

Reviewing Organic Synthesis by Integrating Catalysis and Sustainable Chemistry

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Abstract

Organic synthesis is central to the development of pharmaceuticals, agrochemicals, functional materials, and numerous industrial products, but conventional synthetic processes can generate significant waste, consume large quantities of energy, and rely on hazardous reagents and solvents. This review examines the integration of catalysis with sustainable chemistry as an approach to developing more efficient, selective, and environmentally responsible synthetic methodologies. Catalysis enables chemical transformations to proceed under milder conditions while improving reaction rates, selectivity, and resource efficiency. The study reviews the contribution of homogeneous, heterogeneous, organocatalytic, biocatalytic, and photocatalytic systems to sustainable organic synthesis. Particular attention is given to the use of renewable feedstocks, recyclable catalysts, safer solvents, solvent-free reactions, one-pot processes, atom-economical transformations, and energy-efficient reaction conditions. Emerging approaches such as visible-light photocatalysis, electrochemical synthesis, and catalytic biomass valorisation are also considered for their potential to reduce environmental impact and expand synthetic possibilities. The review highlights the importance of evaluating synthetic routes not only in terms of chemical yield but also through parameters such as atom economy, reaction efficiency, waste generation, energy consumption, catalyst recyclability, and overall environmental impact. Despite significant advances, challenges remain regarding catalyst cost, scalability, stability, recovery, selectivity, and industrial implementation. The study concludes that combining innovative catalytic strategies with the principles of sustainable chemistry can significantly improve the efficiency and environmental performance of organic synthesis. Continued interdisciplinary research is essential for translating laboratory-scale sustainable methods into practical and economically viable industrial processes.

Keywords: Organic Synthesis, Catalysis, Sustainable Chemistry, Green Chemistry, Organ catalysis, Biocatalysis, Photocatalysis, Renewable Feedstocks, Atom Economy, Green Solvents, Waste Reduction, Sustainable Synthesis, Biomass Valorisation.

