



Editorial: Nanocatalysts in Biofuel Process Optimization

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Keywords: biofuels, energy, nanocatalyst, biodiesel, bioenergy

Editorial on the Research Topic

Nanocatalysts in Biofuel Process Optimization

OPEN ACCESS

Edited by and reviewed by:

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Technische Universität Braunschweig,
Germany

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Specialty section:

This article was submitted to
Bioenergy and Biofuels,
a section of the journal
Frontiers in Energy Research

Received: 21 September 2021

Accepted: 28 September 2021

Published: 12 October 2021

Citation:

Rehan M, Nizami A-S, Tabatabaei M,
Moustakas K, Laeeq Khan A, Amjad M
and Khan MZ (2021) Editorial:
Nanocatalysts in Biofuel
Process Optimization.
Front. Energy Res. 9:780638.
doi: 10.3389/fenrg.2021.780638

INTRODUCTION

The world is facing severe environmental challenges, including increasing consumption of fossil-based energy and its consequent devastating impact, i.e. global warming and climate change. Biofuels are promising alternatives to fossil fuels with tremendous environmental and socio-economic benefits. There has been a considerable deal of research and development carried out on the production of biofuels in the last 2 decades. However, there is still a huge potential for achieving more cost-effective and efficient biofuel production processes through the application of nanotechnology. The exceptional properties of nanomaterials (nanocatalysts) such as high surface area, catalytic performance, crystallinity, durability, energy storage capacity, etc. offer great potential for optimizing biofuel production systems. Nanocatalysts could also serve recovery, reusability, and recycling purposes.

This Research Topic is designed to attract the state-of-the-art recent developments in fabrication, modification, and optimization of advanced nanocatalysts and nanostructured materials for biofuel production processes (**Figure 1**). This Frontiers Research Topic has attracted and compiled 12 top quality research and review articles. The articles have been written by researchers and academics working in institutions at different countries across the world including Australia, China, Egypt, Greece, India, Iran, Malaysia, Netherlands, Pakistan, Saudi Arabia and South Korea. The editorial team of this research topic is very grateful to all the authors for their excellent contributions and making the research topic successful.

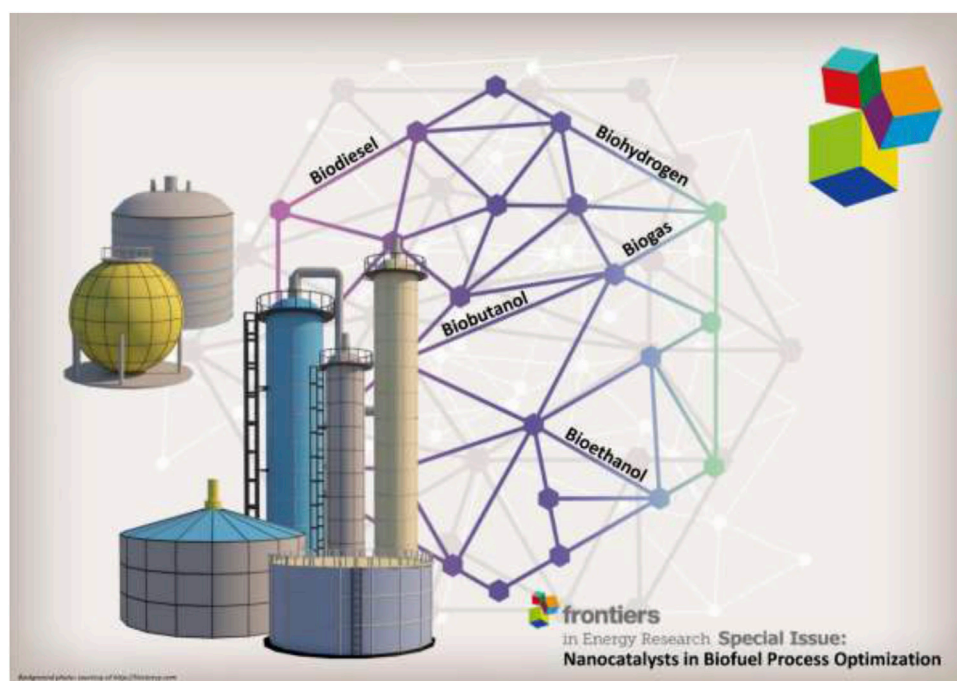


FIGURE 1 | Nanocatalysts in biofuel process optimization

NANOCATALYSTS SYNTHESIS AND CHARACTERIZATION FOR BIOFUEL PRODUCTION

There has been a significant amount of research work conducted in recent years on advanced nanocatalyst fabrication and development for optimization of biofuel processes. Bano et al. presented a comprehensive review on fabrication and optimization of nanocatalyst for biodiesel production. The authors discussed the production of biodiesel produced from various feedstock and using several processes such as pyrolysis, micro-emulsion, direct blending, and *trans*-esterification, with critical discussion focussing on increasing biodiesel production using nanocatalysts. Further, the importance of nanocatalyst in heterogeneous catalysis based *trans*-esterification for large scale biodiesel production was highlighted. Another interesting review on state of the art of catalysts for biodiesel production was published by Rizwanul Fattah et al. The authors reviewed various catalysts used for biodiesel production and compared their suitability and associated challenges in the transesterification process. Homogeneous catalysts are generally efficient in converting biodiesel with low free fatty acid (FFA) and water containing single-origin feedstock. Heterogeneous catalysts, on the other hand, provide superior activity, range of selectivity, good FFA, and water adaptability.

