Catalysis for Controlled Degradation

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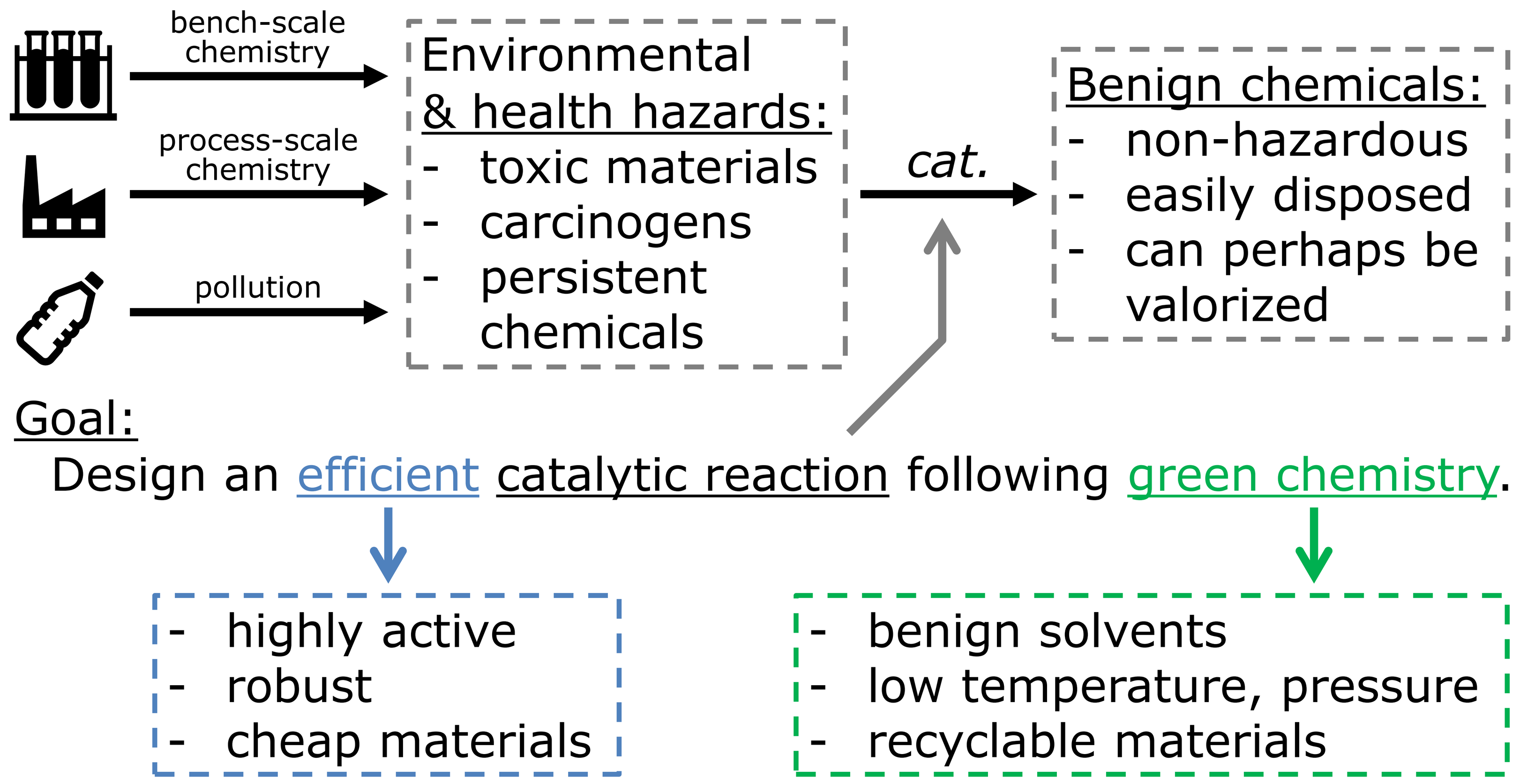
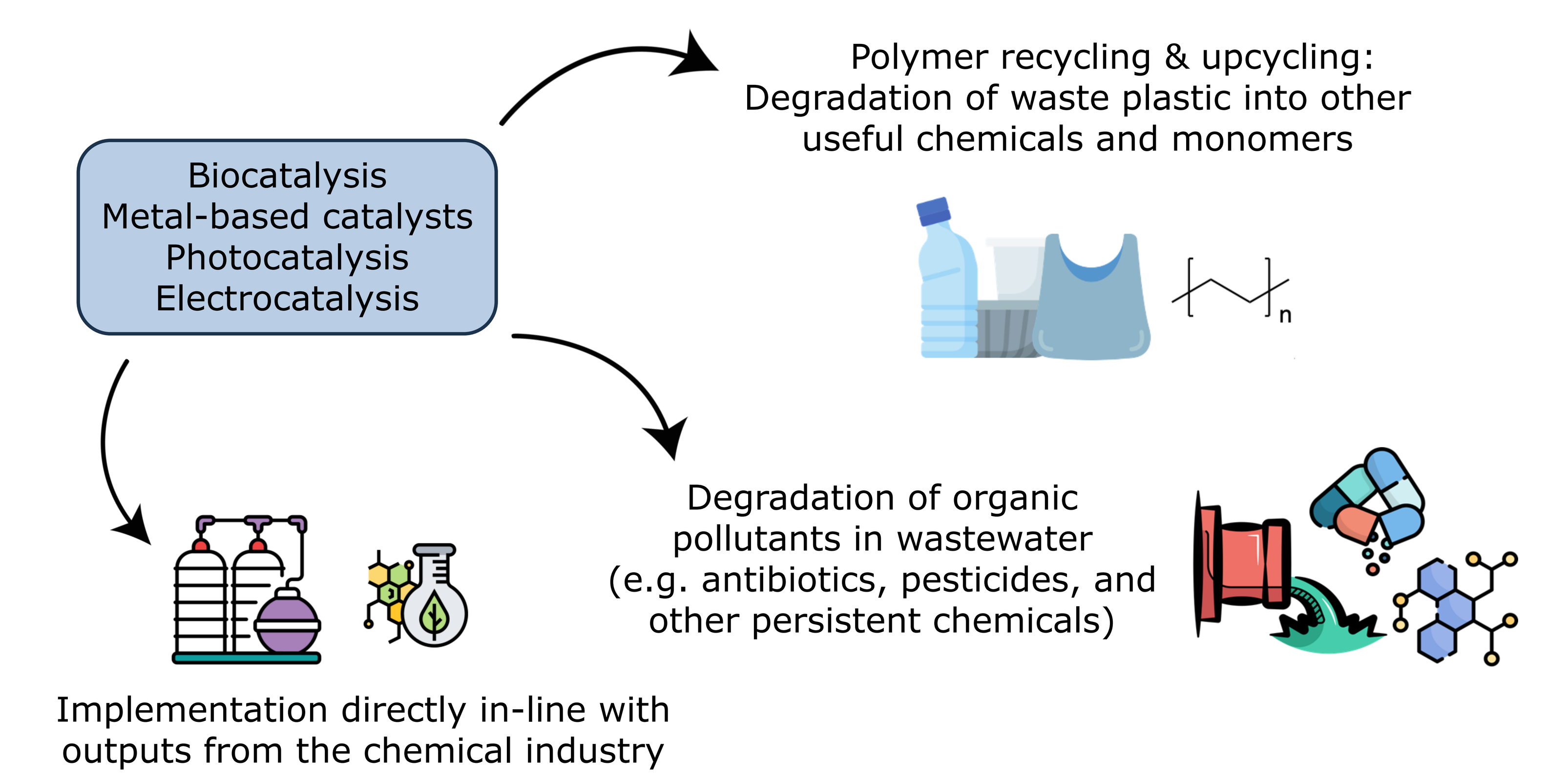
Concept

