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This volume contains the provisional version of the extended abstracts presented at the 13th International Chemical and Biological Engineering Conference (CHEMPOR 2018), held in Aveiro - Portugal, from the 2nd to the 4th of October, 2018.

University of Aveiro & Ordem dos Engenheiros

**13th International Chemical and Biological
Engineering Conference
(CHEMPOR 2018)**

Book of Extended Abstracts

Edited by:

João Araújo Pereira Coutinho

Carlos Manuel Silva

Inês Portugal

Ana Barros-Timmons

Anabela Aguiar Valente

Dmitry Victorovitch Evtyugin

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Title

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SCIENTIFIC PROGRAM

Time		Tuesday, 2/10	Wednesday, 3/10	Thursday, 4/10				
8:00	8:15	Registration	Plenary Lecture (PL3) Rajamani Krishna	Plenary Lecture (PL5) Gabriele Centi				
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8:30	8:45							
8:45	9:00							
9:00	9:15							
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10:15	10:30		O-BB09	O-EE03	O-IM05	O-RS13	O-EE12	O-BS07
10:30	10:45		O-BB10	O-EE04	O-IM06	O-RS14	O-EE13	O-BS08
10:45	11:00		O-BB11	O-EE05	O-IM07	O-RS15	O-EE14	O-BS09
11:00	11:15	Coffee-break	Coffee-break		Coffee-break			
11:15	11:30		Coffee-break		Coffee-break			
11:30	11:45	O-RS01	O-BS01	Bondalti				
11:45	12:00	O-RS02	O-BS02	O-MP01	O-BB12	O-EE06	O-ME01	
12:00	12:15	O-RS03	O-BS03	O-MP02	O-BB13	O-EE07	O-ME02	
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12:30	12:45	O-RS05	O-BB01	O-IM01	O-BB15	O-EE09	O-ME04	
12:45								
		Lunch	Lunch	Lunch				
14:15	14:30	Keynotes (KN1 and KN2) João Rocha Rosa Quinta-Ferreira	Keynotes (KN3 and KN4) Adélio Mendes José António Teixeira	Keynotes (KN5 and KN6) Maria Ascensão Reis Ramesh Gardas				
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14:45	15:00							
15:00	15:15	O-RS06	O-BB02	BB&G	O-RS16	O-EE15	O-IM11	
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15:45	16:00	O-RS09	O-BB05	O-MP04	O-MP05	O-IM09	O-IM14	
16:00	16:15	O-IM02	O-BB06	O-RS10	O-IM08	O-IM10	O-IM15	
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16:30	16:45		P-BB, P-RS, P-MP, P-ME		Awards and Closing Session			
16:45	17:00	Formal Session with Minister of Economy	Bus to Vista Alegre		Multibiorefinery Project Meeting (Coffee-break)			
17:00	17:15		Museum Visit					
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17:30	17:45		Museum Visit					
17:45	18:00		Museum Visit					
18:00	18:15		Museum Visit					
18:15	18:30		Museum Visit					
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18:45	19:00		Conference Dinner					
19:00	19:15		Conference Dinner					
19:15	19:30		Conference Dinner					
19:30			Conference Dinner					

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 [KN] - Keynote Presentation
 [RS] - Reaction and Separation Processes
 [BS]- Biorefinery and Sustainability
 [MP] - Modeling, Synthesis and Integration
 of Chemical Processes

[BB] - Biological Engineering and Biotechnology
 [IM] - Innovative Materials and Applications
 [EE] - Energy and Environment
 [ME] - Multiscale and Multidisciplinary Engineering
 Education

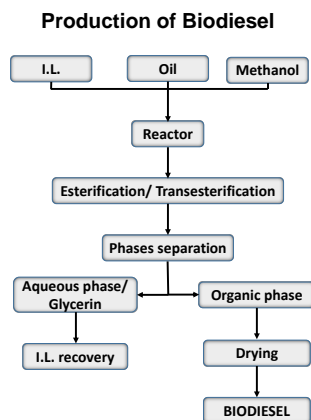
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Production and characterization of biodiesel obtained by transesterification catalysed by ionic liquids based on imidazolium

