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Novel bio-organoclay composites designed to seal leaking wellbores

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Emissions of methane and other hydrocarbons from old or abandoned oil and gas wells are a growing environmental and public safety risk. There is growing interest in identifying materials that are inexpensive and can be easily pumped into the wellbore from above in order to create a permanent seal for leaking hydrocarbons. Here we developed a novel bio-clay composite (BCC) material with the capability of swelling in the presence of methane. Conventional bentonite clays swell significantly in water, which would limit the ability of these materials to penetrate deep into the wellbore. In contrast, modified oragnoclay materials swell poorly in the presence of light chain hydrocarbons like methane. BCCs leverage the growth of microbial organisms such as methanotrophs that metabolize the methane and produce biomass. The growth of these microorganism will result in the accumulation of biomass, which in turn will induce the swelling of the BCCs.

In this talk we will report on experimental results carried out over the past year to characterize this approach. The novel BCCs were synthesized by reacting sodium bentonite clay with amino acids using ion exchange process. Conventional organoclays are typically made using quaternary ammonium compounds and other surfactants but these tend to have biocidal properties. The result of this synthesis was a hydrophobic organoclay that was biocompatible. To evaluate the performance of these BCCs we used E. coli as a model microbial organism. Inhibition tests of E. coli growth by amino acids were conducted wherein cells were exposed to different concentrations of amino acids and a positive control, and the bacterial growth was recorded by measuring their optical density. The results of inhibition tests showed that amino acid-based BCCs have insignificant impacts on the growth of E coli. We also conducted swelling tests and hydraulic conductivity tests to understand how biogenic solution will impact the swell index and permeability of BBCs. BBCs were characterized using small angle X-ray scattering (SAXS) to identify the d-spacing of the samples before and after being mixed with biogenic solution. The results demonstrated that the introduction of biomass creates higher swelling index and dramatically reduced hydraulic conductivity for BBCs.

References

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