Towards Net Zero: Lowering GHG Emissions and Production Cost with Thermophilic Bacteria and N_2 Biogas

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Abstract

Heavy oil reservoirs make up the vast majority of the world's crude oil reserves. Greenhouse gas (GHG) emissions associated with heavy oil production and refining can be double that of conventional oil production. Keeping large-scale heavy oil operations alive and competitive with new emerging energy technologies requires innovations that lower GHG emissions per barrel of produced oil. This work applies the revolution in life sciences and microbial genomics by approaching heavy oil reservoirs as habitats with microbiomes that can be harnessed for emissions reduction. Thermophilic bacteria occurring at warm-temperature (e.g. 40-80 ^{0}C) and as dormant spores at lower temperatures (e.g. <40^{0}C) living in heavy oil reservoirs can be utilized for in-situ gas generation which in turn contributes to increasing reservoir pressure (increase bubble point pressure to above reservoir pressure) and oil mobility, ultimately resulting in higher production rates. When this biogas displaces the need for steam generation, emissions intensity per barrel is lowered.

Nutrient cocktails are designed to activate dormant thermophiles in the reservoir to produce N2 biogas, instead of CH4 biogas commonly produced in anaerobic reservoir conditions. Introducing liquid nutrients avoids the inherent inefficiency of injecting non-condensable gas directly. Since the dormant microorganisms are distributed ubiquitously throughout the reservoir, their biogas production promotes an evenly distributed pressure build-up mechanism.

In warm-temperature reservoirs, thermophiles are not necessarily dormant and can readily be stimulated by introducing nutrient cocktails via existing infrastructure. In cold-temperature reservoirs, dormant thermophile activation requires adding heat into reservoirs. Recent studies have confirmed their activation and significant contribution to pressure build-up in conductively heated zones during thermal recoveries such as Steam Assisted Gravity Drainage (SAGD). Field-scale introduction of nutrient cocktails will require existing delineation wells and/or drilling a new injection well(s) above the steam chamber. Depending on reservoir conditions and geometries, nutrient cocktails can be introduced together with circulating warm water and/or non-toxic solvents. This METEOR technology (i.e., Microbially Enhanced Thermally Engineered Recovery) applies to a wide range of sandstone and carbonate reservoirs worldwide including those in Canada, Venezuela, Russia, Kazakhstan, and Oman.