Nayebzadeh et al. studied the influence of fuel to oxidizer ratio on microwave-assisted combustion preparation of nanostructured $\text{KOH}/\text{Ca}_{12}\text{Al}_{14}\text{O}_{33}$ catalyst used in efficient biodiesel production. Authors demonstrated a high biodiesel yield of 94.5%, using 450 W, 12:1 methanol to oil ratio,

catalyst loading of 4 wt% for 1 h, through this microwave-enhanced biodiesel production process.

Shaker and Elhamifar synthesised a novel magnetic nanocatalyst, methylene-based organosilica with core-shell structure ($\text{Fe}_3\text{O}_4@\text{OS}-\text{SO}_3\text{H}$), and used in the production of biodiesel through esterification process. The synthesised catalyst showed good catalytic features and performance in biodiesel production process. Authors also claimed to have recovered and reused the synthesised catalyst several times without significant decrease in its efficiency and stability.

RECENT ADVANCES IN BIOFUEL PRODUCTION

Many studies have been published on advancements in biofuel production as a renewable source of energy. For example, Gholami et al. presented a review study on recent advances of biodiesel production using ionic liquids supported on nanoporous materials as catalysts. The authors discussed the key issues in current catalysts used in biofuel production as well along with the new developments in nanocatalysts. The economic and environmental aspects of different catalysts in biofuel production were also highlighted. Ruhong et al. proposed the utilization of enzymes as catalysts to enhance biofuel production. White-rot fungi is capable of producing extracellular enzymes that degrade lignin structure and facilitate biofuel production from lignocellulosic biomass wastes. The authors claimed to have shown the synergistic effects of the fungal co-culture for biomass treatment and providing a new approach for increasing lignin degradation

along with improving enzymatic catalysis and biofuel production through fungal coculture.

CARBON CAPTURE

Carbon capture and storage is considered as a potential way forward to mitigate environmental pollution caused by fossil fuels. Researchers are trying to optimize the current methods and develop new ones to achieve maximum benefits. Ishaq et al. proposed novel poly deep eutectic solvents (PDESs) based supported liquid membranes for CO₂ capture. The PDESs were synthesized by mixing choline chloride (hydrogen bond acceptor-HBA) and two hydrogen bond donors-HBDs (polyacrylic acid and polyacrylamide) separately in different molar ratios. The PDESs were then impregnated into microporous polyvinylidene fluoride (PVDF) membrane support to synthesise supported liquid membranes (SLMs). Pure and mixed-gases of CO₂, CH₄ and N₂ were tested on these synthesised PDES-SLMs with excellent permeability and selectivity. These cheap and green membranes with promising gas separation performance make them potential alternative to the competing PILs for capturing the greenhouse acid gases.

ENERGY SYSTEMS OPTIMIZATION

Some very interesting and state-of-the-art studies were published on energy systems optimizations in this research topic. For example, He et al. proposed black hole-inspired optimal design of biomethane liquefaction process for small-scale applications. Authors found that the specific energy consumption could be reduced with significant reduction in total exergy destruction by introducing the cryogenic liquid turbine to the single mixed refrigerant-based biomethane liquefaction process. The findings of this research work is a step forward in designing and improving the small-scale biomethane liquefaction process.

Qyyum et al. presented an interesting study on process systems engineering evaluation of prospective working fluids for organic rankine cycles facilitated by biogas combustion flue gases. Authors presented technical and economic analysis along with process system engineering perspective. Authors found i-butanol and n-butanol as promising working fluids, both technically and economically, for high-temperature organic Rankine cycle systems in comparison with toluene. These results will help to develop more energy efficient organic Rankine cycle systems for producing power.

Another interesting study was published on process optimization of nanocatalytic conversion of microalgae to clean bioenergy utilizing the fuzzy multi-criteria decision making processes by Kokkinos et al. Authors assessed technical, economic, environmental and social aspects of the proposed biofuel production system.

Arora et al. presented review study on the valorization of wastewater resources into biofuel and value-added products using microalgal system. Authors reviewed different microalgae cultivation processes including open, closed, and integrated for simultaneous treatment of wastewater and resource recovery. Key

factors affecting the growth of microalgae, such as sunlight, temperature, pH, and nutrients, were also discussed. It was stated that by integrating the wastewater treatment with microalgae biorefinery, it is possible to solve wastewater treatment problems along with generating revenue leading towards a sustainable and circular bio-economy.

A comparative study of techno-economic analysis of two biodiesel production processes was presented by Al-Sakkari et al. One process utilized waste cooking oil as a feedstock with potassium hydroxide homogeneous catalyst and the second process used virgin soybean oil as feedstock with cement kiln dust heterogeneous catalyst. The theoretical purities of biodiesel and glycerol obtained upon conducting the simulation of both processes are high, i.e., 99.99%. However, the homogeneous process was found economically superior as sensitivity analysis revealed that the profitability of biodiesel production is very sensitive to the feedstock price and recommends shifting toward waste vegetable oils as a cheap feedstock to have a feasible and economic process.

OUTLOOK

Biofuels are promising alternatives to fossil fuels with tremendous environmental and socio-economic benefits. This research topic highlights the emerging technologies and recent developments in nanocatalysts and process optimizations of biofuel production. 12 top quality articles have been published in this research topic on recent developments in nanocatalysts synthesis and biofuel production, carbon capture and energy systems optimization. Key challenges in biofuel and bioenergy are highlighted along with potential of emerging nanocatalysts, biofuel production and process optimization as way forward to shift from fossil fuels towards renewable energy resources.

AUTHOR CONTRIBUTIONS

MR, A-SN, MT, MZ, and KM contributed to conception and design of the study. MR wrote the first draft. AL, MA, and AN reviewed/corrected the first draft of the manuscript with addition of some text in different sections. All authors contributed to manuscript revision, read, and approved the submitted version.

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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