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Editorial: Microfluidic-based technologies for sustainable process intensification

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Editorial on the Research Topic
Microfluidic-based technologies for sustainable process intensification

The growth in global demand for sustainable and efficient processes is one of the main factors driving the competitiveness of industrial technology. In this context, process intensification using microfluidic devices has stands out due to the inherent advantages of reduced length scale, providing enhanced heat and mass transfer efficiency, high selectivity, and superior yields in chemical processes. The ability to control process variables more precisely also enables a high level of safety, essential in situations involving toxic or explosive reagents. Moreover, the development of high-efficiency modular plants with variable production rates offers adaptability and flexibility for diverse industrial applications.

This editorial presents a Research Topic of five papers that explore the state of the art of microfluidics-based technologies for the intensification of sustainable processes, covering a range of applications from chemical synthesis to environmental treatment. Each article contributes uniquely to demonstrate how microfluidic devices can be applied in process intensification, providing a broader view of technological advances, challenges, and opportunities in the field.

In the first article, Oliveira et al. discussed the modeling and simulation of photoredox catalysis in microreactors, emphasizing the importance of Computational Fluid Dynamics (CFD) in optimizing process efficiency and improving the understanding of reagent interactions and the influence of light within the reaction medium. This work highlighted the relevance of computational tools in advancing photoredox catalysis, especially in pharmaceutical applications where high selectivity and yield are crucial for the production of high-value compounds.

The continuous synthesis of Diazepam in microreactors, demonstrating how process intensification can enhance the efficiency of essential drug production, is discussed by Nicholas et al. The developed process achieved high purity and yield in a short period, reinforcing the potential of microreactors as a promising solution to strengthen pharmaceutical supply chains and ensure drug production with greater safety and reduced environmental impact.

Ge et al. investigate an integrated planar photocatalytic microreactor for water treatment, combining a highly efficient photocatalyst with the microreactor design. The doping of TiO_2 nanoparticles with rare earth ions significantly enhances the photodegradation efficiency, making the process effective under visible and UV light irradiation. This paper underscored the potential of microreactors in environmental applications, especially for continuous effluent treatment, highlighting the capability of process intensification using photocatalytic techniques.

One of today's most important primary chemicals, methanol, was explored in the paper by Silva et al. The authors addressed methanol synthesis in catalyst-coated microreactors, comparing different microreactor configurations with fixed-bed reactors. Numerical analysis showed that microreactors can achieve performance equivalent to traditional reactors, with significant advantages in terms of pressure drop and scaling efficiency. This study was essential for understanding how microreactors can be effectively scaled, retaining the benefits of microscale while meeting industrial production demands.

Finally, Masouleh et al. used time-scale analysis (TSA) to optimize a microfluidic device for the enzymatic reduction of uric acid for biomedical applications. TSA is presented as a valuable tool for identifying bottlenecks in biochemical processes and proposing intensification improvements without the need for complex computational modeling. This article is particularly relevant for biomedical processes, where limited access to biological samples makes optimization a crucial task.

This Research Topic of papers clearly illustrates how microfluidics is being used to intensify processes in areas such as chemical synthesis, environmental treatment, and biomedical applications, contributing to more sustainable and efficient solutions. The diversity of applications presented in the articles in this Research Topic reflects the great potential of microfluidic devices to transform industrial processes by reducing costs, enhancing safety, and optimizing resource use.

We hope this Research Topic inspires new advancements and promotes collaborations between scientists and engineers to overcome current challenges and further explore the opportunities that microfluidics can offer for the intensification of sustainable processes.

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