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Editorial

Special Issue “Production of Biofuels and Numerical Modelling of Chemical Combustion Systems”

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Biofuels have recently attracted a lot of attention, mainly as alternative fuels for applications in energy generation and transportation. The utilization of biofuels in such controlled combustion processes has the great advantage of not depleting the limited resources of fossil fuels, but leads to emissions of greenhouse gases and smoke particles similar to traditional combustion processes, i.e., those of fossil fuels. On the other hand, a vast amount of biofuels is subjected to combustion in small-scale processes, such as for heating and cooking in residential dwellings, as well as in agricultural operations, such as crop residue removal and land clearing. In addition, large amounts of biomass are consumed annually during forest and savanna fires in many parts of the world. These types of burning processes are typically uncontrolled and unregulated. Consequently, the emissions from these processes may be larger compared to industrial-type operations. Aside from direct effects on human health, especially due to a sizeable fraction of the smoke emissions remaining inside residential homes, the smoke particles and gases released from uncontrolled biofuel combustion imposes significant effects on the regional and global climate. Estimates have shown the majority of carbonaceous airborne particulate matter to be derived from the combustion of biofuels and biomass.

This Special Issue on “Production of Biofuels and Numerical Modelling of Chemical Combustion Systems” contains sixteen high-quality studies (fifteen research papers and one review paper) addressing techniques and methods for bioenergy and biofuel production as well as challenges in the broad area of process modeling and control in combustion processes.

First at all, García Martín et al. comprehensively review the latest advances focused on energy production from different olive biomasses, including the production of biofuels such as bioethanol and biodiesel and processes such as combustion, gasification and pyrolysis [1]; all of them can be applied to any type of biomass. For lignocellulose biomasses, mainly composed of cellulose, hemicellulose and lignin, the determination of their content in these fibers and moisture is of major importance to select the most suitable process for energy production. In this sense, Díez et al. provide a new efficient, low-cost and fast method for the determination of these contents in different types of biomasses from agricultural by-products to softwoods and hardwoods [2]. The proposed method is based on applying deconvolution techniques on the derivative thermogravimetric pyrolysis curves obtained by thermogravimetric analysis through a kinetic approach based on a pseudocomponent kinetic model.

Biofuels cannot replace our current dependence on coal, oil, and natural gas, but they can complement other renewable energies such as solar and wind energies. Thus, due to the merits of biofuel energy for environmental sustainability, biofuel and bioenergy technologies play a crucial role in the renewable energy development and replacement of chemicals from highly functional biomass. The following six research papers investigate the production of biofuels from biomass.

Starting with liquid biofuels, Cuevas et al. obtain bioethanol from the acid hydrolysis at high temperature of olive stones followed by enzymatic hydrolysis and fermentation of the released sugars with the yeast *Pachysolen tannophilus* [3]. The pretreatment was optimized by means of response surface methodology with two independent variables (temperature and reaction time). With regard to the production of biodiesel by transesterification, García Martín et al. deal with the issue caused by waste cooking oils with high acidity, which cannot be directly transformed into fatty acid methyl esters by transesterification due to the soap formation [4]. The solution proposed, within the biodiesel production framework and the circular economy concept, is the esterification of these high acidity oils with the residual glycerol from transesterification. On the other hand, the existence of excess water content in the starting oil can retard the transesterification rate and make the resulting biodiesel not comply to legal specifications for its use as biofuel. Hence, Lin and Ma assess the optimum water content in the raw oil and its effects on burning characteristics of the resulting biodiesel [5].

Biomethane and syngas stand out among the gaseous biofuels. Alonso-Fariñas et al. obtain biomethane from the anaerobic digestion of olive pomaces within an olive oil mill framework [6]. These authors study the life cycle assessment of a scheme consisting of the production of biogas from the anaerobic digestion of the olive pomace, heat and electricity cogeneration by the combustion of the generated biogas, and composting of the anaerobic digestate. Syngas can be obtained from biomass as a renewable energy source though gasification. However, syngas from biomass contains some impurities, such as organic tars, which must be removed before its application. To perform this, Díez et al. synthesize a catalyst based on layered double hydroxides with a molar cation concentration Ni/Cu/Fe/Mg/Al of 30/5/5/40/20 for the steam reforming of toluene as a model compound of biomass tar [7], yielding high concentrations of H_2.

