Catalyst Assisted Microwave Plasma for NOx Formation

Authors : Babak Sadeghi, Rony Snyders, Marie-Paule.Delplancke-Ogletree

Abstract : Nitrogen fixation (NF) is one of the crucial industrial processes. Many attempts have been made in order to artificially fix nitrogen, and among them, the Haber-Bosch's (H-B) process is widely used. However, it presents two major drawbacks: huge fossil feedstock consumption and noticeable greenhouse gases emission. It is, therefore, necessary to develop alternatives. Plasma technology, as an inherent "green" technology, is considered to have a great potential for reducing the environmental impacts and improving the energy efficiency of the NF process. In this work, we have studied the catalyst assisted microwave plasma for NF application. Heterogeneous catalysts of MoO_3, with various loads 0, 5, 10, 20, and 30 wt%, supported on γ-alumina were prepared by conventional wet impregnation. Crystallinity, surface area, pore size, and microstructure were obtained by X-ray diffraction (XRD), Brunauer–Emmett–Teller (BET) adsorption isotherm, Scanning electron microscopy (SEM), and Transmission electron microscopy (TEM). The XRD patterns of calcined alumina confirm the γ-phase. Characteristic picks of MoO_3 could not be observed for low loads (< 20 wt%), likely indicating a high dispersion of metal oxide over the support. The specific surface area along with pores size are decreasing with increasing calcination temperature and MoO_3 loading. The MoO_3 loading does not modify the microstructure. TEM and SEM results for loading inferior to 20 wt% are coherent with a monolayer of MoO_3 on the support as proposed elsewhere. For loading of 20 wt% and more, TEM and Electron diffraction (ED) show nanocrystalline $_3$-D MoO_3 particles. The catalytic performances of these catalysts were investigated in the post-discharge of a microwave plasma for NOx formation from N_2/O_2 mixtures. The plasma is sustained by a surface wave launched in a quartz tube via a surfaguide supplied by a 2.45 GHz microwave generator in pulse mode. In-situ identification and quantification of the products were carried out by Fourier-transform infrared spectroscopy (FTIR) in the post-discharge region. FTIR analysis of the exhausted gas reveal NO and NO_2 bands in presence of catalyst while only NO band were assigned without catalyst. On the other hand, in presence of catalyst, a 10% increase of NO_x formation and of 20% increase in energy efficiency are observed.

Keywords : γ-Al2O_3-MoO_3, µ-waveplasma, N2 fixation, Plasma-catalysis, Plasma diagnostic
Conference Title : ICPCPP 2022 : International Conference on Plasma Chemistry and Plasma Processing
Conference Location : Paris, France
Conference Dates : September 20-21, 2022