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Overcoming major challenges in lignocellulose catalytic pyrolysis by combination of low-temperature thermal decomposition and co-processing with vegetable oils over ZSM-5 zeolite: boosted production of aromatic hydrocarbons and prolonged catalyst lifetime

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Oral Presentations #14

Overcoming major challenges in lignocellulose catalytic pyrolysis by combination of low-temperature thermal decomposition and co-processing with vegetable oils over ZSM-5 zeolite: boosted production of aromatic hydrocarbons and prolonged catalyst lifetime

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Keywords: *Catalytic co-pyrolysis, ZSM-5 zeolite,Lignocellulosic biomass, Camelina oil, Monoaromatic hydrocarbons, Catalyst deactivation*

Catalytic pyrolysis of lignocellulosic biomass is a promising route for producing renewable fuels and chemicals, monoaromatic hydrocarbons (MAHs), key petrochemical intermediates, and fuel components. ZSM-5 zeolites are widely used due to their Brønsted acidity and shape selectivity, which promote deoxygenation and aromatization. However, scale-up is limited by low MAH yields and rapid catalyst deactivation caused by coke formation. This study investigates the co-processing of oak biomass and camelina oil over nanocrystalline ZSM-5 zeolite, emphasizing the effect of thermal pyrolysis temperature on catalyst stability.

Experiments were performed in an ex-situ fixed-bed reactor with two reaction zones and continuous feeding systems for oak and camelina oil, allowing catalyst performance and deactivation to be monitored along time on stream. Camelina oil was used as a hydrogen-rich co-feed to compensate the hydrogen deficiency of lignocellulosic vapours and mitigate catalyst deactivation. As shown in Figure 1, operating the thermal pyrolysis zone at 350 °C and co-feeding camelina oil improved MAH production and extended catalyst lifetime compared with conventional catalytic pyrolysis of oak alone and with high-temperature co-processing. Although MAH yields decreased and oxygen content increased with time on stream due to progressive deactivation, this effect was sharply mitigated when oak pyrolysis was carried out at 350 °C.

The improved performance is attributed to the influence of thermal pyrolysis temperature on oak-derived vapours. At 500 °C, the vapour stream becomes enriched in deactivating species, particularly aromatic oxygenates from lignin decomposition, which act as coke precursors. In contrast, low-temperature oak pyrolysis limits the release of heavy oxygenated compounds while increasing char formation at the expense of gas production, without affecting bio-oil yield. Camelina oil co-feeding promotes synergistic aromatization over ZSM-5, through Diels-Alder reactions between oak-derived furans and olefins from camelina oil cracking.

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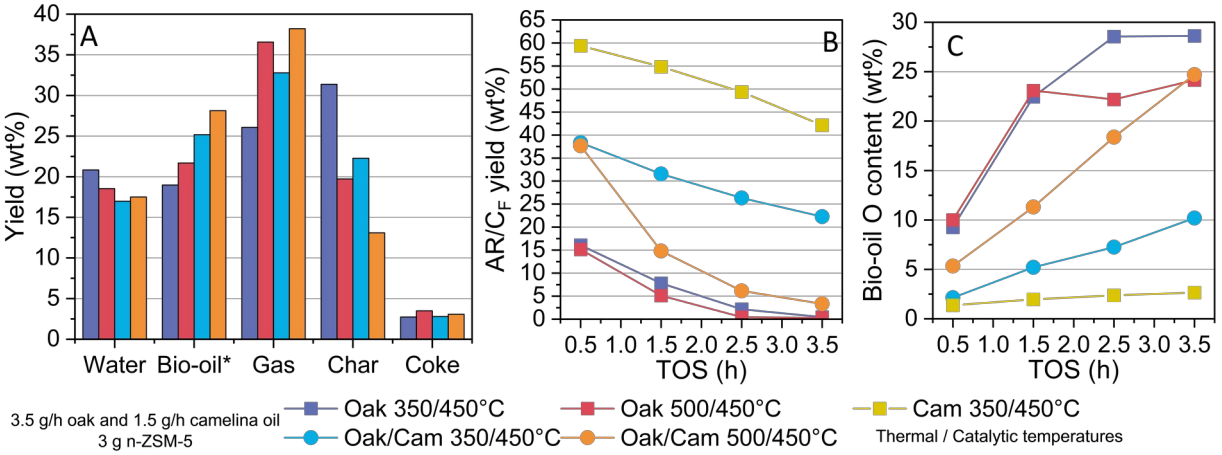


Figure 1. (A) Global and (B) carbon-to-aromatic hydrocarbons yields and (C) bio-oil* O content.

Post-reaction and regenerated catalyst characterization showed that the zeolite preserved its crystalline and textural properties. In conclusion, low-temperature oak pyrolysis coupled with camelina oil co-processing enhances MAH production and mitigates deactivation.

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