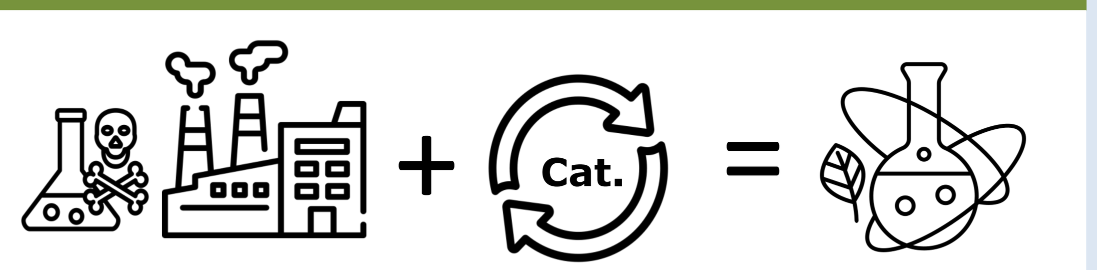


Applications



Relation to Green Chemistry

A way to mitigate hazardous material outputs from industrial chemical processes!



Catalytic systems enhance energy efficiency and atom economy, aligning with green chemistry principles. This helps us to tackle environmental problems derived from ongoing processes, while we continue to develop more sustainable processes.

Advantages

Selective catalyst design: Designing catalysts to selectively degrade a chemical to known compounds (useful or benign) by a characterized route.

Advantages (cont.)

Highly efficient reactions: since catalysts increase reaction rates and can be used in small amounts, catalytic degradation offers a more efficient way to degrade compounds compared to traditional methods that are already applied in large-scale processes such as physical adsorption, membrane filtration and chemical oxidative degradation.

Disadvantages

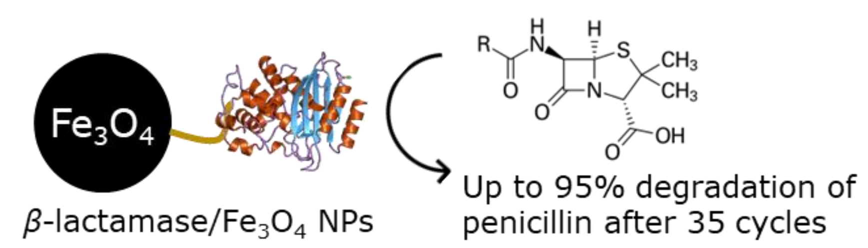
Complex composition of real samples obtained from large-scale processes or wastewater: one of the main challenges is to obtain a catalyst that can be used directly in a real sample or at the end of an industrial production line, for example. Real samples may contain a complex mixture of compounds that can interfere in the performance of the catalysts.

Degradation of catalyst: these materials should tolerate several catalytic cycles without losing its catalytic activity. In many cases, catalysts suffer from leaching, deactivation and degradation processes.

Examples

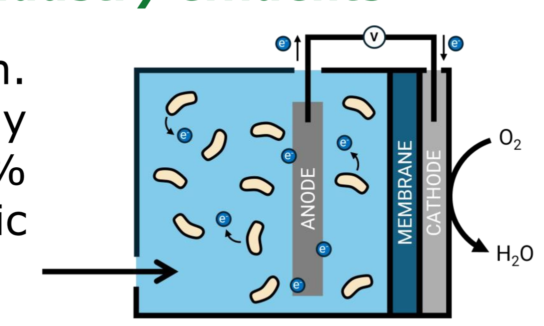
Example 1. Degradation of antibiotic in water

Enzymes are considered eco-friendly catalysts and could be used to biodegrade several antibiotics that can cause adverse effects in aquatic systems and may be related to the increased bacterial resistance. For example, β-lactamase was immobilized on the surface of Fe_3O_4 magnetic nanoparticles to obtain a highly active and easily recoverable catalyst to degrade penicillin in water with an efficiency that remained above 95% after 35 of repeated use. [1]



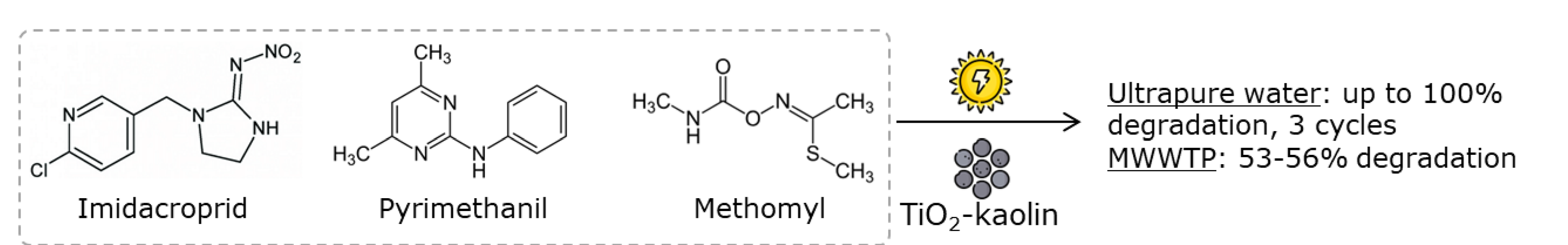
Example 2. Microbial fuel cells to decolorize textile industry effluents

