CARBON CIRCULARITY IN PLASTIC WASTE: CROSS-METATHESIS OF ETHYLENE AND 1-BUTENE OVER WO_3/Al-MCM-41 CATALYST TOWARDS PROPYLENE PRODUCTION

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ABSTRACT

Mixed plastic waste (MPW), instead of traditional energy recovery, incineration or landfill can be valorized into valuable chemicals and fuels. This aligns with the European plastics industry's current transition toward net-zero carbon emissions and circularity goals by 2050 [1]. Chemical recycling of MPW contains a range of methods, all aim at converting MPW into valuable monomers (carbon circularity). Pyrolysis is a promising method for valorizing MPW to value-added products and has advantages, such as flexible feed, simple operation and low-cost technology. Pyrolysis is a thermal decomposition method at high temperatures (300-700°C) in an inert atmosphere which yields three main products: solids (chars), liquids (pyrolysis oil) and non-condensable pyrolysis gases (NCPGs). NCPGs mainly contain light olefins such as ethylene, propylene, and C_4 alkenes; nevertheless, they are commonly used for their calorific value [2]. On the other hand, propylene as a major commodity chemical plays a leading role in the market. However, the inequality between supply and demand created the so-called 'propylene gap', which highlights the necessity for on-purpose propylene production. The propylene gap in Europe has been estimated at 347 ktn in 2021 [3]. This work aims at valorizing the NCPGs, produced via MPW pyrolysis, through the catalytic cross-metathesis reaction between ethylene and 2-butene to produce propylene. A series of WO_3/Al-MCM-41 catalysts with different Si/Al ratios were synthesized and ex-situ and in-situ characterization techniques (XRD, Raman spectroscopy, TEM, BET, FT-IR (study of pyridine adsorption), TPO, TPR, MeOH-TPSR and EXAFS) were applied to the fresh and used catalysts. A comprehensive parametric study on the effect of temperature, Si/Al ratio, WO_3 loading, residence time (W_{cat}/F^0), feed ratio (ethylene/1-butene) and reactants' partial pressures were investigated. The 20%WO_3/Al-MCM-41 catalyst, with a Si/Al ratio of 30, attained a promising performance at 550°C and 101.3 kPa, with a carbon-based propylene selectivity of 73.3% at ethylene and 1-butene conversions of 28.3% and 97.1%, respectively. Therefore, the upgrading of NCPGs via the cross-metathesis reaction not only narrows the propylene gap but also advances sustainable management of MPW.

KEYWORDS: Propylene Production, Catalysis, Pyrolysis, Plastic Recycling.

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