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Biodiesel is a fuel that shows an increasing demand as a promising alternative to petroleum-based fuels. Biodiesel is produced by means of esterification or transesterification reactions, from renewable raw materials, as animal and vegetable oils and fats. The biodiesel generated by the traditional method of production proved that is economically and environmentally disadvantageous, due to this, in its production process changes are necessary to reduce its costs and make it an ecological product, such as, the introduction of used oils as feedstock. Moreover, the catalysts traditionally employed are not so effective due to the fact that these oils presents low quality, since they contain high levels of fatty acids in their composition. Ionic liquids arise as one promising solution to this problem, and some studies with hydrogen sulfate 1-butyl-3-methylimidazolium [BMIM][HSO₄] refer that this ionic liquid can be an viable catalyst choice for biodiesel production processes.

Introduction

Biodiesel is a fuel produced from fats or oils, vegetable or animal, consisting of esters of fatty acids. Its main advantages are due to the fact that they can be obtained from renewable resources, to have an ecological emission profile, in addition to being biodegradable and environmentally friend, but has the disadvantage of a high cost of production. The International Energy Agency reported that biodiesel produced with current technology is about two to three times more expensive than petrol and diesel oil due to the high cost of the raw material used. Several studies show that the value added of the raw material represents about 75% of the biodiesel production cost [1, 2]. The production of biodiesel from waste cooking oils and the application of ionic liquids as catalysts have been applied as a possible alternative to overcome the disadvantages in the traditional production process. Ionic liquids can be recovered and the recycled, making the industrial process economically and environmentally friendly, in addition to the fact that there is no conflict with the food industry due to the reuse of oils that are no longer edible. The reutilization of waste oils to biodiesel production has the potential to decrease approximately 45% of the all cost of production, even taking into account the coast increase with pre-treatments necessary for the reduction of water content and free fatty acids [3].

The biodiesel produced from oils and fats from vegetable and animal sources are a promising alternative for replacing the use of fossil fuels, but their high viscosity can be a disadvantage to the engine ignition. The most widely used processing option is the transesterification reaction, which is favorable to obtain fuel from triglycerides, and the esterification reaction, which is a great option for the conversion of free fatty acids (FFA) present in oils, in esters of fatty acids. In both reactions, the presence of catalysts for the production of biodiesel is required for an effective conversion [2, 4-5].

Basic catalysts are widely used because they have lower costs and high availability requires low amounts of alcohol, with acceptable reaction times. However, this base-catalyzed process is very sensitive to the presence of water and FFAs, which leads to saponification reactions. The saponification,

besides causing an unproductive consumption of the catalyst hinders the purification process of the final product. Therefore, the use of basic catalysts in oils which have high rates of FFAs, as is the case of waste oils, is complex, and some pre-treatments are mandatory, which makes the process time-consuming and therefore expensive. On the other hand, acid catalysts are not sensitive to FFAs, which makes them excellent alternatives to use in oils with high levels of acidity. However, these catalysts lead to reaction times up to 4000 times higher, higher alcohol/oil molar ratios; higher reaction temperatures and can lead to corrosion of equipment, increasing the costs. Ionic liquids used in catalytic systems, come as an alternative to solve this issue in biodiesel production [4-5].

Ionic Liquids

By definition, ionic liquids are organic salts with exceptional thermal and chemical stability, high catalytic activity and solvability, low viscosity, low toxicity, non-flammable and are easily handled. One of the most significant characteristics of ionic liquids is the possibility of designing the molecule according to its specific application, tracing a certain set of properties. Since these compounds are high priced, this property makes it highly attractive. The recycling process, most of the time, occurs through distillation, solvent extraction, adsorption or the application of separation membranes [5].

When it refers to the production of biodiesel linked to ionic liquids, some published studies shows that the acidic character of the ionic liquid has a high influence on the catalytic action of biodiesel production. In addition, ionic liquids are able to reduce significantly the number of purification stages in the process of producing the fuel, reducing the costs of its production [6].

Ionic Liquids in Biodiesel Production

Imidazolium-based ionic liquids have been the most studied for biodiesel production due to their ionic standards, low pressure and capacity for self-organization in different states, including hydrogen sulfate 1-butyl-3-methylimidazolium [BMIM][HSO₄], which has been showing promising results.

