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Review

Use of bioethanol for biodiesel production

C. Brunschwig [a], W. Moussavou [a], J. Blin [a,b,*]

[a] Institut International d'Ingénierie de l'Eau et de l'Environnement (2iE), Rue de la Science, 01 BP 594, Ouagadougou 01, Burkina Faso, France
[b] Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD), UPR Biomasse Energie, TA B-42/16, 73 rue Jean-François Breton, 34398 Montpellier Cedex 5, France

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ABSTRACT

Faced with the energy crisis and environmental degradation, due to the massive use of fossil energy sources, biodiesel is an attractive alternative to diesel fuel. With a view to developing local biodiesel production, using bioethanol as a sustainable reactant for biodiesel production, rather than methanol, is leading to increasing interest, notably in emerging countries. Indeed, bioethanol, which is less toxic than methanol, is produced from local and renewable agricultural resources, being more sustainable and providing access to greater energy independence. However, some issues are limiting the process like purification problems, or the presence of water in bioethanol leading to a drop in yield. Although several studies have already been published on ethyl ester production, most of them primarily focus on homogeneous alkaline catalysis, and report various data. Therefore, this paper aims at presenting a review of previous studies on the subject.

The aim of this article was to analyze all the literature data available on ethyl ester production, to gain a clearer insight into the advances made in the process, and bring out prospects for developing ethyl ester production, along with the limitations.

This paper compares the different catalytic pathways that have been investigated for ethyl ester production. It discusses the effect of the main reaction parameters on the yield, the purification issues, and the characteristics and specifications of ethyl esters. This study shows that all authors formerly agreed in saying that ethyl esters separation and purification were a limiting stage. But these limitations can be overcome as high yields over 90% can be obtained by optimizing all the reaction parameters. Moreover, the negative effect of the water contained in bioethanol remains controversial.

Finally, ethyl esters proved to be a viable alternative to diesel fuel being more sustainable than methyl esters. Some aspects of their production are worth a closer look for shifting the use of bioethanol to large-scale production.

Contents

* Corresponding author. Institut International d'Ingénierie de l'Eau et de l'Environnement (2iE), Rue de la Science, 01 BP 594, Ouagadougou 01, Burkina Faso, France. Tel./fax: +33 226 76 16 75 59.
E-mail address: joel.blin@cirad.fr (J. Blin).

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1. Introduction

In order to cope with growing demand for energy, the depletion of fossil fuel resources and environmental problems raised by fossil fuel use, countries wishing to limit their energy dependence on petroleum exporting countries are developing alternative energy sources, such as biofuels [1]. As early as the 19th century, Mr Rudolph Diesel developed the first biofuels using vegetable oils in compression ignition engines [2]. Vegetable oils are easy to produce as they are obtained by simple pressing of oil-bearing biomass prior to decanting and filtration. However, using vegetable oils in diesel engines designed to run on diesel fuel raises certain problems. Indeed, partly due to their high viscosity and partly due to their low cetane number compared to diesel fuel, vegetable oils are harder to pump, inject and ignite in diesel engines. Moreover, the use of vegetable oils may generate the accumulation of gums in the inner parts of the diesel engine due to the presence of phospholipids in the fuel, depending on the pressing temperature and on the nature of the biomass used upstream [3]. Some modifications therefore have to be made to the engine. The aim of the modifications is to maintain a high vegetable oil temperature to lower viscosity and improve ignition [3] and thereby ensure durable engine operation. Using vegetable oils as fuel is particularly adapted to static engines. Once that type of engine has been started up, they are sized to operate permanently at a high regime, hence at high temperatures. However, it is difficult to use vegetable oil for vehicle engines, which undergo substantial variations in load, resulting in wide temperature ranges inside the combustion chamber.

To avoid adapting vehicle engines, one alternative consists in chemical modification of vegetable oils by transesterification to obtain biodiesel. This biofuel has fuel characteristics similar to those of diesel fuel. It can therefore easily be used as a pure fuel or blended with diesel fuel in diesel engines, without any major engine modifications [4]. Only a few seals or hose adaptations may prove necessary, as biodiesel is an excellent rubber solvent. Biodiesel is therefore a very interesting alternative to diesel fuel. It contributes toward sustainable development [5] as i) it makes it possible to use locally available, renewable resources [6] and ii) it reduces greenhouse gas emissions when compared to diesel fuel [7], without sacrificing engine performance [4,8]. In the transesterification reaction, triacylglycerides (commonly called triglycerides) in vegetable oils are converted into fatty acid alkyl esters called “biodiesel” in the presence of short chain alcohol and a catalyst, with glycerol as a by-product (Fig. 1). The transesterification reaction proceeds generally with a catalyst to increase reaction speed. Catalysts used for the transesterification of triacylglycerides are usually classified as homogeneous, heterogeneous or enzymatic catalysts depending on the mechanism [9,10].

On an industrial scale, biodiesel is primarily synthesized from methanol, itself a refinery residue and therefore mostly synthesized from fossil resources [11]. The resulting biodiesel carbon is therefore not of 100% vegetable origin. With the enthusiasm for biofuels over the last twenty years, technologies for synthesizing biodiesel from methanol have been very widely studied and optimized in industrialized countries. This resulted in highly efficient and increasingly perfected processes that are only cost-effective on