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**Short Communication**

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# Advances in Green Chemistry Approaches for Sustainable Pharmaceutical Synthesis

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## DESCRIPTION

Advances in green chemistry have transformed pharmaceutical synthesis, offering sustainable, efficient and eco-friendly pathways that reduce waste, minimize energy consumption and replace toxic reagents with safer alternatives. Traditional pharmaceutical synthesis often involves hazardous solvents, resource-intensive processes and the generation of significant chemical waste, which poses challenges for both environmental health and human safety. In order to overcome these problems, green chemistry techniques concentrate on designing chemical processes that prioritize sustainability at every stage of production while simultaneously maximizing efficiency. Core principles of green chemistry such as waste minimization, atom economy, use of renewable feedstocks and reduced toxicity guide the development of new methodologies, reagents and reaction conditions, transforming how pharmaceuticals are manufactured [1]. One of the most notable advancements in green pharmaceutical synthesis is the adoption of alternative, greener solvents. Solvents are used in nearly every stage of pharmaceutical production, yet they contribute significantly to the environmental footprint of these processes. Traditional organic solvents like dichloromethane and acetonitrile are effective but are also hazardous, toxic and often difficult to dispose of responsibly. In response, green chemistry has promoted the use of water, supercritical $CO_2$ and bio-based solvents derived from renewable resources, which are safer and less impactful on the environment [2,3]. For instance, supercritical $CO_2$, which behaves as both a gas and liquid under specific conditions, has proven to be a valuable solvent in various pharmaceutical reactions due to its low toxicity and easy removal from final products.

Meanwhile, ionic liquids salts that are liquid at room temperature offer versatile alternatives because of their non-volatile nature and ability to be tailored to specific reactions. By reducing reliance on hazardous solvents, these advancements have led to safer, less polluting synthesis methods, marking a critical shift in pharmaceutical manufacturing. Biocatalysis has also emerged as a green approach in pharmaceutical synthesis, capitalizing on the specificity, efficiency and mild operating conditions of enzymes to catalyze reactions [4]. Enzymes can carry out transformations that would be challenging or inefficient using traditional synthetic chemistry, often requiring milder temperatures, less energy and fewer toxic reagents. This results in greater selectivity and atom economy, reducing byproducts and streamlining purification processes. Biocatalysis has proven particularly effective for asymmetric synthesis, which is essential in the pharmaceutical industry, as many drugs are chiral and require selective synthesis of a single enantiomer [5]. Enzymatic processes, such as the use of lipases, oxidases and dehydrogenases, have been incorporated into the synthesis of complex pharmaceutical compounds, improving efficiency while lowering environmental impact. For example, lipases are widely used for enantioselective transformations in the synthesis of Nonsteroidal Anti-Inflammatory Drugs (NSAIDs), creating high-purity compounds with minimal waste. The application of biocatalysis in pharmaceutical synthesis not only makes processes more sustainable but also enhances the quality of final products, establishing it as a cornerstone of green chemistry. Catalytic reactions, particularly those utilizing transition metal catalysts, have also advanced under green chemistry principles. Catalysis increases reaction efficiency, allowing for lower temperatures, shorter reaction times and reduced chemical inputs. Transition metals, such as palladium, copper and nickel, catalyze cross-coupling reactions integral to forming carbon-carbon bonds, a fundamental step in many pharmaceutical syntheses [6-8]. Innovations in green chemistry have sought to minimize or replace toxic catalysts with more sustainable options. For instance, chemists have developed reusable metal catalysts and implemented techniques that allow for easier recovery and recycling of catalysts after each reaction cycle, significantly reducing waste and environmental impact. Additionally, iron-based catalysts have gained traction as safer alternatives to heavy metals due to iron’s abundance and lower toxicity, making it a sustainable choice for various pharmaceutical applications. Green catalytic methods have streamlined complex multi-step synthesis processes, reducing resource demands and improving the overall sustainability of pharmaceutical production [9,10].

Finally, green chemistry is reshaping pharmaceutical synthesis, providing more sustainable methods for drug production. Green chemistry not only solves the environmental issues of pharmaceutical production but also increases process efficiency and product quality by lowering the environmental impact of solvents, increasing the effectiveness of catalysts, streamlining synthetic routes and employing renewable resources. As the pharmaceutical industry continues to embrace green chemistry, these advances are setting a new standard for sustainable development, aligning drug manufacturing with the goals of environmental responsibility and public health of repeated dosing or in vulnerable populations such as the elderly, young children and individuals with compromised immune systems.

## REFERENCES

[1] Jambrak AR, Da Cruz AG, Chen J. *Ultrason Sonochem*. 2024;106.

[2] Cantillo D. *Curr Res Green Sustain Chemi*. 2024:100416.

[3] Pastorino P, Barceló D. *Ecol Indic*. 2024:112337.

[4] Ahmad S, Jaiswal R, Yadav R, et al. *Sustain Chem*. 2024:100029.

[5] Gupta TK, Gupta D, Chandel NK, et al. *Sustaina Chem and Pharm*. 2024;42:101823.

[6] Assis RS, Barreto JA, Santos MJ, et al. *Trend Environ Anal Chemi*. 2024:e00247.

[7] de Oliveira ML, Rodrigues LM, da Veiga MA, et al. *Green Anal Chem*. 2024;11:100148.

[8] Detke SJ, Karwande AD, Ponugoti SS, et al. *Synth Commun*. 2024;54(23):2024-2037.

[9] Sahu M, Singh S, Prajapati S, et al. *RSC Adv*. 2024;14(45):32733-53278.

[10] Voukkali I, Papamichael I, Loizia P, et al. *Chem Eng J*. 2024;497:155039.