Microbiologically influenced corrosion (MIC): Development of a model system to investigate the role of biofilm communities within MIC

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Abstract

The energy sector faces major challenges due to corrosion. In the oil and gas industry alone, a significant number of pipeline failures, have resulted from microbiologically influenced corrosion (MIC). A key pathway in microbial activity is the formation of biofilms on metallic surfaces. Here, the impact of surface roughness on biofilm characteristics, and the associated threat of MIC on carbon steel was assessed using an anaerobic, multi-species, marine consortium. A range of molecular microbiological methods, image analysis, corrosion tests and electrochemical methods demonstrated that 25 µm polished (25M) coupons increased the contact area of the coupon surface compared to the As Received (AR) coupons, which allowed for greater biofilm attachment and resulted in greater pit rates and pit density compared to an abiotic control. Complementary electrochemical methods were used to give an indication of when initial biofilm attachment and formation occurred and the influence that the biofilm had on the surface of the carbon steel coupons. However, whilst these findings gave an indication of redox reactions across the entire surface and the influence that the biofilm had on the surface of the carbon steel coupons it did not give an indication of specific activity on the surface in relation to pitting. Underneath the biofilm, understanding the incidence of pitting is more important in the context of understanding the threat of MIC in the energy sector. Surface profilometry analysis demonstrated a significant biological impact caused by the microbial community and biofilms when comparing the control and test reactor, and that MIC was significantly affected by surface roughness. This work demonstrates the importance of using multiple lines of evidence when analysing MIC, incorporating a multidisciplinary approach in order to develop a holistic understanding of the mechanistic relationship between the biofilm and metal surface.

