IOP Publishing

Measurement Science and Technology

Meas. Sci. Technol. **26** (2015) 025103 (8pp)

doi:10.1088/0957-0233/26/2/025103

Thermally assisted sensor for conformity assessment of biodiesel production

M S Kawano, R C Kamikawachi, J L Fabris and M Muller

Federal University of Technology-Pr, Av. Sete de Setembro 3165, Curitiba, PR 80230-901, Brazil

E-mail: mmuller@utfpr.edu.br

Received 31 October 2014, revised 24 November 2014
Accepted for publication 2 December 2014
Published 7 January 2015

Abstract

Although biodiesel can be intentionally tampered with, impairing its quality, ineffective production processes may also result in a nonconforming final fuel. For an incomplete transesterification reaction, traces of alcohol (ethanol or methanol) or remaining raw material (vegetable oil or animal fats) may be harmful to consumers, the environment or to engines. Traditional methods for biodiesel assessment are complex, time consuming and expensive, leading to the need for the development of new and more versatile processes for quality control. This work describes a refractometric fibre optic based sensor that is thermally assisted, developed to quantify the remaining methanol or vegetable oil in biodiesel blends. The sensing relies on a long period grating to configure an in-fibre interferometer. A complete analytical routine is demonstrated for the sensor allowing the evaluation of the biodiesel blends without segregation of the components. The results show the sensor can determine the presence of oil or methanol in biodiesel with a concentration ranging from 0% to 10% v/v. The sensor presented a resolution and standard combined uncertainty of 0.013% v/v and 0.62% v/v for biodiesel–oil samples, and 0.007% v/v and 0.22% v/v for biodiesel–methanol samples, respectively.

Keywords: fibre optic transducer, chemical sensor, refractometric sensor, biodiesel analysis

(Some figures may appear in colour only in the online journal)

1. Introduction

Biodiesel was officially introduced into the Brazilian energy matrix in 2005, when it was established that the diesel fuel blend commercialized from 2013 on should contain at least 5% of biodiesel. Biodiesel is an alkyl ester formed from chemical reactions involving oils and fats that can be of both the vegetable and animal variety. Such reactions may or may not rely on a catalyst, which in turn can be an acid, alkali or enzymatic. The reaction occurring in the presence of a catalyst and involving the division of triglycerides into smaller molecular chains of fatty acid esters, which bond to an alcohol molecule (methanol or ethanol), is called transesterification. The characteristic temperature for this reaction depends on the specific raw material employed, and is followed by the extraction of glycerin from the oil. The biodiesel's final quality is not sensitive to the origin of the raw material, provided that the production process is efficient [1]. Methanol is more widely employed for the alcoholysis reaction of oils, as it is available at lower prices due to its low cost production. Also, due to its small molecular chain and high polarity, methanol is less soluble than ethanol in the ester. These characteristics make it easier to separate the ester and glycerin, a secondary product obtained from the reaction. Furthermore, the production of methyl ester—the biodiesel produced by the methylic route—develops in a faster and more efficient reaction [2].

Biodiesel quality is associated with factors such as the molecular structure of the ester (position, size and amount of carbon chain); oxidation triggered by absorption of humidity due to inappropriate storage and/or fuel conservation; inefficient production resulting from the lack or excess of key reactants for the transesterification (free glycerin, residual alcohol, unreacted glycerides, detergents, residual catalysts and water). The remaining impurities from the fabrication process (alcohol, the catalyst and oil) must also be removed from the final product. In an incomplete methyl ester

