

Editorial

Editorial Overview of the Special Issue “Second Edition of Innovation in Chemical Plant Design”

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Plant innovation extends beyond equipment and process layout to the smart integration of materials science, reaction engineering, and system design [1]. Several studies address this coupling by developing intensified and integrated processes that reduce energy consumption and waste [2,3]. For example, new conceptual and pilot-scale schemes for the production of cosmetic emulsions from Amazonian oils demonstrate how process intensification can translate natural feedstocks into high-value products with lower environmental impact than traditional methods [Contribution 1]. Through careful analysis of hydrodynamics, emulsification kinetics, and economic parameters, these studies show that combination of extraction and formulation in a single modular unit can minimize water and energy intensity [Contribution 2]. Other contributions focus on the integration of renewable energy within conventional systems. The thermal coupling of solar fields to combined cycles exemplifies how hybrid energy integration can reduce carbon emissions without sacrificing power output, thus merging process engineering with sustainable energy management [Contribution 3].

This Special Issue also includes research that expands the concept of process intensification beyond energy and mass transfer, addressing instead the challenge of waste valorization and resource recovery. The design of a biorefinery based on non-marketable edible mushroom waste illustrates how circular-economy principles can be applied to convert residues into chitin, citric acid, and organic fertilizer [Contribution 4]. By combining process simulation, economic assessment, and environmental analysis, the authors highlight the feasibility of such biorefineries as viable routes to close material loops and diversify the bioeconomy. Likewise, the coupling of energy integration and inherent safety evaluation in suspension-polyvinyl-chloride production underscores that process optimization must always be balanced by safety considerations, prompting the need for new design strategies that simultaneously optimize efficiency and safety [Contribution 5].

Innovation in chemical plant design is increasingly linked to the development of novel materials. The synthesis of porous zinc nano-wafer aerogels, for instance, introduces an advanced nanostructured electrode for high-performance supercapacitors, combining lightweight architecture with superior electrical properties and durability [Contribution 6]. In parallel, biologically derived stabilizers and biosurfactants are explored as eco-friendly tools for nanoparticle production and hydrocarbon remediation. The use of fungal biosurfactants as stabilizers for polymeric nanoparticles demonstrates the potential of biologically sourced amphiphiles to replace synthetic surfactants in colloidal processing [Contribution 7]. Similarly, sophorolipid biosurfactants show excellent emulsification



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performance in oil recovery and marine clean-up, bridging biotechnology and environmental engineering [Contribution 8]. Multifunctional hydrogels and composite exhibit dual capabilities for dye adsorption and antibacterial activity, highlighting how multifunctional materials can support sustainable remediation and water-treatment operations [Contribution 9].

Some works of this issue address reaction kinetics and separation processes under complex conditions, providing insights that are essential for the rational design of large-scale units. The kinetic study of barium sulfate precipitation in the presence of organic additives elucidates the interplay between solvent composition, supersaturation, and crystal morphology, offering strategies to control fouling and particle formation in industrial crystallizers [Contribution 10]. Similarly, the selective extraction of nitrogen-containing heterocycles from crude methylnaphthalene oil through formamide demonstrates how tailored solvent systems can enhance the purification of aromatic streams and improve downstream product quality [Contribution 11]. Other contributions analyze adsorption–desorption cycles for dye removal from tanning wastewaters and critically review biological and hybrid systems for the treatment of tannery effluents, with a particular focus on nitrogen and sulfur species removal [Contribution 12, Contribution 13]. These works emphasize the importance of coupling experimental studies with modeling and process evaluation to ensure scalability and robustness in real-world applications.

Complementing these investigations, comparative studies on photocatalysis, sonophotolysis, and sonophotocatalysis offer a systematic understanding of advanced oxidation processes for wastewater treatment [Contribution 14]. The kinetic and energetic analyses performed highlight both the potential and the limitations of these emerging technologies when applied to complex organic mixtures. The integration of such oxidation systems into existing treatment chains could represent a decisive step toward achieving near-zero discharge targets in industrial water management.

Beyond these core themes, several unconventional but thought-provoking contributions broaden the traditional boundaries of chemical plant design. Numerical simulations of methane combustion in industrial gas turbine injectors provide a detailed analysis of flame stabilization, vortex formation, and pollutant formation, guiding more sustainable combustion strategies [Contribution 15]. The exploration of smart card-based vehicle ignition systems, incorporating materials science, sensor technology, and regulatory compliance, reflects the growing convergence between process engineering, electronics, and safety systems, integrating multidisciplinary knowledge to design safer, more efficient, and more sustainable systems [Contribution 16].

Studies included in this Special Issue capture the dynamism and breadth of contemporary research in chemical plant design. They demonstrate that innovation today lies not only in technological advancement but also in methodological integration. The interplay between intensified operations, advanced materials, kinetic understanding, and environmental responsibility is reshaping the landscape of process engineering. As digitalization, artificial intelligence, and process simulation tools continue to evolve, future plant designs will increasingly rely on real-time optimization, modular architectures, and closed-loop sustainability assessment.

The final message of this Special Issue is clear: the future of chemical plant design will depend on our ability to merge creativity with rigor, sustainability with profitability, and micro-scale innovation with macro-scale implementation, as affirmed by many researchers and colleagues [4]. Therefore, we extend our sincere gratitude to all authors for their contributions, to the reviewers for their invaluable insights, and to the editorial staff of *Processes* for their continued support. We hope that the ideas presented here will inspire

further research, fostering innovation in chemical plant design toward a cleaner, safer, and more resilient future.

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List of Contributions

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