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Short communication

A sustainable method to produce biodiesel through an emulsion formation induced by a high shear mixer

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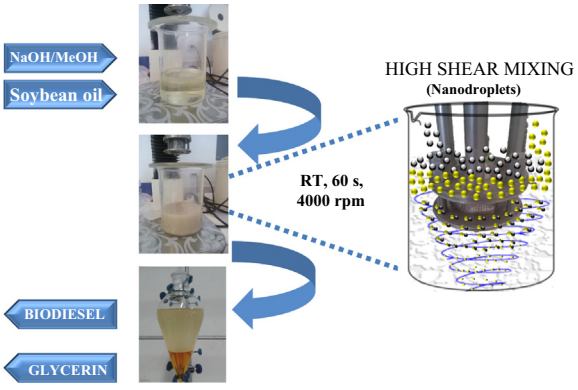
HIGHLIGHTS

- Biodiesel was obtained in 60 s and normal conditions.
- The process consisted of an emulsion production induced by a HSM process.
- Nanodroplets performed a fast and efficient mass-transfer among reactants.

GRAPHICAL ABSTRACT



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ABSTRACT

This paper describes a sustainable alternative for biodiesel production. It consists in producing an emulsion by a high shear mixing process (4000 rpm) between two immiscible liquids (methanol and soybean oil), in the presence of NaOH as catalyst. This simplified process improved significantly the biodiesel production since the transesterification reaction was carried out at room temperature, in 60 s, at 22 °C and 1% catalyst concentration. The operation conditions allowed generating nanodroplets which acted as efficient mass-transfer reactors. The effect of the catalyst amount and conversions achieved after centrifugation and decantation were investigated. It was demonstrated that the highest conversion was achieved after total glycerin decantation which was completed after 3 h of settling. A quantitative conversion of triglycerides to methyl esters was achieved permitting the easy recovering of glycerin.

1. Introduction

Energy diversification has become an important issue worldwide in the last years. In this sense, biomass-derived energy has a considerable technical potential among alternative energy resources for biofuels production and is an alternative for petroleum-derived fuels.

Vegetable oils have been considered as a feasible feedstock for biofuel production due to their non-toxic and renewable characteristics. However, the main problem associated to the use of crude vegetable oils in diesel engines is their high viscosity causing problems such as engine ignition in cold weathers, plugging and

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Table 1
Representative reports dealing with high shear mixers use for biodiesel production.

Author(s)	Reactants/catalyst	Reaction temperature, °C	Reaction time, min	Conversion%	Shear speed, rpm	Reference
Noureddini et al.	Soybean oil Methanol NaOH	70	6.67	98	0–3600	[10]
McFarlane et al.	Soybean oil Methanol 30% Methanol/methylate	80	2	90	3000–4800	[11]
Da Silva et al.	Soybean oil Ethanol NaOH	78	12	99.26	7900	[12]
Choedkiatsakul et al.	Palm oil Methanol NaOH	N. R.	5	99.8	N. R.	[13]

N.R. = Not reported.

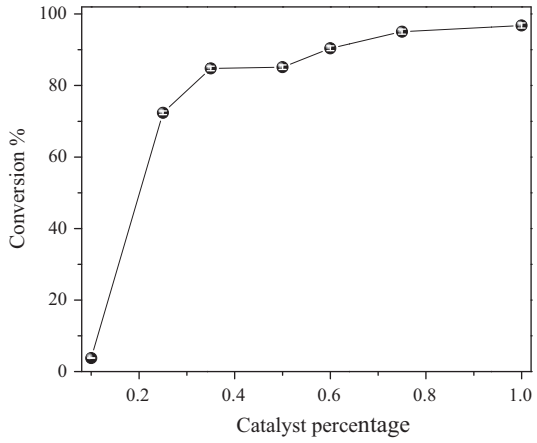

Fig. 1. Conversion of soybean oil vs catalyst concentration, determined immediately after centrifugation.

gumming of filters and tubings, coking of injector nozzles, among others [1].

To reduce the viscosity of vegetable oils several methods such as dilution, microemulsion, pyrolysis, and transesterification have been evaluated, being the last one the most studied option [2,3]. Transesterification involves the reaction between an alcohol (mainly methanol), and an ester, v. gr. the triacylesters present in vegetable oils and animal fats, to generate a new ester (mainly methyl esters), in the presence of a catalyst. It is worth mentioning that a large number of methodologies have been developed looking for its sustainability. Those methodologies include reactive distillation [4], supercritic conditions [5], reactive extraction column [6], microwave [7] and ultrasound assistance [8]. However, although great progress has been achieved there is still a long road ahead. A viable alternative for biodiesel production is represented by an emulsion production promoted by high shear mixers. Those mixers are generally used for homogenization, solubilization, emulsification, powder wet-out, grinding and particle size reduction. The mixers are comprised of a rotor that turns at high speed within a stationary stator, mechanically shearing particles and droplets, expelling the material at high velocity into the surroundings and creating intense hydraulic shear [9].

The use of high shear mixers in biodiesel production is scarce in the literature. Some representative reports are presented in Table 1.

It is worthwhile to remark that although high-shear mixing could simplify substantially biodiesel production the use of temperature is still required.

In this paper an innovative methodology for biodiesel manufacture at room-temperature and ambient pressure based only of an emulsion production between the raw materials (soybean oil and methanol) and the catalyst is reported. The effect of the catalyst amount and biodiesel/glycerin separation procedure (centrifugation and decantation) were studied.

2. Materials and methods

2.1. Materials

Technical grade methanol was purchased from Meyer and dried using metallic magnesium turnings and iodine. Soybean oil was

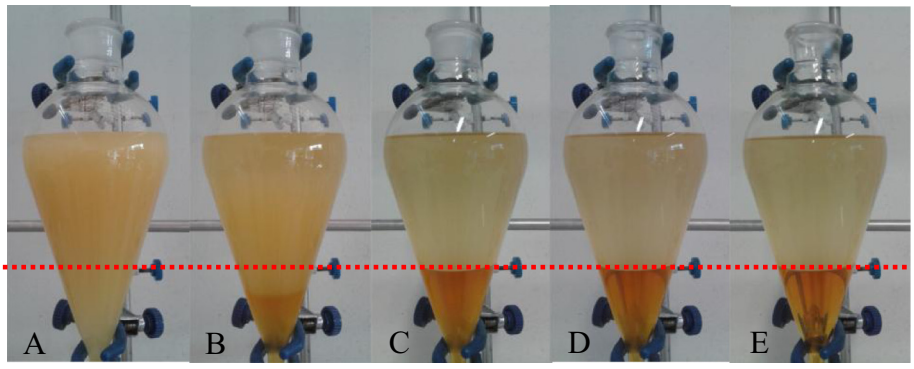

Fig. 2. Biodiesel separation from glycerin/NaOH (lower layer), in a separation funnel: (A) 0 min, (B) 1 h, (C) 2 h, (D) 3 h and (E) 4 h.