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Nitrate-based Treatments Control Hydrogen Sulfide in Reservoirs

Daniel Hitzman

Geo-Microbial Technologies (GMT), Ochelata, Oklahoma, USA

The pervasive biogenic formation of hydrogen sulfide occurs in most oil and gas reservoirs - particularly those flooded with sea water. Hydrogen sulfide can cause serious operational problems, including reservoir souring, sulfide corrosion, iron sulfide plugging, reduced product value, and health and environmental hazards and thus add significantly to the costs of maintaining production. Historically, this sulfide problem has been treated with toxic and expensive biocides which have ultimately been proven to be mostly ineffective. The petroleum industry has begun implementing a nitrate-based microbial treatment technology for both the prevention and removal of sulfide from reservoirs and produced waters, as well as surface facilities, pipelines and gas storage reservoirs.

These innovative reservoir treatments recognize that detrimental sulfate-reducing bacteria (SRB), which produce sulfide, can be replaced by a naturally occurring suite of beneficial microorganisms enhanced by the introduction of an inorganic nitrate-based formulation. This purposeful manipulation of the reservoir ecology has been termed Biocompetitive Exclusion (BCX) technology - simply put, the "good bugs" are directed to outcompete the "bad bugs." Key to this development was the discovery that the SRB, while reducing sulfate to sulfide, utilize naturally occurring Volatile Fatty Acids (VFA) in the reservoir waters as their carbon source. With a BCX treatment, the introduction of low concentrations of a nitrate/ nitrite formulation will more readily and energetically replace the sulfate as an electron acceptor, which encourages the already present, natural Nitrate-Reducing Bacteria (NRB) population to proliferate and use the VFA preferentially, thereby denying the SRB this required nutrient. Since the alternate NRB populations are already present, the technology does not require the addition of organisms and can be utilized in almost all reservoirs that contain microbial populations.

A BCX formulation is composed of a mixture of nitrate/ nitrite salts that can be adjusted and altered to conform to different reservoir characteristics, water compositions and sulfide concentrations. This ability to tailor the BCX formulations to match the individual field parameters has proven more versatile to treatments in which only the nitrate concentration can be changed.

Due to the mixture of petroleum fluids, huge amounts of water, and dynamic microbial populations, oil and gas reservoirs can be viewed as massive bioreactors. The BCX system recognizes these relationships and functions in-situ, perpetually stimulating targeted indigenous de-nitrifying microorganisms to produce chemical and physical oil-releasing agents. It literally creates a gas and chemical "factory" that is situated within the reservoir, where its effectiveness is optimized. Two approaches to solving the sulfide problem can be initiated: proactive and

reactive. In the reactive program, a BCX treatment is added to an already contaminated and sulfide-generating system, to decrease and remove the already existing SRB populations and sulfide concentrations. Such systems are usually treated on the injection side to establish the beneficial population throughout the reservoir or system. With the proactive methodology, the treatment is initiated prior to contamination of the reservoir, so that the SRB populations never become dominant and the sulfide problem is prevented. Case studies will be presented.