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Continuous Flow Biocatalysis - A Green Revolution in API Manufacturing

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Abstract: *Continuous flow biocatalysis is redefining the production of active pharmaceutical ingredients (APIs) by merging the selectivity and mild conditions of enzymatic reactions with the efficiency, control, and scalability of continuous flow systems. This approach overcomes challenges of conventional batch biocatalysis, such as limited mass transfer, enzyme instability, and scale-up difficulties. Innovations in enzyme immobilization, cofactor recycling, and reactor engineering have improved catalyst longevity, substrate throughput, and multi-step process integration. Additionally, hybrid chemoenzymatic cascades and automated flow operations enhance productivity while reducing solvent usage and chemical waste.*

Evaluations using green chemistry metrics, including atom economy and process mass intensity, demonstrate its environmental benefits. This review discusses the principles, recent advances, industrial implementations, and future directions of continuous flow biocatalysis, highlighting its potential as a sustainable and efficient platform for API manufacturing.

Keywords: Biocatalysis, Enzyme Catalysis, Active Pharmaceutical Ingredients (APIs), Green Chemistry, Enzyme Immobilization

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