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Catalytic ozonation of toluene, ethanol, and their mixture over Copper-Manganese oxide catalysts

Keywords
VOC; catalytic ozonation; $CuMnO_x$ catalyst; mixture

Aim
Assessment of interaction effects during simultaneous catalytic ozonation of toluene and ethanol over a $CuMnO_x$ catalyst.

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.
The catalytic ozonation of individual VOC components has been widely studied. However, VOCs typically occur as mixtures in both indoor and outdoor environments. Previous studies have noted mutual effects in binary VOC mixtures during catalytic ozonation. For example, in the catalytic ozonation of a toluene and acetone mixture, it was found that while the conversion of acetone was inhibited, the conversion of toluene was enhanced [2]. This underlines the necessity of investigating the mutual effect between different VOC components in catalytic ozonation.

Program
Given that aromatic hydrocarbons and alcohols significantly contribute to overall VOC emissions, the activities in the framework of this thesis focus on toluene and ethanol as model compounds representing these two groups. Both pure model component experiments as well as their mixtures will be investigated, seeking to understand the effectiveness and limitations of catalytic ozonation of VOC mixtures:

- Acquiring intrinsic kinetic data for catalytic ozonation of toluene and ethanol, individually (T=50 – 150 °C, C_{VOC} = 100 – 1000 ppm, O_3/VOC= 2 – 15, P_{tot}=100 kPa, spacetime = 100 – 600 kg_{cat} $s/mol_{VOC,0}$)
- Acquiring intrinsic kinetic data for catalytic ozonation of binary mixture of toluene and ethanol (T=100 °C, C_{tol} = 100 – 1000 ppm, C_{eth}=100 – 1000 ppm, C_{tot}= 1000 ppm, p_{tot}=100 kPa, O_3/(eth+tol)= 10 , spacetime = 300 kg_{cat} $s/mol_{VOC,0}$)
- Exploring the effect of operating conditions on catalytic ozonation of the binary mixture (T=50 – 150 °C, C_{tol} = 500 ppm, C_{eth}=500 ppm O_3/VOC= 2 – 15, P_{tot}=100 kPa, spacetime = 100 – 600 kg_{cat} $s/mol_{VOC,0}$)

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). https://doi.org/10.1016/j.jhazmat.2021.126847.

[2] M. Aghbolaghy, J. Soltan, N. Chen, Low Temperature Catalytic Oxidation of Binary Mixture of Toluene and Acetone in the Presence of Ozone, Catal Letters. 148 (2018) 3431–3444. https://doi.org/10.1007/s10562-018-2536-8.

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