Egyptian Journal of Petroleum (2016) xxx, xxx–xxx

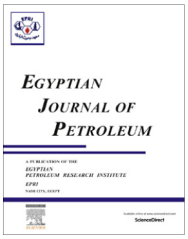
HOSTED BY

ELSEVIER

Egyptian Petroleum Research Institute

Egyptian Journal of Petroleum

www.elsevier.com/locate/egyjp
www.sciencedirect.com



FULL LENGTH ARTICLE

Manufacturing of environment friendly biolubricants from vegetable oils

Ebtisam K. Heikal, M.S. Elmelawy *, Salah A. Khalil, N.M. Elbasuny

Egyptian Petroleum Research Institute, Nasr City 11727, Cairo, Egypt

Received 3 November 2015; revised 1 March 2016; accepted 10 March 2016

KEYWORDS

Biodiesel;
Biolubricant;
Transesterification;
Palm oil methyl ester;
Jatropha oil methyl ester

Abstract Environment friendly products such as fuels and lubricants are among the candidates which are studied in several countries including Egypt. The purpose of this work was to utilize commercially available palm oil and Jatropha oil for the production of biolubricants, through two stages of Transesterification. The first stage is the process of using methanol in the presence of potassium hydroxide to produce biodiesel. The second stage is the reaction of biodiesel with trimethylolpropane using sodium methoxide as catalyst to yield palm or Jatropha oil base trimethylolpropane esters (biolubricants). Palm oil based trimethylolpropane esters with yield of 97.8% was obtained after 4 h of reaction at 130 °C. Under similar reaction conditions, Jatropha oil based trimethylolpropane esters with a yield of 98.2% was obtained. The resulting products were confirmed by FTIR and evaluated by ASTM analyses. The obtained Jatropha oil based trimethylolpropane esters exhibited high viscosity indices (140), low pour point temperature (−3 °C), and moderate thermal stabilities and met the requirement of commercial industrial oil ISO VG46 grade. In spite of the high pour point of Palm oil based trimethylolpropane esters (5 °C), which needs pour point depressant to reduce the pour point, other lubrication properties such as viscosity, viscosity indices and flash point are comparable to commercial industrial oil ISO VG32 and VG46.

1. Introduction

Plant-based oils are showing great potential and are a highly attractive candidate to replace the conventional mineral oils for the use in lubricant production because they are structurally similar to the long chained hydrocarbons in mineral oils with the characteristics of being renewable, non-toxic, economic and environmental friendly [1–4]. The increased environmental awareness is a primary driving force for the new technological developments. Therefore, biodegradable synthetic products used in environmentally sensitive areas have been extensively explored.

One of the biggest challenges is the development of universal biodegradable base stock that could replace mineral oil base stocks is the new generation lubricants [5–9]. From the better performance point of view these should be friendly to the environment and be eventually biodegradable.

The environmental issues associated with the use of petroleum products and the geopolitical strategies concerning crude oil manipulation are the driving forces behind the introduction of alternative fuels and lubricants from renewable raw materials that can contribute to the vertical organization of the

* Corresponding author.
Peer review under responsibility of Egyptian Petroleum Research Institute.

http://dx.doi.org/10.1016/j.ejpe.2016.03.003

national economies [9–11]. The search for bio-based material as industrial and automotive lubricants has been accelerated in recent years.

Vegetable oils, a renewable resource, are finding their way into lubricants for industrial and transportation applications. Waste disposal is also of less concern for vegetable oil-based products because of their environment-friendly and nontoxic nature. Oleochemical esters is a class of products that improve the thermal and cold-flow instability of the neat vegetable oils and fulfill the basic requirements as lubricant base stocks [12,13]. Among the esters used for the production of biolubricants are the polyol esters such as trimethylolpropane (TMP), pentaerythritol (PE), and neopentylpolyol (NPG). These biobased esters (Fig. 1) deliver good low temperature fluidity and although they cannot be used at extremely high temperatures still they can be suitable in less extreme applications [14–20].

