

To: Engineering Development Branch  
From: Thomas Knotts  
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Re: Catalytic Hydrogenation of CO<sub>2</sub> to Methane

A large challenge of replacing fossil-fuels with renewable energy is the intermittency of the latter. One solution to this problem is to “store” the energy in the form of chemical bonds. Many have proposed the electrolytic splitting of water to form H<sub>2</sub> and O<sub>2</sub>, and the subsequent storage of the hydrogen, to accomplish this, but hydrogen is highly reactive and thus not ideal for storage.

The division in our company charged with reducing our carbon footprint has come up with a possible solution to this problem. Hydrogen, when combined with CO<sub>2</sub> over a nickel catalyst, will form methane. The idea is to store the excess energy as methane rather than hydrogen.

Further development of this idea cannot be done until the rate law for the reaction is determined. Your assignment is to obtain kinetic data (reaction orders, pre-exponential factors, and activation energies) for the methanation reaction over one nickel catalyst (Harshaw G-87) at compositions that are stoichiometric or excess in hydrogen and contain from 1.0 to 4.0 % CO<sub>2</sub>. The temperature range should be around 250 to 330 °C.

As you perform your experiments, please determine at what temperature pore diffusion limitations begin to become significant, if at all. Also, comment on the catalyst's stability with time both during a run and over long periods of time. Finally, once you have modeled the kinetics, determine how much methane can be produced in an isothermal CSTR containing one ton of the G-87 catalyst if you operate at 270 °C and 1 atm with a feed of 10<sup>4</sup> SLM containing 4.0 % CO<sub>2</sub> and 20 % H<sub>2</sub>.