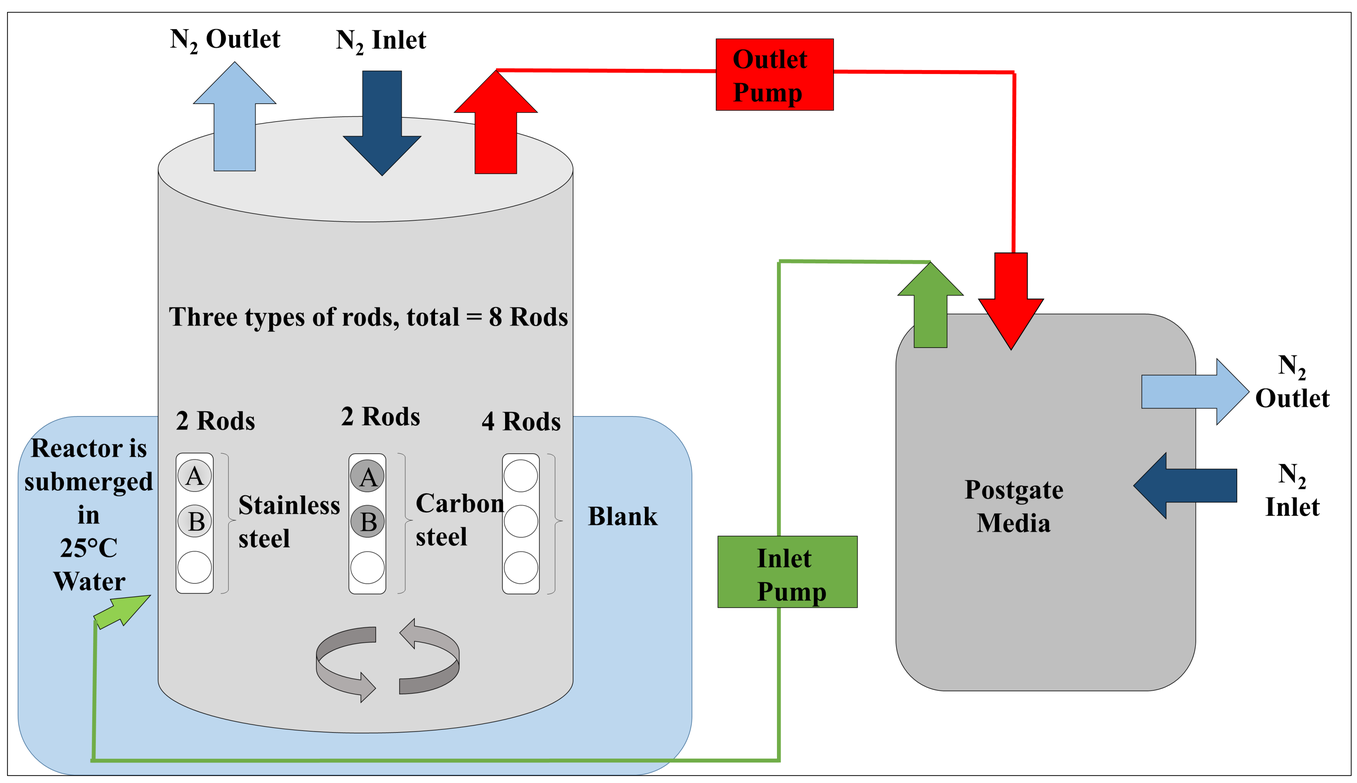
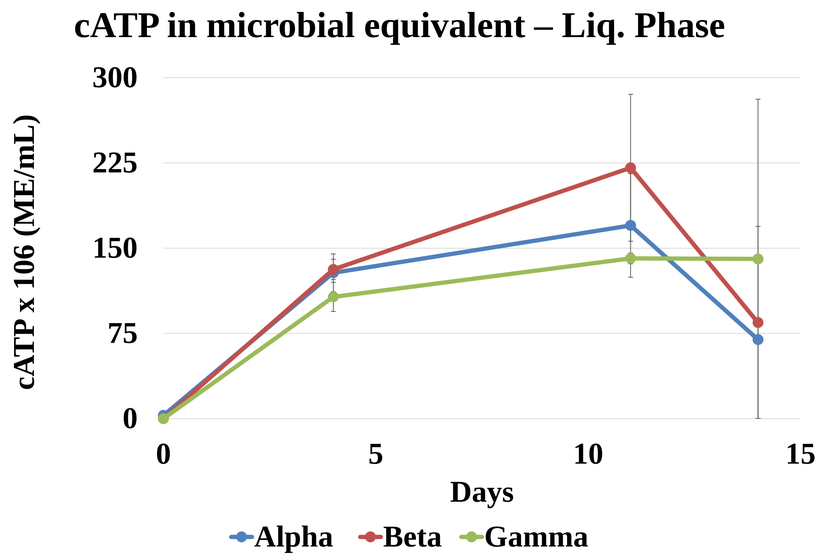
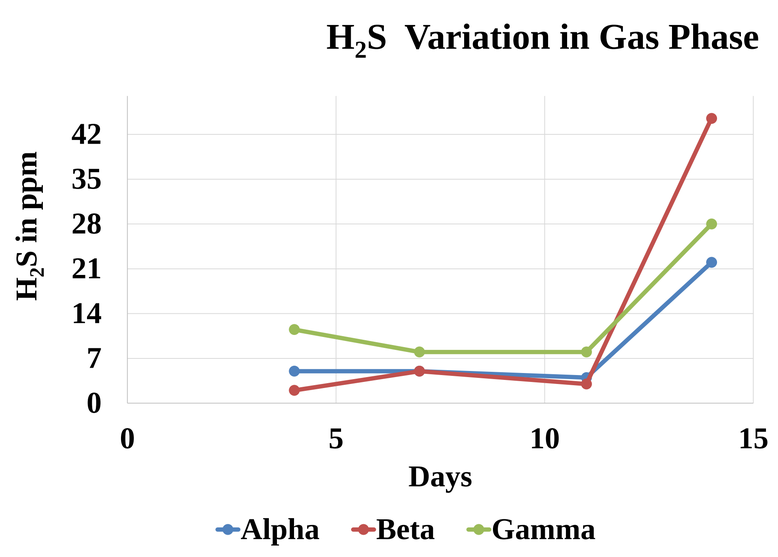


