

Monolithic TiO₂-CeO₂ and Pt/TiO₂-CeO₂@VUKOPOR®A ceramic foams in oxidation of dichloromethane and methanol

Ivana Troppová^{1*}, Lenka Matějová¹, Kateřina Karásková¹, Satu Pitkääho², Vasiliki Papaefthimiou³, Benoit Louis³, Ondřej Kania⁴, Riitta L. Keiski²

¹Institute of Environmental Technology, CEET, VSB-Technical University of Ostrava, 17. listopadu 15/2172, 708 00 Ostrava-Poruba, Czech Republic, *corresponding author: (ivana.troppova@vsb.cz)

²Environmental and Chemical Engineering Unit, Faculty of Technology, University of Oulu, P.O.Box 4300, FI-90014 University of Oulu, Finland

³Institut de Chimie et Procédés pour l’Energie, l’Environnement et la Santé, UMR 7515 du CNRS - Université de Strasbourg 25, rue Becquerel 67087 Strasbourg Cedex 2, France

⁴Elvac Ekotechnika s.r.o., Tavičská 337/23, 703 00 Ostrava-Vítkovice, Czech Republic

INTRODUCTION

Dichloromethane and methanol, solvents widely used in chemical and pharmaceutical industry, belong to the group of volatile organic compounds (VOCs). Both represent a produced large-volume harmful liquid waste from production processes, which needs to be effectively disposed. Considering the development of forms of catalysts for combustion processes, the monolithic form is preferred prior to the granulated form for industrial applications. The main aim of this study was to prepare the monolithic form of catalysts, namely TiO₂-CeO₂ and Pt/TiO₂-CeO₂ catalytic layers deposited on inert open-cell VUKOPOR®A ceramic foam (LANIK, s.r.o.), investigate their catalytic performance (activity and selectivity) in dichloromethane (Cl-VOC) and methanol (oxygenated VOC) oxidation, and evaluate their application potential via critical judgement with other studied commercial or laboratory prepared monolith-based catalysts.

EXPERIMENTAL

TiO₂-CeO₂@VUKOPOR®A foam and Pt/TiO₂-CeO₂@VUKOPOR®A foam were prepared via using a simple reverse micelles-assisted sol-gel method, dip-coating and calcination. Catalytic foams were examined in oxidation of two VOCs - dichloromethane and methanol. The catalytic performance of foams was studied in the combustion reactor unit with calibrated online FTIR for dichloromethane oxidation in the temperature range of 100–500°C, for methanol oxidation in the range of 45–400°C, at the space velocity (GHSV) of 11, 600 h⁻¹ which corresponds close to industrial scale conditions.

RESULTS AND DISCUSSION

In dichloromethane oxidation, Pt/TiO₂-CeO₂@VUKOPOR®A foam showed improved CO₂ selectivity compared to TiO₂-CeO₂@VUKOPOR®A foam while their activity and HCl selectivity were comparable. The catalyst acidity/acid sites play the key role in adsorption of dichloromethane on catalyst surface and C-Cl bonds rupture affecting the HCl and Cl₂ yield, the reducibility/reducible centers are key in deep oxidation of C-H from by-products and oxidation of CO to CO₂, affecting CO₂ yield (1, 2). Impregnated PtOx species were responsible for higher reducibility of the Pt/TiO₂-CeO₂@VUKOPOR®A foam leading to higher CO₂ selectivity. In methanol oxidation, Pt/TiO₂-CeO₂@VUKOPOR®A foam showed improved catalytic activity as well as CO₂ selectivity compared to parent TiO₂-CeO₂@VUKOPOR®A. A weak Lewis acidity and high weak basicity of TiO₂-CeO₂ support and easily reducible PtOx species in the Pt/TiO₂-CeO₂@VUKOPOR®A foam were responsible for its improved catalytic performance.

CONCLUSION

Derived from the comparison with other studied commercial and laboratory prepared monolith-based catalysts it can be stated the investigated Pt/TiO₂-CeO₂@VUKOPOR®A ceramic foam could be an interesting monolithic candidate for VOCs industrial oxidation. But, some improvements must be still done within the catalyst itself. CuO should be used rather than platinum to ensure higher reducibility and Al₂O₃ or ZrO₂ should be mixed with TiO₂-CeO₂ to increase medium and strong Brönsted catalyst acidity. Besides that, it is necessary to investigate the long-term stability of the developed catalytic foam.

REFERENCES

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