Nitrogen fixation: Synergy between microwave plasma and catalyst

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Nitrogen fixation, the foundation of fertiliser production, currently relies on the energy-intensive Haber-Bosch process, contributing significantly to global energy consumption (2%) [1,2]. New greener technologies are urgently required to sustainably feed the world's growing population [3]. In this work, the synergy of electrically driven microwave plasma and heterogeneous catalyst was investigated. Using air as feedgas, nitrogen fixation is achieved by the formation of NO_x (i.e. NO, NO_2, and less significantly also N_2O_4), directly through the plasma process and through interactions of plasma activated species with catalyst surfaces. WO_3 and Al_2O_3 pellets were used as catalysts in a post-plasma packed-bed configuration. The produced NO_x densities were quantitatively measured using gas-phase Fourier Transform Infrared (FTIR) spectroscopy. Parameter studies were carried out actively varying gas flowrate, pressure, microwave power, catalyst material and catalyst temperature. The energy cost of the reactor was improved beyond the 0D modelling limitation of the plasma process (2.61 MJ/mol), reaching 2.17 MJ/mol (figure 1). Measurements show that the NO_2/NO ratio correlates with the reactor performance, with higher ratios resulting in higher efficiencies. This is attributed to an oxygen donating effect of the catalyst, which enhances NO production and its further oxidation to NO_2. In this work, it was demonstrated that heterogenous post-plasma catalyst can significantly enhance microwave plasma's energy efficiencies for NO_x production.

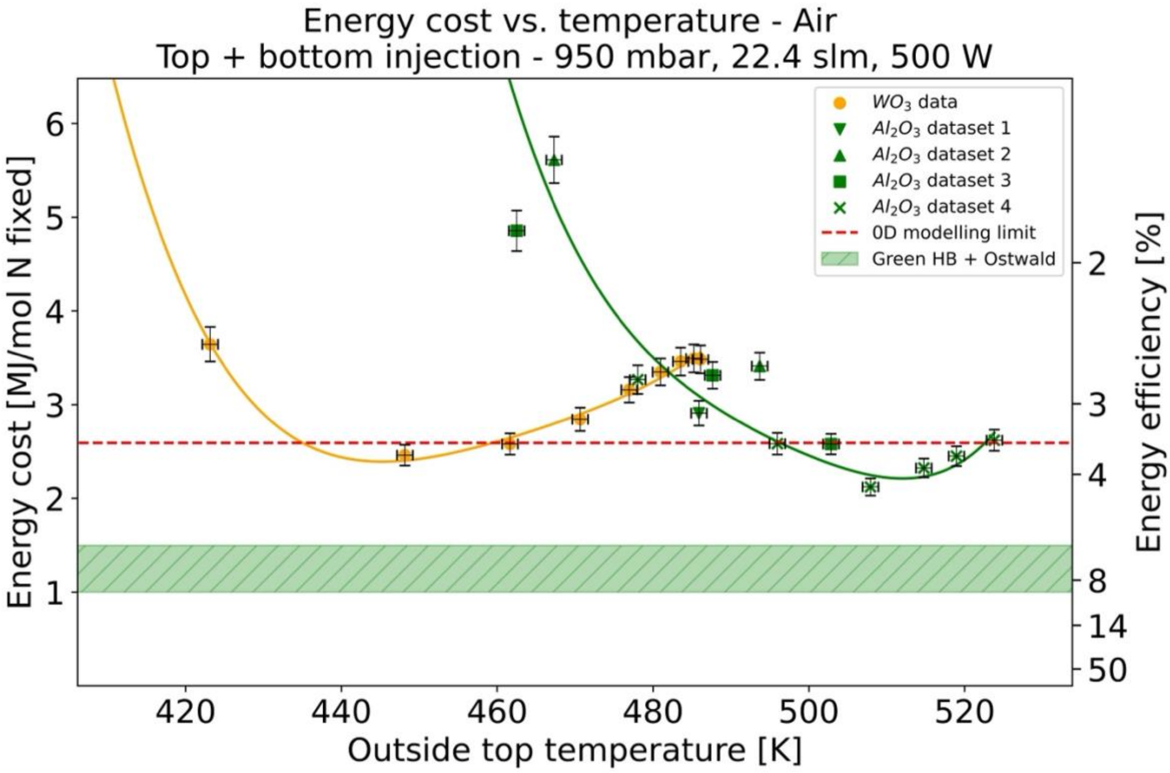

Figure 1: Reactor energy cost vs. outside top catalyst bed temperature at 950 mbar, 22.4 slm and 500 W operating condition for WO_3 and Al_2O_3 catalyst pellets.

References:

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