Fig: 3a Biofilm

Fig: 3b Corrosion in Pipes





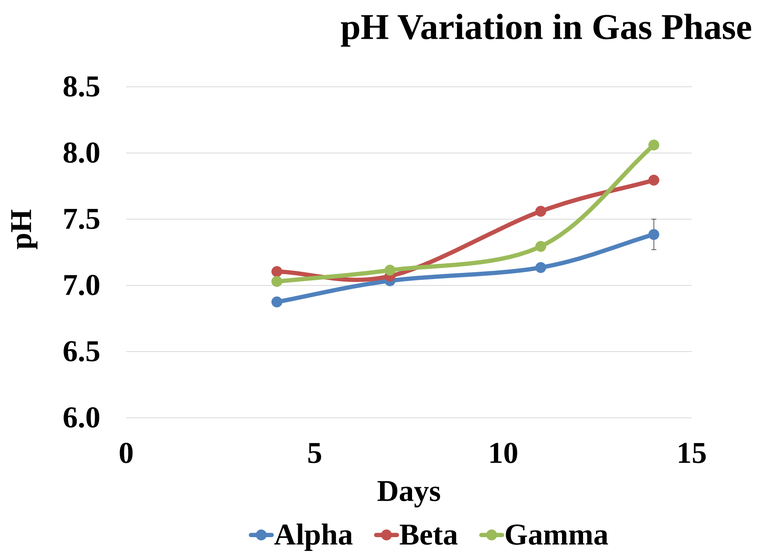


Figure 4: Graphs highlighting microbial activity and, thus the growth of biofilm formation in the three reactors

Note: The three reactors have similar behavior during Phase 1 of the experiments as halophyte extract has not been added at this stage

LONG TERM IMPACT

The petroleum industry today relies on biocides to avoid MIC, souring and biofouling. Huge savings can be achieved by switching to cheap and environmentally safe antimicrobials or alternative biofilm inhibitors. Halophyte extracts along with combination of phyto-chemicals would be a novel, biologically inspired, and lasting solution to MIC and souring. Next generation sequencing (NGS) of DNA from bacteria and archaea will help identify the strains and study the effects of antimicrobials on the microbial populations. The inhibitory effect of using selected halophyte plant extracts on SRB, SRA, and methanogens will be studied in the second phase of these experiments.

Reference : 1. Mand, J., Park, H.S., Jack, T.R. and Voordouw, G., 2014. The role of acetogens in microbially influenced corrosion of steel. Frontiers in microbiology, 5, p.268.

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