The whole cell can also be a catalyst for biodegradation. Microbial fuel cells are a cheap and low-energy technology for degradation of aqueous pollutants. Studies report >90% decolorization of Acid Orange 7 dye from an anaerobic microbial consortium cleaving azo bonds at the anode. [2]



Example 3. Degradation of persistent pesticides in water

TiO_2-based catalysts combined with UV-light irradiation are promising methodologies to degrade persistent pesticides. For example, TiO_2-kaolin composite completely degraded pesticides such as imidacloprid, pyrimethanil, and methomyl in solar photoreactors. The catalytic activity was also evaluated for the treatment of two samples from Municipal Wastewater Treatment Plant (MWWTP) obtaining promising results. [3]

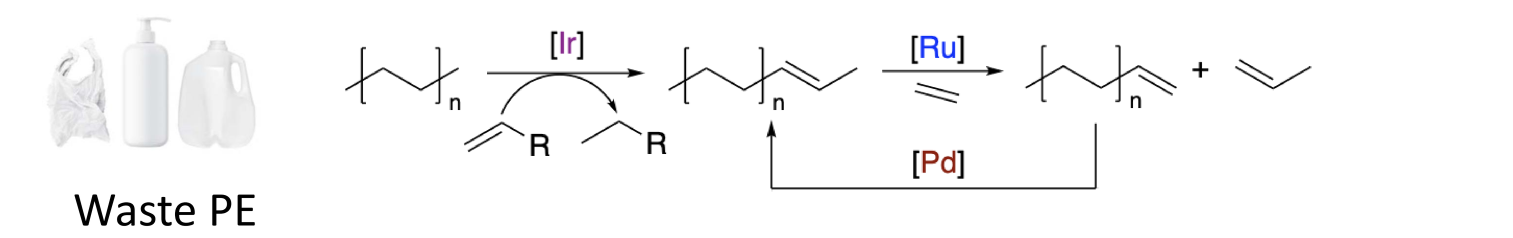


Examples (cont.)

Example 4. Selective Degradation of Waste Polyolefins

Transition metal catalysts (both homogenous and heterogenous) have been applied to *hydrogenolysis* and tandem *dehydrogenation/olefin metathesis* reactions to deconstruct waste polyolefins into **fuels, lubricants, waxes and even monomer units.** [4,5]

Catalytic deconstruction of waste polyethylene to form propylene:

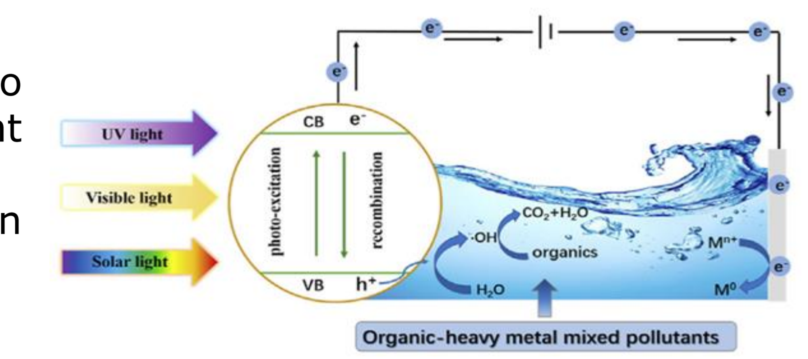


- Tandem reaction involving 1) dehydrogenation 2) isomerization and 3) olefin metathesis reactions;
- Reported yields of propylene up to 80%;
- Reactions can be carried out neat (i.e. solvent free);
- Catalysts tolerant of additives in waste polyolefin samples.

Example 5. Degradation of organic pollutants and heavy metals in wastewater combining photocatalysis with electrochemistry

The bias potential can remarkably promote the oxidation of organic pollutants on the photoanode by suppressing the recombination of photogenerated electron-hole pairs and extending the lifetime of photogenerated holes. [6,7]

- High energy efficiency, amenability to automation and simple equipment required;
- Electrochemical Advanced Oxidation Processes (EAOPs);
- High price of solar photovoltaic cell.



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