Advances in biodiesel production research

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EDITORIAL

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Global energy demand is increasing alongside the growing concern for environmental protection. The energy crisis triggered by the current political and economic situation in the world requires the transition to a more sustainable and secure energy system. Therefore, the focus is on alternative fuels as a solution to replace fossil oil sources in the transport sector. Biofuels stand out as the most promising alternative to fossil fuels providing energy transition without changes in the current infrastructure. Among biofuels, biodiesel is a renewable alternative to fossil diesel obtained from bio-sources such as vegetable oils (edible, nonedible, and waste/used), animal fats, or algae oil. It has many advantages, such as biodegradability, low toxicity, reduced emissions of char, benzene, toluene, sulphur oxides, harmful nitrogen compounds, and other greenhouse gasses due to the closed CO_2 cycle, and improved engine combustion due to the adequate O_2 content. In addition, it can be used without the internal combustion engine modification and mixed in any ratio with ordinary fossil-based diesel fuel, so it can be easily commercialized. Besides the environmental aspect, biodiesel production has a positive impact on the rural economy. Still, there is a need for improvements in the biodiesel production concerning the replacement of edible oils as feedstocks for the manufacturing process, reducing the high synthesis cost, and increasing the quality of the final product. Therefore, this special issue aims to provide recent developments and advances in sustainable biodiesel production regarding feedstocks, catalysts, properties, and technologies.

Significant advances were made in the valorisation of waste materials into biodiesel. Reusing wastes without a practical value and other applications is essential for reducing production costs and, thus, biodiesel prices. In this respect, Marinković and Pavlović [1] provide a comprehensive overview of the utilization of waste-based and natural zeolitic materials as catalysts or catalyst supports in biodiesel production. Synthesis routes of the zeolite-based catalysts are analysed in detail with an emphasis on the economy of the process and then the catalyst stability and reusability in transesterification of oils into biodiesel. Furthermore, the reaction mechanisms are also discussed in detail for reaction conditions optimization. This article can be valuable as a new ideas generator for researchers interested in the further investigation of waste-based zeolites and their applications.

A contribution to the valorisation of waste materials as catalysts was also given by a study by Miladinović *et al.* [2]. The catalytic activity of ashes obtained after combustion of waste plum stones and stone shells for heat generation was tested in transesterification of plum kernel oil into biodiesel. In this way, the complete utilization of waste plum stones in biodiesel production was demonstrated. The study revealed the plum stone shell ash as the most active catalyst compared to waste plum stones ash and plum kernel cake ash, so that it was characterized in detail, and investigated regarding the effect of reaction temperature on methyl esters synthesis. Kinetic analysis was performed to determine the reaction rate constant and activation energy. This study is significant for the development of biodiesel production processes based on utilization of the same low-cost materials as a source for the oily feedstock and for the catalyst because it provides data for predicting the reaction rate and reactor design.

Considering that mass transfer can limit the rate of transesterification catalysed by solid catalysts, the study of Todorović *et al.* [3] proposed co-solvents based on deep eutectic solvents (DES) to improve the rate of ethanolysis of cold-pressed black mustard (*Brassica nigra* L.) seed oil catalysed by either calcined or non-calcined CaO. Several lecithin-

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based DES were characterized, and the lecithin : glycerol system was selected as a co-solvent. The use of DES accelerates not only the reaction but enhances separation of the final reaction mixture phases. This paper provides novel knowledge on the use of lecithin for DES preparation and its utilization as co-solvents for biodiesel production.

Although the utilization of waste oily feedstocks for biodiesel production adds value to the wastes, these oils require pretreatment due to the high content of free fatty acids (FFA). In the study of Lukić *et al.* [4], the adsorptive capacity of quicklime, which was already proved as an inexpensive and suitable catalyst in transesterification of oil into biodiesel, was tested for removal of FFA from waste cooking oil. The results have indicated that quicklime has considerable potentials for the FFA removal from the WCO at lower temperatures, being inexpensive, available, and efficient. This study can be of interest to biodiesel producers since both the removal of FFA and the heterogeneously catalysed methanolysis are environmentally and economically acceptable processes.

