MECHANO-CATALYTIC DEPOLYMERIZATION OF POLYOLEFINS

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Improving current recycling technology could help increase the currently low plastic recycling rate of 12% [1]. The aim of depolymerization is to produce monomers to make high-quality plastics again. However, the state-of-the-art for polypropylene (PP) is pyrolysis, which produces low-value product mixtures, due to the high temperature applied, which is required for thermal C–C bond cleavage.[1] The team of Vollmer investigates polymer conversion in a mechano-chemical ball mill reactor (Figure 1A), which enables conversion below 60 °C instead of the more than 500 °C used in pyrolysis.[1] Mechano-chemical bond scission is combined with heterogeneous catalysis by directly functionalizing the surface of ceramic grinding spheres to create catalytically active sites.[2] This led to the discovery of a new catalytic mechanism, where the activated surface of the grinding spheres can interact with the organic radicals formed by the mechano-chemical action of colliding grinding spheres to promote monomer formation. This is fundamentally different from thermal conversion using heterogeneous catalysts, such as solid acids, where the polymer backbone C-C bonds are activated via the formation of carbocations. The team developed a model based on the Zhurkov relation[3] to predict the conversion rate based on ball milling parameters.

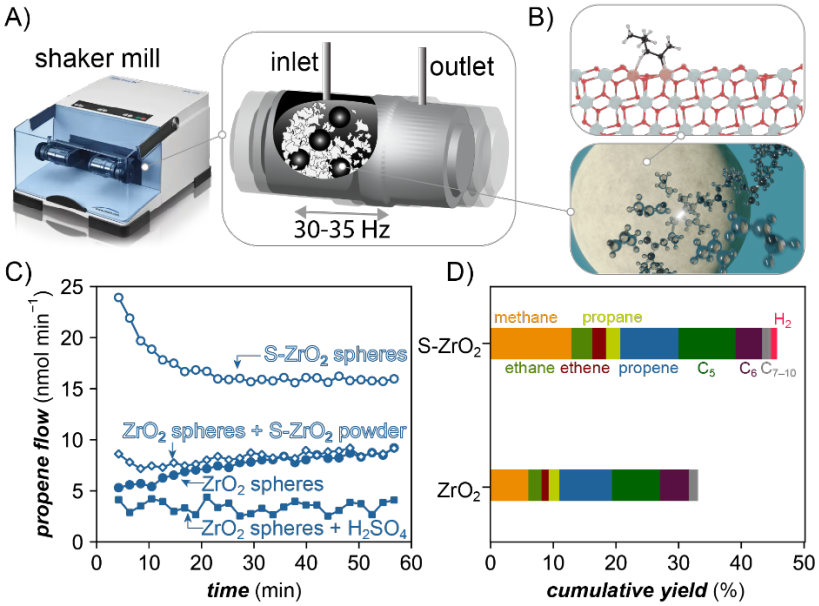

Figure 1. A) Milling container modified with gas in- and outlet to track gaseous products. B) Visualization of the mechano-chemical chain cleavage upon ball impact as well as density functional theory optimized structure of a radical interacting with the catalytic surface of the grinding sphere. C) Propene flow during milling of PP with untreated ZrO_2 spheres, sulfuric acid treated (S-ZrO_2) spheres, untreated spheres with sulfated ZrO_2 added as powder, and untreated spheres with sulfuric acid added as liquid. C) Cumulative yields obtained from model PP after 1 h of milling with untreated and S-ZrO_2 spheres using optimized conditions.

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