Kinetics of Direct Oxidation of H_2S in Coal Gas to Elemental Sulfur

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Abstract

Removal of hydrogen sulfide (H_2S) from coal gases and sulfur recovery are key steps in the development of Department of Energy's (DOE's) advanced Vision 21 plants that employ coal and natural gas and produce electric power and clean transportation fuels. These Vision 21 plants will require highly clean coal gas with H_2S below 1 ppm and negligible amounts of trace contaminants such as hydrogen chloride, ammonia, alkali, heavy metals, and particulate.

There is an immediate as well as long-term need for the development of cleanup processes that produce highly clean coal gas for next generation Vision 21 plants. To this end, a novel process is being developed for the H_2S in coal gas to be directly oxidized to elemental sulfur over a selective catalyst. Such a process is ideally suited for coal gases from commercial gasifiers with a quench system to remove essentially all the trace contaminants except H_2S. This direct oxidation process has the potential to produce a super clean coal gas more economically than both conventional amine-based processes and the hot-gas desulfurization (HGD) using regenerable metal oxide sorbents followed by Direct Sulfur Recovery Process (DSRP). The main objectives of this research project are as follows:

- Measure the kinetics of direct oxidation of H_2S to elemental sulfur over selective catalysts in the presence of major coal gas components.

- Develop kinetic rate equations and model the direct oxidation process to assist in the design of large-scale Vision 21 plants.

The following research activities were carried on to accomplish main objectives of this project.

- A differential micro reactor was fabricated with a ¼-inch Teflon tee. The volume of a 160-μm C-500-04 alumina catalyst packed in the reactor is 0.008 - 0.1 cm^3. A simulated coal gas mixture containing H_2S and sulfur dioxide was reacted with the aid of the catalyst in the differential micro reactor at 130 - 150^oC, 61 – 113 psia, and 0.01 – 0.5 s in space time.

Conversion of hydrogen sulfide into elemental sulfur was analyzed with a gas chromatograph. A differential reactor assembly mainly consists of four mass flow meters for gases, one differential reactor, two preheaters, one high pressure liquid pump for water, one four-way switch valve, one oven, five filters for gases, four check valves, and one water collection bottle. The differential reactor is fabricated with one ¼-inch Teflon tee. The preheaters are made of 1/16-inch Teflon tubing.

- Concentrations of moisture also appear to affect reaction rates for the conversion of H_2S into elemental sulfur in the moisture range of 5.2 – 9.8 v% in a simulated coal gas mixture at 111 psia. However, concentrations of moisture appear to affect slightly reaction rates for the conversion of H_2S into elemental sulfur in the moisture range of 5 – 14 v% in a simulated coal gas mixture at 61 – 64 psia.

- Space times appear to affect significantly reaction rates for the conversion of H_2S into elemental sulfur in the space time range of 0.011 – 0.064 seconds. Catalyst loadings appear to affect significantly reaction rates for the conversion of H_2S into elemental sulfur in the space time range of 0.011 – 0.064 seconds. Reaction pressures appear to affect significantly reaction rates for the conversion of H_2S into elemental sulfur in the pressure range of 64 -113 psia.

Publications and Presentations

"Heterogeneous catalytic Reaction of H_2S and SO_2 into Elemental Sulfur", submitted for presentation at the AIChE Annual Meeting, November 3-8, Indianapolis Convention Center, Indianapolis, IN

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