The Future of Petroleum Resources: From Fuels to Electricity?

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Based on the latest IPCC report, if the global CO_2 emissions are not halved in the next 12 years, the Earth's climate might reach a tipping point with catastrophic consequences [1]. To avoid such scenario, most world's oil resources cannot be used as combustion fuels, and may become economically stranded; unless novel, innovative and massively scalable non-combustion uses for petroleum are developed. Most likely, electricity will be the global energy source of the future; thus, we are investigating possible routes for the use of petroleum resources in the green, electricity-powered 21st century.

Our multidisciplinary team involved in the project SYZYGY is developing and evaluating a zero-emission energy system at the interface of biogeochemistry and electrochemistry. The goal of SYZYGY is direct electricity production from the oil reservoirs by "harvesting" of biogeochemical energy of in-reservoir oil oxidation. An electron shuttle (manganese, iron, quinone, etc.) is injected into the reservoir via a well; microbes, already present in the reservoir, use the shuttle as terminal electron acceptor to oxidize the fossil fuel molecules in situ, with a concurrent reduction of the electron shuttle, and sequestration of generated CO_2 in the reservoir. The reduced shuttle is flowed above ground via a production well, where it is re-oxidized with atmospheric oxygen yielding electricity in a fuel cell.

Here, we will present the results of a proof-of-concept experiment involving microbial anaerobic crude oil oxidation with manganese oxide (birnessite) and AQS reduction, serving as energy vectors. Both birnessite and AQS reduction has been observed, coupled to oil degradation, which was confirmed in the experiments using isotopically labelled model compounds. We discuss feasibility and challenges of such approaches.

Finally, we will discuss our research into production of organic redox-active species from petroleum fractions, which could be used in more conventional redox-flow energy storage/conversion systems.

[1] www.ipcc.ch/report/sr15/