Quality of biodiesel is important for its commercialization. The biodiesel stability during extended storage depends on its oxidation stability. Therefore, Djurišić-Mladenović *et al.* [5] investigated the oxidation stability of biodiesel obtained from sunflower oil using the RapidOxy method as an alternative technique and compared it with the use of the standard Rancimat method. Improvements in the oxidation stability were achieved by adding a synthetic antioxidant and a mixture of bio-based antioxidant compounds extracted from vinery waste. This study is important and serves as a starting point for further developments of bio-based antioxidants from vinery waste and employing the RapidOxy method for high-throughput analysis with high repeatability for determination of oxidation stability of biodiesel.

We hope that the selected papers will have an impact on the scientific as well as broader community and become a driving force for research and developments in the future leading to sustainable solutions.

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Guest Editors
Dr. Ivana Banković-Ilić, Full professor
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REFERENCES

[1] Marinković DM, Pavlović SM. Recent advances in waste-based and natural zeolitic catalytic materials for biodiesel production *Hem Ind.* 2023; 77(1): 5-38. https://doi.org/10.2298/HEMIND220804007M

[2] Miladinović MR, Pavlović S, Banković-Ilić IB, Kostić MD, Stamenković OS, Veljković VB. Utilization of waste plum stones as a source of oil and catalyst for biodiesel production. *Hem Ind.* 2023; 77(1): 39-52 https://doi.org/10.2298/HEMIND221113009M

[3] Todorović ZB, Đorđević BS, Troter DZ, Veselinović LjM, Zdujić MV, Veljković VB. Effects of temperature on physicochemical properties of the lecithin-based deep eutectic solvent and their use in the CaO-catalyzed transesterification. *Hem Ind.* 2023; 77(1): 53-67. https://doi.org/10.2298/HEMIND220527016T

[4] Lukić I, Kesić Ž, Zdujić M, Skala U. Adsorptive pretreatment of waste cooking oil using quicklime for fatty acid methyl esters synthesis. *Hem Ind.* 2023; 77(1): 69-84 https://doi.org/10.2298/HEMIND220628005L

[5] Đurišić-Mladenović N, Tomić M, Pajin B, Buljovčić M, Lončarević I, Rankov Šicar M. Stability evaluation of biodiesel supplemented with synthetic and bio-based antioxidants by a pressurized accelerated oxidation method. *Hem Ind.* 2023; 77(1): 85-93. https://doi.org/10.2298/HEMIND220808003D

Napredak u istraživanju proizvodnje biodizela

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Kao rešenje za zamenu izvora fosilnih goriva u sektoru transporta i osiguranja održivog energetskog sistema ističu se biogoriva, a među njima biodizel koji se dobija iz bio-izvora kao što su biljna ulja, životinjske masti ili ulje algi. Potreba je da se proizvodnja biodizela unapredi zamenom jestivih sirovina nejestivim ili već korišćenim, da se smanje visoki operativni troškovi i poveća kvalitet finalnog proizvoda. Stoga, ovo specijalno izdanje časopisa Hemijska industrija ima za cilj da pruži najnovija saznanja u razvoju i napretku održive proizvodnje biodizela u pogledu sirovina, katalizatora, svojstava i tehnologija. U tom pogledu najpre je dat sveobuhvatan pregled primene otpadnih i prirodnih zeolitnih materijala kao katalizatora ili nosača katalizatora, a zatim opisana katalitička aktivnost pepela dobijenog sagorevanjem otpadnih koštica šljive radi primene u reakciji transesterifikacije ulja iz jezgara koštica šljive do biodizela. U cilju poboljšanja brzine reakcije i razdvajanja faza finalne reakcione smeše, predložena je upotreba eutektičkih smeša kao korastvarača. Kako otpadne uljne sirovine često imaju visok sadržaj slobodnih masnih kiselina, to se za njihovo efikasno otklanjanje preporučuje korišćenje negašenog kreča kao adsorbenta. Na kraju, pokazano je da se oksidaciona stabilnost biodizela, kao mera njegovog kvaliteta, može efikasno odrediti korišćenjem RapidOxy metode i poboljšati dodavanjem mešavine antioksidativnih jedinjenja na biološkoj bazi.

REČ UREDNIKA

Ključne reči: zaštita životne sredine; otpadne materije kao katalizatori; zeolitski materijali; eutektički rastvarači; sposobnost adsorpcije negašenog kreča; oksidaciona stabilnost