Biofuels have already been accepted around the world for their advantages over conventional petroleum fuels, including the opportunity for energy independency. Now, similar growth is expected for biolubricants, which are derived from renewable vegetable oils for different niche applications. Recently, the idea of producing vegetable oil-based biolubricants has led researchers to develop process technologies for their commercialization. Biolubricants are esters of heavy alcohols derived from vegetable oil based feedstock and have lubricating properties similar to those of mineral oil-based lubricants. Even though biolubricants are priced twice as high as conventional petroleum lubricants, industries are investing in R&D toward increasing oil recovery from seeds, reducing the costs of processes and exploring niche application areas.

2. Materials and methods

2.1. Materials

Purified palm oil was purchased from domestic market. The properties of palm oil are given in Table 1, and Jatropha oil was purchased from Sudan. Specifications of crude Jatropha oil are shown in Table 4.

Methanol 99.8% (Sigma–Aldrich), sodium methoxide, 95% powder (Sigma–Aldrich), trimethylolpropane (TMP) 98% (Aldrich), magnesium sulfate anhydrous 97% and ethyl acetate 99.5% (Sigma–Aldrich), were used in the manufacturing process.

2.2. Synthesis of TMP-based esters

Palm oil and Jatropha oil were converted to fatty acid methyl esters (FAME) using methanol transesterification process, followed by several purification steps as described elsewhere [28].

The obtained methyl palm/Jatropha biodiesel was treated with silica gel for the 30 min to remove soap, and then the sample was filtered and dried overnight in an oven at 105 °C.

Palm oil based TMP esters and Jatropha oil based TMP esters were prepared using transesterification reactions (Fig. 1) which were carried out in a rotary vacuum evaporator model N-1110S (Tokyo Rikakikai CO., LTD) with round bottom flask 500 ml. The batch weight of methyl palm/Jatropha biodiesel was 150 g in all transesterification experiments.

Trimethylolpropane (TMP) was initially dissolved into small amount of the obtained biodiesel with the aid of heating (70–90 °C) and stirring to melt the crystalline solid.

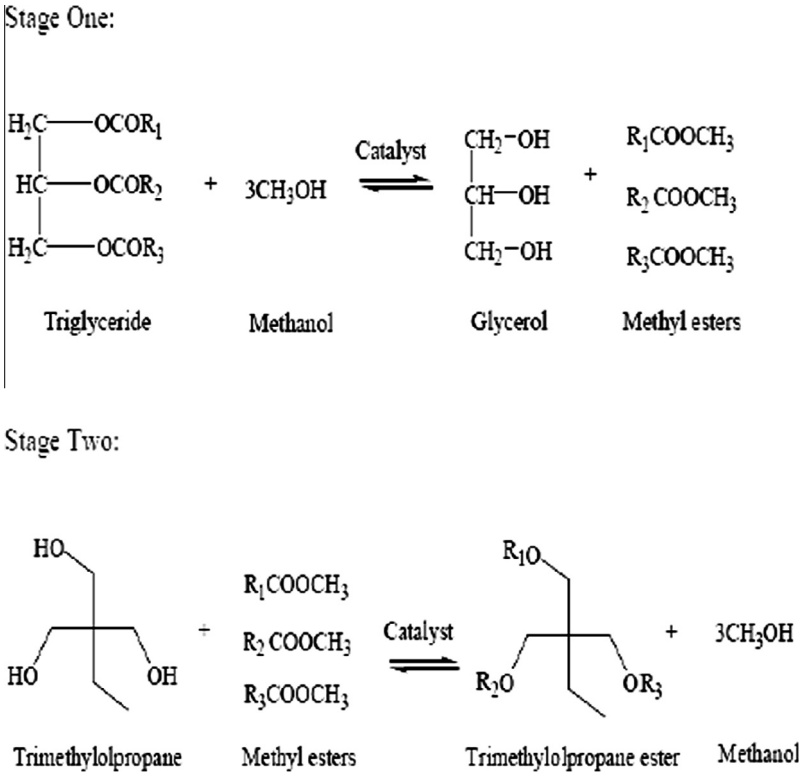


Figure 1 Synthesis of palm/Jatropha oil based TMP esters.