Elsheikh *et al.* (2011) carried out a study on the production of biodiesel from the transesterification reaction. They used crude palm oil and investigated ionic liquids containing imidazolium, [BMIM][HSO₄], [BIM][HSO₄], [MIM][HSO₄], to study which one had the highest catalytic potential. The best results were obtained once again, with the [BMIM][HSO₄] ionic liquid, reaching a conversion of 91.2% in its optimum reaction conditions, represented by 4.4% catalyst concentration, molar ratio of alcohol/oil of 12:1, reaction temperature of 160°C and reaction time of 120 min [7].

Hafidz *et al.* in 2013, performed a multi-objective optimization in the esterification reaction using oleic acid and methanol catalyzed by [BMIM][HSO₄]. They study some reaction parameters such as, the reaction temperature, reaction time, molar ratio between methanol and oleic acid and the dosage of catalyst. They concluded that optimal reaction conditions occurred with a temperature of 87°C, a reaction time of 5.2 hours, alcohol/oil molar ratio of 9:1 and catalyst charge of 0.06 mol, resulting in 80.4% acid conversion oleic acid and 81.8% yield of methyl oleate [8].

In 2013, the same group studied the production of biodiesel from the esterification reaction of oleic acid with methanol, using as catalyst [BMIM][HSO₄]. They identified as the reaction optimal conditions an alcohol/oil molar ratio of 9:1, the catalyst load was 3.4% by mass, a reaction time of 4 hours and a reaction temperature of 90°C, resulting in an oleic acid conversion of 84.4% [9].

Li *et al.* (2014) also carried out a study of biodiesel production from the transesterification reaction. They used *Camptotheca acuminata* seed oil in the presence of several imidazolium-based acidic liquids acting as catalysts. Using a methanol/oil ratio of 6:1, catalyst concentration of 5%, temperature of 60°C and a reaction time of 30 min, [BMIM][HSO₄] was only the third of the five catalysts studied with the best result, with a conversion of 38.5% [10].

Ullah *et al.*, in 2015 published a research on the production of biodiesel from a two-step process. In the first step, an esterification reaction was carried out, using palm oil and methanol, catalyzed by an ionic liquid with the purpose of

reducing the acidity of this oil. In the second step, KOH was used to catalyze the transesterification reaction. Three ionic liquids were used in the first phase of the process [BMIM][HSO₄], [BIM][HSO₄] and [MIM][HSO₄]. The best result was obtained with hydrogen sulfate 1-butyl-3-methylimidazolium, [BMIM][HSO₄]. The best reaction conditions for this step used a catalyst concentration of 5% by weight, an alcohol/oil molar ratio of 15:1, a reaction time of 60 min and reaction temperature of 160°C. In the second phase, the KOH-catalyzed transesterification was carried out at 60°C, 1% by weight catalyst load and a reaction time of 60 min. At the end of the two steps, the overall yield reached 95.65% [11]. Irana Alimova, in 2016 studied the production of biodiesel in the esterification reaction of oleic acid and methanol, using the same ionic liquid, [BMIM][HSO₄]. The optimum operating conditions were time and reaction temperature of 4 hours and 90°C respectively, a molar ratio alcohol/oil of 10:1 and a catalyst loading of 10%, thus resulting in a conversion of 89.7% [12].

In 2017, Arevik Tadevosyan, in a similar study, of the production of biodiesel by esterification reaction with, [BMIM][HSO₄] as catalyst, determined as optimal conditions the alcohol/oleic acid ratio of 10:1, catalyst load of 20%, reaction temperature of 90°C and reaction time of 6 hours. It resulted in an oleic acid conversion of 84.8% [13].

Conclusions

With these information brought from the literature we can conclude that [BMIM][HSO₄] shows promising results in the catalytic system of biodiesel production. Therefore, the objective of this work is the study of the application of hydrogen sulfate 1-butyl-3-methylimidazolium ionic liquids in the catalysis of transesterification reactions of mixtures of triglycerides with high free fatty acid contents in transesterification reactions of high acidity waste cooking oils. Besides performing the characterization of the quality of the biodiesel produced, the kinetic study of the reaction and the recovery of the catalyst employed will be extensively studied.

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