Tailoring fiber grating sensors for assessment of highly refractive fuels

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Three approaches that allow the tailoring of long period gratings based refractometric sensors for concentration measurement in fuel blends are employed to assess the fuel quality in biodiesel and biodiesel-petrodiesel blend. To allow the analysis of fuel samples with refractive index higher than fiber cladding one, the samples refractive indices were changed by thermo-optic effect and by dilution in a standard substance with low refractive index. The obtained results show the sensor can detect oil concentration in biodiesel samples with resolution as better as 0.07% and biodiesel concentration in biodiesel-petrodiesel samples with average resolution of 0.09%.

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1. Introduction

As far as the history of human evolution is concerned, the access to energy sources and its rational use is an issue commonly addressed [1]. In the 2002 World Summit on Sustainable Development (Rio + 10), this subject was considered one of the most critical in the human development [2]. About one-third of humanity has deficient access to electricity, presenting a high dependence on local biomass for cooking and heating. However, most of such thermal sources lack sustainability and are not greenhouse-neutral. Another concern is related to the use of non-renewable fossil fuels. Negative environmental effects, as well as the economy world-wide scenario, contributed to the search for new energy sources. Within this context, biofuels emerge as an alternative solution, and among them ethanol and biodiesel present as viable options [3].

Biodiesel is defined as monoalkyl esters of long chain, fatty acids derived from vegetable oils or animal fats, and transesterification is the most commonly employed process to produce biodiesel fuel [4]. Although the use of vegetable oil as fuel for diesel engines dates back to Rudolf Diesel's time more than a hundred years ago [5], the use of biodiesel as alternative energy source experienced an increase due to the recent shortage of fossil fuel resources [6].

In Brazil, the use of ethanol as fuel is already a successful program, with even the possibility of complete replacement of gasoline in the car engines. In the attempt to further mitigate the problems arisen from the exploitation of non-renewable fuel resources, addition of biofuels to fossil fuels also composes the Brazilian fuel program [7]. Anhydrous ethanol produced from sugar cane is added to gasoline in proportions between 20% v/v and 25% v/v. Additionally, for diesel engines, inclusion of biodiesel to petrodiesel in increasing amounts intended to reach 40% v/v in 2035 also comprises the Brazilian fuel program.

In order to be viable, biodiesel production and use must fulfill a number of requirements related to net gain of energy, environmental benefits, economical competitiveness and preservation of food supplies

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