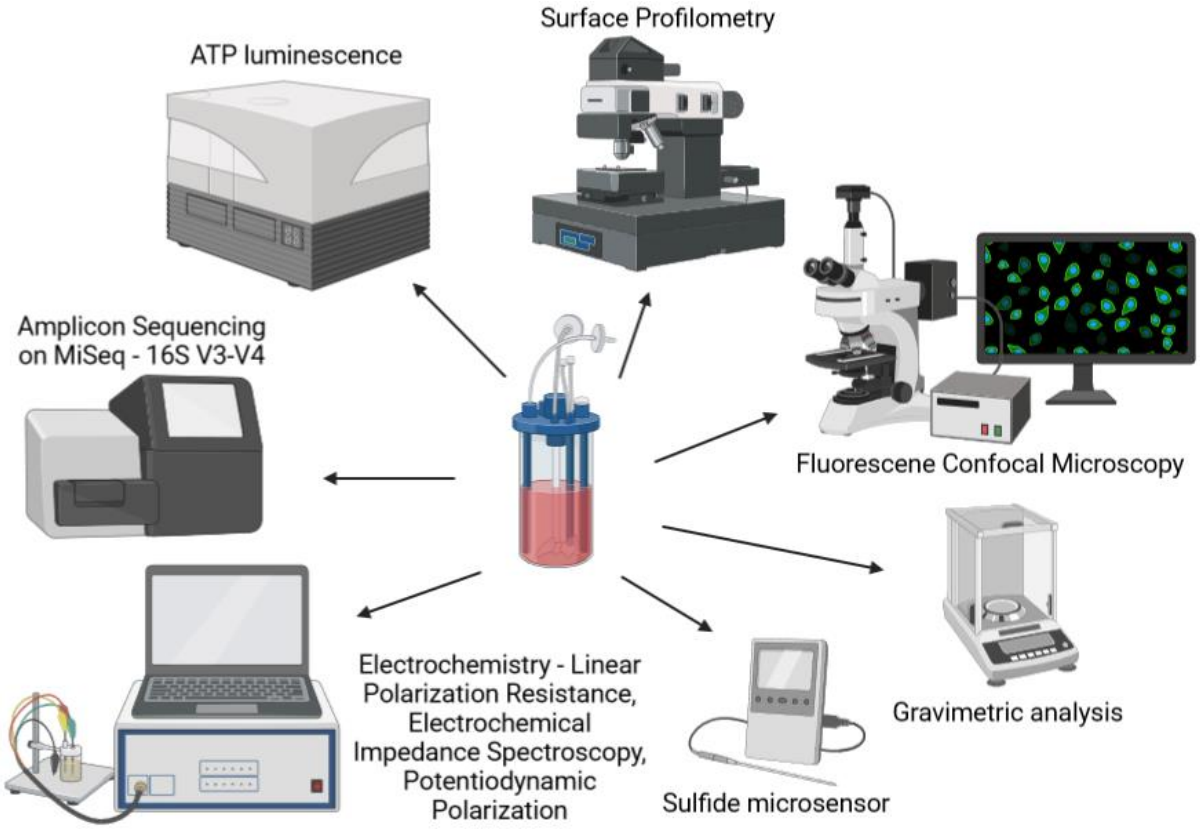

Figure 1. Illustration of the methods employed for this study, using multiple lines of evidence and incorporating a multidisciplinary approach.

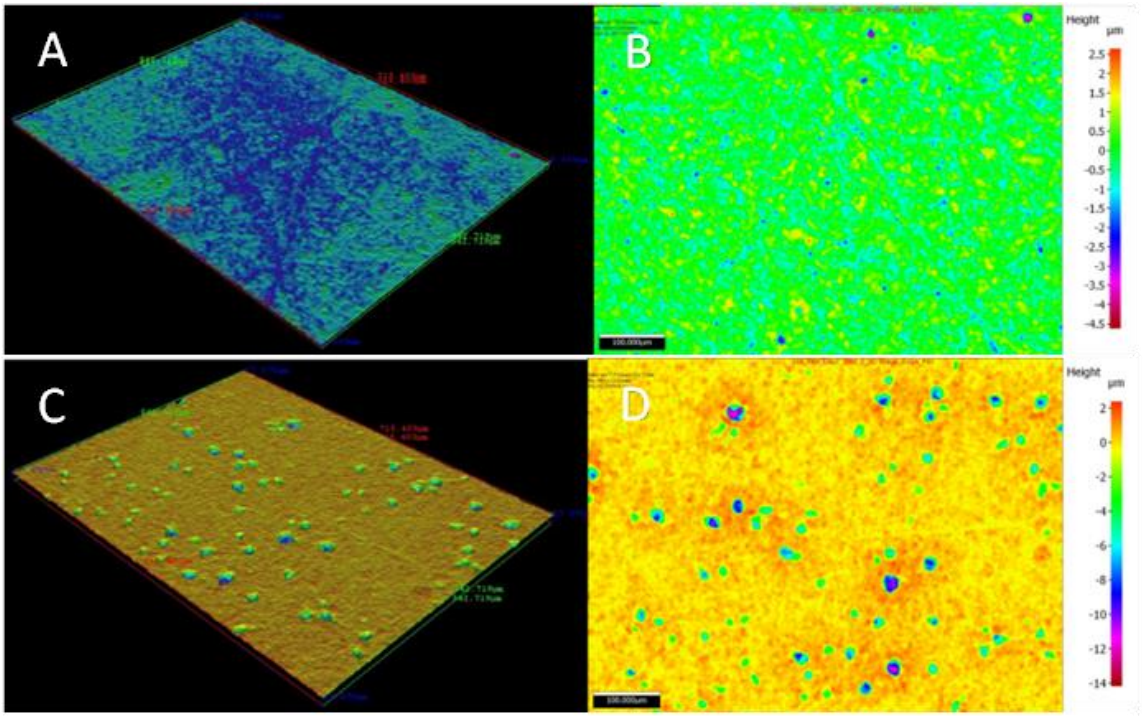

Figure 2. Alicona IFM images taken after cleaning coupons on day 7. **A** 20x 3D surface profile of pits for a 25M Control coupon. **B** 2D roughness profile for pits for a 25M Control coupon. **C** 20x 3D surface profile of pits for a 25M Test coupon. **D** 2D roughness profile for pits for a 25M Test coupon.