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# A process model to estimate the cost of industrial scale biodiesel production from waste cooking oil by supercritical transesterification

J.M.N. van Kasteren [a,*], A.P. Nisworo [b]

[a] *Telos, Brabant's Institute for Sustainable Development, P.O. Box 90153, 5000 LE Tilburg, The Netherlands*
[b] *Eindhoven University of Technology, Department of Chemical Engineering, Process and Product Design, Den Dolech 2, 5612 AX Eindhoven, The Netherlands*

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**Abstract**

This paper describes the conceptual design of a production process in which waste cooking oil is converted via supercritical transesterification with methanol to methyl esters (biodiesel).

Since waste cooking oil contains water and free fatty acids, supercritical transesterification offers great advantage to eliminate the pre-treatment capital and operating cost.

A supercritical transesterification process for biodiesel continuous production from waste cooking oil has been studied for three plant capacities (125,000; 80,000 and 8000 tonnes biodiesel/year). It can be concluded that biodiesel by supercritical transesterification can be scaled up resulting high purity of methyl esters (99.8%) and almost pure glycerol (96.4%) attained as by-product.

The economic assessment of the biodiesel plant shows that biodiesel can be sold at US$ 0.17/l (125,000 tonnes/year), US$ 0.24/l (80,000 tonnes/year) and US$ 0.52/l for the smallest capacity (8000 tonnes/year).

The sensitive key factors for the economic feasibility of the plant are: raw material price, plant capacity, glycerol price and capital cost.

Overall conclusion is that the process can compete with the existing alkali and acid catalyzed processes.

* Corresponding author. Tel.: +31 13 4662203; fax: +31 13 466 3499.
*E-mail address:* j.m.n.v.kasteren@tue.nl (J.M.N. van Kasteren).

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Especially for the conversion of waste cooking oil to biodiesel, the supercritical process is an interesting technical and economical alternative.


*Keywords:* Biodiesel; Waste cooking oil; Supercritical transesterification; Process design

## 1. Background

It is estimated that in the coming years, the fossil oil price will increase because the oil production cannot meet the projected demand due to oil depletion (Association of Peak Oil and Gas, 2004). This is a result of overconsumption in the developed countries and overpopulation in the developing countries (Korbitz, 1999).

A lot of efforts have been carried out to develop an alternative fuel for the current energy and transportation vehicle system, i.e.: fuel cell, electric power, hydrogen or natural gas for internal combustion engines, etc. One of the promising alternatives that are applied in small scale production is biodiesel.

The American Society for Testing and Materials (ASTM) defines biodiesel fuel as monoalkyl esters of long chain fatty acids derived from renewable lipid feed stocks, such as vegetable oil or animal fat. "Bio" represents its renewable and biological source in contrast to traditional petroleum based diesel fuel; "diesel" refers to its use in diesel engines. As an alternative fuel, biodiesel can be used in neat form or mixed with petroleum based diesel.

Several sources for producing biodiesel have been studied such as rape seed, coal seed, palm oil, sunflower oil, waste cooking oil, soybean oil, etc. Due to the high cost of the fresh vegetable oil, waste cooking oil gives interesting properties because it can be converted to biodiesel and it is available with relatively cheap price (Nisworo, 2005; Zhang et al., 2003).

The most common way to produce biodiesel is by transesterification, which refers to a catalyzed chemical reaction involving vegetable oil and an alcohol to yield fatty acid alkyl esters (biodiesel) and glycerol (by-product) as can be seen in Fig. 1.

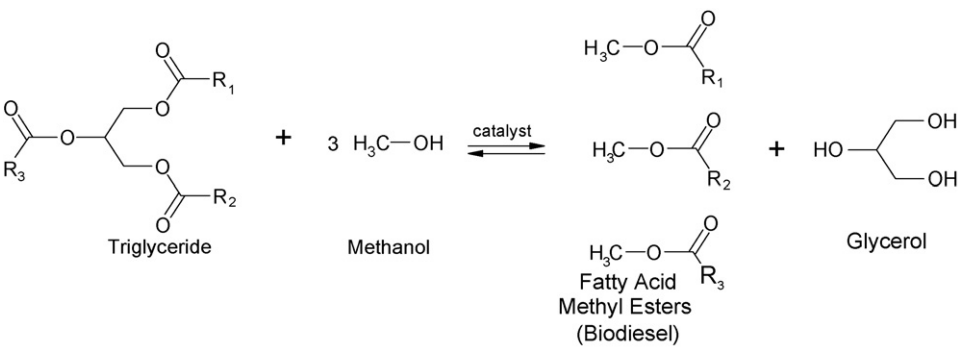


Fig. 1. Transesterification reaction of triglyceride and methanol to fatty acid methyl esters (biodiesel) and glycerol.