LABORATORY FOR CHEMICAL TECHNOLOGY
Technologiepark 125 9052 Gent, Belgium

Coach	Supervisor(s)	Funding
Reza Monjezi	Prof. Joris Thybaut Dr. Ana Bjelić	COP-CAT

Experimental investigation of catalytic ozonation of methane using manganese oxide catalysts

Keywords
VOC; catalytic ozonation; MnOx catalyst; Methane

Aim
Investigation the role of Cu/Mn ratio in MnO_x-based catalysts in the catalytic ozonation of methane.

Justification
In recent years, the emission of volatile organic compounds (VOCs) from industries and transportation has increased significantly, which is harmful to all ecosystems. The presence of VOCs, which are defined as carbon-based chemicals with boiling points below 250°C, can lead to a decrease in air quality and contribute to a variety of health issues. Among all the VOC removal techniques, catalytic oxidation stands out as an economically viable technology for the abatement of VOCs pollutants. However, the catalytic oxidation method requires a high reaction temperature (200 – 500 °C), being thus a high energy consumption technique. Nonetheless, it has been reported that changing the oxidant from oxygen to ozone can significantly reduce the reaction temperature to 50 – 150 °C [1]. Therefore, catalytic ozonation seems to be a promising technology for the complete oxidation of VOCs at low temperatures.

Methane is the most abundant hydrocarbon VOC in the atmosphere, therefore being selected as a model compound in this work. The catalytic ozonation of hydrocarbon VOCs has been investigated using various catalysts. Among them, MnO_x-based catalysts performed well in VOCs ozonation due to high oxygen storage capacity, high oxygen mobility, and superior performance in ozone decomposition [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 synergetic effect of Cu and Mn in the catalytic ozonation of methane has yet to be explored. This thesis, therefore, aims to investigate the influence of Cu/Mn ratio on the performance of catalytic ozonation of methane by acquiring intrinsic kinetic data.

Program
- Selecting the best catalyst (Cu_x-Mn_{1-x}/Hydroxyapatite, x= 0 – 1) upon screening at T=100 °C, P_{CH4}=50 Pa, P_{O3}=500 Pa, and spacetime=300 kg_{cat} s/$mol_{CH4,0}$
- Finding the optimal temperature and O_3/VOC ratio by varying operating conditions (T=50 – 150 °C, P_{CH4} = 10 – 100 Pa, P_{O3} = 10 – 1000 Pa, spacetime = 100 – 600 kg_{cat} s/$mol_{CH4,0}$) such that highest CO_2 yield can be achieved
- Performing catalyst characterization techniques such as XRD, N_2 Adsorption, TPR-H_2, TPD-O_2, TPD-NH_3
- Correlating catalyst characteristics to the observed performance

Reference
[1] B. Liu, J. Ji, B. Zhang, W. Huang, Y. Gan, D.Y.C. Leung, H. Huang, Catalytic ozonation of VOCs at low temperature: A comprehensive review, J. Hazard. Mater. 422 (2022) 126847. https://doi.org/10.1016/j.jhazmat.2021.126847.

[2] G. Chen, Z. Wang, F. Lin, Z. Zhang, H. Yu, B. Yan, Z. Wang, Comparative investigation on catalytic ozonation of VOCs in different types over supported MnOx catalysts, J. Hazard. Mater. 391 (2020) 122218. https://doi.org/10.1016/j.jhazmat.2020.122218.

[3] H. Einaga, N. Maeda, S. Yamamoto, Y. Teraoka, Catalytic properties of copper-manganese mixed oxides supported on SiO2 for benzene oxidation with ozone, Catal. Today. 245 (2015) 22–27. https://doi.org/10.1016/j.cattod.2014.09.018.

GHENT UNIVERSITY
LCT DRIVING CHEMICAL TECHNOLOGY