

CHEMICAL RECYCLING OF POLYETHYLENE BY TANDEM CATALYTIC CONVERSION TO PROPYLENE

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Plastic pollution is among the most difficult and urgent environmental challenges of our time. The vast majority of all plastics ever produced is accumulated in landfills and, unfortunately, the natural environment. While polyethylene (PE) and polypropylene (PP) are by far the world's largest plastics by volume, only a small fraction of these energy-rich polyolefins is presently recycled via mechanical, chemical and energy recovery routes. In particular, current chemical recycling involves energy intensive processes with low selectivity such as pyrolysis. In this work, we present an alternate approach to break down PE to propylene (the commodity monomer used to make PP) involving tandem catalysis (Figure 1a). The strategy combines the introduction of a single unsaturation in the polymer backbone via transfer dehydrogenation (TD) followed by multiple ethenolysis (E) and isomerization (I) events. As a result, the mono-unsaturated PE is progressively disassembled at mild reaction conditions to propylene (Figure 1b). This concept is demonstrated using both homogeneous and heterogeneous catalysts. While selectivity under batch conditions is limited at high conversion by the equilibrium mixture of olefins, high selectivity to propylene (greater than 94 %) is possible in a (semi)continuous process due to the continuous removal of propylene from the system.

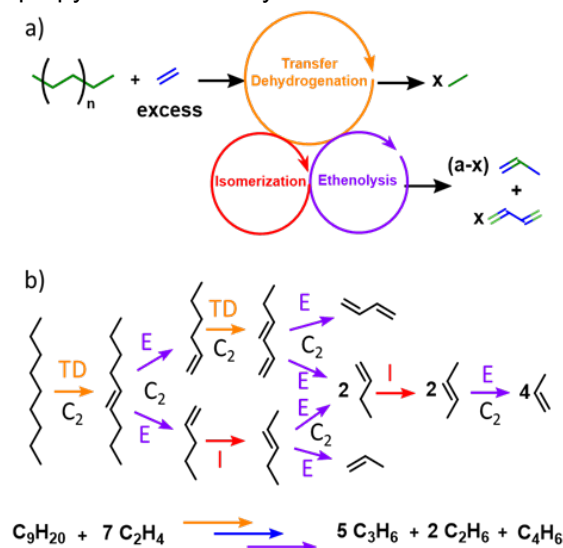


Figure 1: (a) Tandem dehydrogenation/ethenolysis/isomerization reactions for the conversion of PE to propylene and butadiene. (b) Example of the complete conversion of n-nonane into five molecules of propylene, two molecules of ethane, and one molecule of butadiene via two transfer dehydrogenation steps (TD), two isomerization steps (I), and 8 ethenolysis steps (E).