LABORATORY FOR CHEMICAL TECHNOLOGY
Technologiepark 914, 9052 Gent, Belgium

Coach	Supervisors	Funding
Qing He	Kevin M. Van Geem	

Catalytic pyrolysis of plastic vapors using structure-modified and metal-doped catalysts

Aim

This project aims to develop a high performance catalyst for upgrading of polyolefin plastic vapors. The relationship between catalyst structure and performance will be investigated.

Justification

The extensive use of plastics has led to widespread white pollution. The recycling of plastics is not only benefit for mitigating environmental pollution but also for reducing excessive dependence on resources. Catalytic pyrolysis of plastics, which can convert plastics into lightweight olefins or monocyclic aromatics, is a highly promising technology.

The Brønsted acid sites (BAS) of zeolite catalysts are considered as active sites for catalytic cracking of hydrocarbons. HZSM-5 is a microporous catalyst with pore diameters ranging from 5.2 to 5.9 angstroms. Due to the larger molecular chains of plastic vapors, the acidic sites located within the microporous structure are significantly affected by steric hindrance and diffusion resistance [1]. On the other hand, plastic-derived vapors are rich in unsaturated hydrocarbons, which are prone to forming coke deposits on the surface, particularly on zeolites with a low Si/Al ratio. Therefore, the introduction of mesoporous and shell structures has the potential to enhance the diffusion of macromolecules and inhibit coke formation on catalyst surface during plastic catalytic pyrolysis.

The incorporation of metals into zeolite catalysts introduces new active sites. Gallium (Ga) can facilitate the conversion of hydrocarbons into light aromatics, such as benzene, toluene, ethylbenzene, xylenes, and naphthalene (BTEXN). This process depends on the synergistic interaction between the metal active sites and the acidic sites of HZSM-5. According to the literature, several potential Ga species can be present, including Ga_xO_y, Ga^+, and $[GaH_2]^+$, etc. [2]. The incorporation of metals into structure-modified catalysts adds additional complexity, requiring further research to clarify the relationship between the catalyst's structure and reactivity.

This study will modify the structure of commercial catalyst by introducing mesoporous and shell structures. Gallium (Ga) will also be loaded using the formic acid impregnation method, followed by H_2 reduction and O_2 reoxidation to enhance Ga dispersion and the formation of Ga_xO_Y active sites. The physicochemical properties of the catalyst will be tested, including the pore structure, acidic sites, etc. Catalytic pyrolysis experiments will be conducted on a micro-pyrolyzer coupled with a two-dimensional gas chromatography instrument. Based on the experimental data, the relationship between catalyst structure and pyrolysis performance will be studied to elucidate the catalytic pyrolysis mechanism.

Program

1. Literature review on catalytic pyrolysis for plastic wastes.
2. Preparation, characterization, and performance evaluation of catalysts.
3. Analysis of the structure-performance relationship and catalytic pyrolysis mechanism.

References

[1] O. Akin, et al., Journal of Analytical and Applied Pyrolysis, 181, (2024) 106592.
[2] Y. Zhou, et al., Angewandte Chemie (International ed. in English), 59, (2020) 19592.

GHENT UNIVERSITY

LCT DRIVING CHEMICAL TECHNOLOGY