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Kinetics investigation of methane oxidation over manganese oxide catalysts

Keywords
Total oxidation; VOC; MnOx catalyst; Methane; Kinetic modeling

Aim
To investigate the influence of manganese oxide on the total oxidation of methane.

Justification
The ever-growing industrialization and urbanization are raising emissions of Volatile Organic Compounds (VOCs), i.e., carbon-based chemicals with boiling points below 250 °C. VOCs lead to a decrease in air quality, being the source of severe hazards, such as the formation of photochemical smog and a diversity of adverse health issues for humans [1]. VOC emission can be controlled by techniques based on recovery and destruction. The Recovery techniques such as adsorption and absorption are uneconomical for the mean VOC concentration in an indoor/outdoor environment (<0.5 vol%). However, catalytic oxidation stands out as an economically viable destructive technology for the abatement of VOCs pollutants. Methane is the most abundant hydrocarbon VOC in the atmosphere, which can be eliminated by catalytic oxidation to avoid the formation of dangerous pollutants.

The choice of catalyst is key to the development of efficient VOC oxidation technologies. Transition metal oxide catalysts have shown promising results in oxidation reactions. Among them, MnO_x performed well in VOC degradation due to high oxygen storage capacity and oxygen mobility. The switch between oxidation states (Mn^{+2}, Mn^{+3}, and Mn^{+4}) resulted in high oxygen transfer [2]. It is also reported that mixed metal oxide materials such as $CuMnO_x$ possessed higher catalytic activity than their analogous single metal oxide forms [3]. However, the influence of MnO_x in the total oxidation of methane has not yet been fully explored. This thesis, therefore, aims to investigate the effect of Mn on the performance of methane oxidation by acquiring intrinsic kinetic data and correlating the catalyst activity to catalyst descriptors (type and number of active sites).

Program
- Screening of Mn containing catalysts (Cu-$Mn_{y(wt\%)}$/Hydroxyapatite) by varying operating conditions (T=300-500 °C, P_{CH4}=1-10 kPa, P_{O2}=10-50 kPa, Spacetime=100-600 kg_{cat} .s/$mol_{CH4,0}$)
- Performing characterization techniques such as XRD, N_2 Adsorption, TPR-H_2, TPD-O_2, TPD-NH_3
- Using characterization techniques to explain the influence of Manganese oxide on oxidation of methane
- Development of a microkinetic model to quantitatively verify the mechanistic hypotheses resulting from the assessment of the experimental kinetics on the basis of catalyst descriptors

Reference
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