Microwave and Beam Activation of Nanostructured Catalysts for Environmentally Friendly, Energy Efficient Heavy Crude Oil Processing

The goal of this nanomanufacturing concept definition study is initial evaluation and development of energy efficient processes which take advantage of the benefits offered by nanostructured catalysts which can be activated by microwave, RF, or radiation beams. Microwave activation is expected to lower process energy by selective heating of catalyst surface sites, where reaction occurs, rather than the bulk of the material being processed. Additionally, the technology has the potential for increasing product yield by minimizing back reactions. Successful technology development is expected to lead to industrial deployment.

Heavy crude oil was selected for initial evauation for four reasons. First, a significant and increasing fraction of the petroleum produced in North and South America is heavy crude or tar sands. Second, the three highest-energy catalytic processes in petroleum refining, catalytic cracking, reforming, and hydrotreating, are used to help convert heavy crude oils to consumer fuels, such as gasoline and home heating oil. Third, energy used in these three processes is nearly 1.3 Quadrillion Btu, or over 40% of total process energy used in U.S. petroleum refineries. Fourth, these three processes are, in many refineries, bottlenecks. Improving catalysis and increasing throughput are expected to improve overall petroleum product production by existing refineries. The catalysts and microwave activation technology used in heavy crude oil processing are expected to have widespread use in other chemical, biorefinery, and petrochemical processing.

Oak Ridge National Laboratory, the Materials Technology Institute (a non-profit technology institute serving the refining and petrochemical industry), and Mach I Corporation (a leading nanocatalyst manufacturer) will work to delineate process conditions under which microwave activation of nanostructured catalysts increasing catalyst performance on models for heavy crude oil. This concept definition study builds on an earlier evaluation performed in collaboration with the Materials Technology Institute. The results of the previous study showed that heavy oils are microwave transparent in industrially permitted frequencies (between 915 MHz and 2.45GHz) which couple with a refinery catalyst (cobalt/molybdenum oxides on alumina). Microwave transmission distances in a catalyst-heavy oil system are sufficient for retrofit deployment in existing refineries. Mach I Corporation manufactures, at industrial scale, 3 to 25 nanometer multilayer and solid metal oxide catalysts suitable for refinery use.

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