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Materials chemistry and applications

Valorization of used cooking oils through ionic liquid catalyzed biodiesel conversion processes

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Population growth has been increasing dramatically in recent decades, with approximately 8 billion inhabitants worldwide. The industrialization and urbanization increasing leads to high energy demand and to an increasing need for clean air, both mandatory factors concerning the socio-economic development of society. To date, fossil fuels predominate as the primary source of energy, with high consumption in transport and industries, which makes them a major problem for our Planet, due to the weak environmental sustainability, as the case of its high greenhouse gas emissions to the atmosphere and also because there are limited reserves. To overcome these high percentages of fossil fuels, several alternatives must be found to avoid serious consequences for our ecosystem.[1]
In this context, biodiesel emerges as a biofuel, that is biodegradable and less toxic when compared to fossil diesel, and since it is environmentally sustainable is already commercialized in several countries in a pure or mixed form with diesel. Biodiesel, can de chemically defined as a mixture of fatty acid alkyl esters (usually fatty acid methyl esters – FAME), produced through transesterification reactions of a raw material, normally vegetable oils or animal fat, with an alcohol, typically methanol, in the presence of homogeneous basic or acid catalysts, which are highly corrosive and difficult to recover.[2]
The objective of this work is to study the production of biodiesel applying 1-methylimidazolium hydrogen sulfate ([HMIM][HSO_4]) ionic liquid as a catalyst in esterification/transesterification reactions with methanol in artificially acidified waste cooking oil conditions.
In order to estimate the optimal operating conditions, Design Expert 11 software was used for the construction of a Box-Behnken Design (BBD) for a Response Surface Methodology (RSM) analysis. An experimental design was used to generate a matrix with four factors with three levels and two extra central points. The chosen factors were: percentage of incorporated oleic acid (20, 40 and 60% wt.), oil/methanol molar ratio (1:5, 1:10 and 1:15), catalyst dosage (5, 10 and 15% wt.) and reaction time (2, 4 and 6 h). Through this methodology a set of 27 runs was established to quantify the influence of each factor on the two responses, acidity reduction and fatty acid methyl ester (FAME) conversion. A reaction temperature of 65ºC was maintained during all runs.
After the biodiesel synthesis, the reaction conversion in terms of acidity decrease was determined by volumetric titration of the organic phase with potassium hydroxide standard solution and the FAME content of the biodiesel samples was quantified by gas chromatography (GC-FID). Table 1 shows the experimental values for both types of conversion for 3 selected run using different reaction conditions.

Table 1: Conversions in terms of acidity reduction and FAME's.

Run	Time (h)	Catalyst dosage (% wt)	Molar ratio oil:methanol	Incorporation of Oleic Acid (% wt)	Conversion in terms of acidity reduction (%)	Conversion in FAME's (%)
1	2	10	1:15	40	57.35	29.28
2	2	10	1:10	60	32.25	19.68
3	2	10	1:5	40	22.12	15.61

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