Finally, the production of solid biofuels, such as pellets, is also highlighted. Notwithstanding, pellets from biomass cannot compete with those from fossil fuel sources because the biomass densifying process and the raw materials price make pellet production economically unfeasible. To overcome these issues, Clavijo et al. propose the use of eucalyptus kraft lignin as an additive for tree-leaf pellet production [8]. The resulting pellets fulfilled all requirements of European standards for certification except for ash content.

The following four research papers are focused on the production of biomass and biocrude from microalgae. Advanced biofuels obtained from microalgae have attracted great interest because they do not compete with food production since they can grow on non-arable land. The production of biomass is a key prerequisite in the production process of biocrude and other valuable compounds from microalgae. Thus, Fuentes et al. produce biomass at a large scale from the microalgae *Coccomyxa onubensis* in an 800-dm^3 tubular photobioreactor [9]. These authors obtained a biomass productivity of 0.14 g dm^{-3} day^{-1} along with high contents of lutein, an interesting food colorant, when growing the microalga under outdoor conditions. Hydrothermal liquefaction has proven to be an attractive process for the production of biofuels from microalgae, rendering biocrude (the liquid organic phase), aqueous phase compounds, solid residue, and gas phases, as illustrated in three works published in this Special Issue by Dr. Vicente's research group. In the first, Megía-Hervás et al. assess the temperature, reactor loading and time of the hydrothermal liquefaction of the microalga *Nannochloropsis gaditana* at mild temperatures in order to reduce the N and O content in the biocrude and to maximize the yield of the pretreated biomass [10]. Subsequently, Sánchez-Bayo et al. improve the hydrothermal liquefaction of the same microalgae using heterogeneous catalysts [11]. To be specific, the catalysts were based on metal oxides (CaO, CeO_2, La_2O_3, MnO_2, and Al_2O_3), yielding remarkable amounts of biocrude, high values of C, H and heating value and low contents of N, O and S. In the third paper, Megía Hervás et al. perform the hydrothermal liquefaction of another microalgae (*Phaeodactylum tricornutum*) in a scale-up photoreactor [12]. The biocrude yields obtained in this scale-up photoreactor were lower than the ones obtained from the biomass cultivated at laboratory scale because of the lower lipid and high ash contents in this biomass. However, the culture scaling-up did not have influence on the heteroatom concentrations in the biocrudes.

The last four research papers study the modelling and design of combustion processes of biofuels. Since biodiesel has higher viscosity than petroleum diesel, which leads to lower performances of compression ignition engine and higher emissions, Hamid et al. perform a numerical investigation of fluid flow and in-cylinder air flow characteristics [13]. As a result, the authors propose to install a guide vane design in the intake manifold, with shallow depth re-entrance combustion chamber pistons, in order to promote better diffusion, evaporation and combustion processes. Next, Orihuela et al. focus on the performance loss of the post-combustion system due to the variability that biofuels introduce in the exhaust particle distribution [14]. These authors use a well-validated particulate filter model available as commercial software to predict the filtration performance of a wall-flow particulate filter made of biomorphic silicon carbide (a bioceramic material made from vegetal waste) with a systematic procedure that allows one to eventually fit different fuel inputs. On the other hand, dual fuel engines (those that use diesel and fuels that are gaseous at normal conditions) are receiving increasing attention because they achieve the same (or better) power density and efficiency, steady state and transient performances than petroleum diesel. In his research paper, Boretti develops a numerical analysis of a novel, high-pressure (1.6×10^8 Pa) liquid phase injector for liquefied natural gas in a high compression ratio, high boost engine featuring two direct injectors per cylinder: one for diesel and one for liquefied natural gas [15]. Finally, Guo et al. assess the effects of the diameter and the angle of the pre-combustion chamber nozzle on the performance of a marine two-stroke dual fuel engine [16], finding that both parameters have influence on the flame propagation in the combustion chamber.

To sum up, this Special Issue on "Production of Biofuels and Numerical Modelling of Chemical Combustion Systems" comprehensively overviews and includes in-depth technical research papers addressing recent progress in biofuels production and combustion processes. All these manuscripts contributed—with their topics and their high quality—to the success of the present Special Issue.

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