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The development of advanced detection and monitoring technologies for methanogenic microbial corrosion

Jaspreet Mand[1], Sven Lahme[1], John Longwell[1], Manuel Castelan[1], Conchita Mendez[1] and Dennis Enning[1]
John Zhang[2], Daniel Fan[2] and Fang Cao[2]
[1]ExxonMobil Upstream Research Company, [2]ExxonMobil Research and Engineering

The methanogenic archaea are a physiological group of oil field microorganisms associated with microbiologically influenced corrosion (MIC) of carbon steel infrastructure. Yet the ability to increase corrosion in pure laboratory cultures has been demonstrated only for a few methanogenic isolates. Furthermore, 16S rRNA gene sequencing and qPCR surveys of steel-associated microbiomes from nine oil pipelines found methanogens to be present in all instances regardless of the perceived severity of MIC. This highlights that the mere presence of methanogens does not serve as a useful indicator of MIC.

In our laboratory tests with produced water from an offshore oil field in West Africa, we measured large variations in microbial corrosion (0.03 – 2.43 mm/yr) despite an abundance of methanogens in most steel-associated biofilms. The most severe cases of MIC in these tests could be attributed to lithotrophic, mesophilic oil field microorganisms. Recently, the molecular mechanism of corrosion in some strains of *Methanococcus maripaludis* has been elucidated and linked to the formation and excretion of a special extracellular [NiFe] hydrogenase. Shotgun DNA sequencing and metagenomic analysis revealed that a West African strain of *M. maripaludis* grown under pipeline-simulating conditions in our experiment contained an identical corrosion-catalyzing hydrogenase. This led to the development of a specific qPCR assay to quantify the 'MIC hydrogenase (*micH*)'. Intriguingly *micH* did in fact serve as a binary marker for methanogenic MIC in oil field biofilms grown in our laboratory tests (n = 13). The biomarker was present in corrosive biofilms, but undetectable in biofilms causing negligible corrosion (< 0.08 mm/yr). The subsequent detection of this proposed biomarker in pipelines in North America, in addition to the West African oil field, points towards a wider, more global distribution of this severe microbial corrosion mechanism as well as the applicability of the assay for MIC detection and monitoring.

Jaspreet Mand

Received her PhD in Environmental Microbiology from the University of Calgary (PI: Dr. Gerrit Voordouw) where she investigated MIC by mixed microbial communities associated with the petroleum industry.
In 2017, she joined the ExxonMobil Upstream Research Company, where she studied the effect of corrosion inhibitor chemicals on MIC. Currently, the MIC team at ExxonMobil is focused on hunting down MIC biomarkers for more reliable and actionable MIC detection and monitoring in the field.

Sven Lahme

Received his Dr. rer nat. from the University of Oldenburg (supervisor: Prof. Ralf Rabus). His dissertation focused on the anaerobic biodegradation of aromatic compounds and the underlying molecular mechanisms.
He then joined Prof. Ian Head's group at Newcastle University (UK) as post-doctoral researcher to study MIC in relation to nitrogen and sulfur cycling.
In 2019 Dr Lahme joined the MIC team at ExxonMobil Upstream Research Company.