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Use of biodiesel in marine fuel formulation: A study of combustion quality

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ABSTRACT

The quality of ignition and combustion of blends of soy biodiesel and marine fuels was evaluated. Faced with the increasing implementation of processes for converting heavier oil fractions, the availability of streams to formulate marine fuels has been reduced. In this context, the use of biodiesel is important to minimize problems caused by the retraction in production of these streams and improve marine fuel quality. Since composition and stability properties are of great importance and influence directly the combustion quality, the composition was determined using the SARA analysis by thin layer chromatography and a flame ionization detector and the mixtures' stability evaluation was made by optical scanning. Using the equipment Fuel Combustion Analyzer, mixtures of marine fuels and soy biodiesel were tested, varying the biodiesel content by volume in the mixture at levels up to 10% v/v. The results show that the addition of biofuel to marine fuels, in the evaluated conditions, does not compromise the combustion quality of the bunker oil and, in some cases, had even increased the estimated cetane number, indicating increased quality of ignition and combustion.

1. Introduction

The increased production of heavy, asphaltic and extra-heavy oils and the development of new refining technologies, such as delayed coking, whose goal is to maximize middle distillates, generate the effect of reducing the amount of available streams for marine fuel production, beyond a worse quality of residual fractions. The impact of this new scenario is a shift in bunker oil quality.

The composition of the streams used in marine fuel formulation has a strong impact on the final product, which may represent a significant loss of quality, affecting mainly properties such as viscosity, density, stability and combustion quality.

For attending the marine fuel market, it then becomes important to identify new streams for developing marine fuels as well as correct evaluation of these fuels' quality. Biodiesel contains smaller molecules than those that are present in bunker oil, and does not have sulfur, so it is an alternative to improve combustion and reduce emissions, mainly of SOx and particulate material [1,2]. This feature should greatly contribute to the use of biodiesel in marine fuel formulation. In technical literature, there are some cases of the use of biofuels in the maritime sector. These applications have been made in small vessels, and the results of these studies indicate that it is possible to use biofuels in distillate marine fuel formulation [3–10].

An important question in marine fuel production is the combustion quality, one of the basic parameters for fuel handling and using. This property indicates the facility with which the fuel has to be ignited in the engine. A delay in ignition generates increased consumption of fuel and can also damage the engine. The most widely used methodology to determine the quality of bunker oil, in terms of ignition characteristics, is the CCAI correlation (Calculated Carbon Aromaticity Index) [11], calculated by an expression using density and viscosity values. Challenged by a series of papers in the literature, many authors agree that this correlation does not guarantee the representativeness of the total ignition process. The ignition and combustion are also influenced by the type of motor and its operational conditions, and other fuel properties such as the content of asphaltenes and carbon residue which are not represented in the CCAI equation [12–15].

In an attempt to simulate the conditions occurring in the combustion process of a diesel engine which works with bunker oil, the equipment FCA (Fuel Combustion Analyzer) was developed based on the technique of Constant Volume Combustion Chamber (CVCC). This equipment has a standard norm test [16] and can also perform repeated measurements in a controlled environment with good accuracy in relatively short test periods, and require small amounts of sample. For these reasons, this was the method chosen for evaluating the combustion quality of biodiesel and marine fuel blends in this work.

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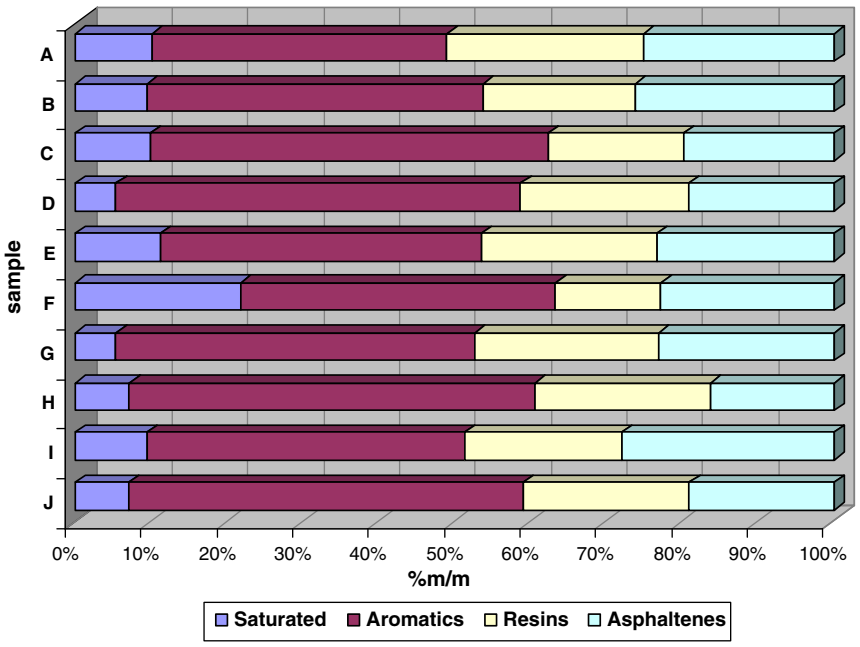

Fig. 1. Composition of RMG 180 samples.

Since the chemical composition and stability properties are of great importance in regard to combustion quality of marine fuels [17,18], tests were performed to determine the composition using the SARA analysis by thin layer chromatography and a flame ionization detector and the mixtures' stability evaluation was made by optical scanning using Turbiscan equipment [19].

This study evaluated the quality of combustion of biodiesel and marine fuel blends. Sixty mixtures of marine fuels and soy biodiesel were tested, varying the biodiesel content by volume in the mixture at levels up to 10% v/v.

2. Materials and methods

2.1. Materials

The marine fuels used in this study, RMG 180 and RMG 380, are the categories of marine fuels of higher production in Brazil and more commercialized worldwide. The samples were obtained from maritime terminals of Petrobras, a Brazilian oil company. These fuels will be designated with the letters A-J, which indicate the maritime terminals that supplied the samples. The bunker samples were stored at room temperature

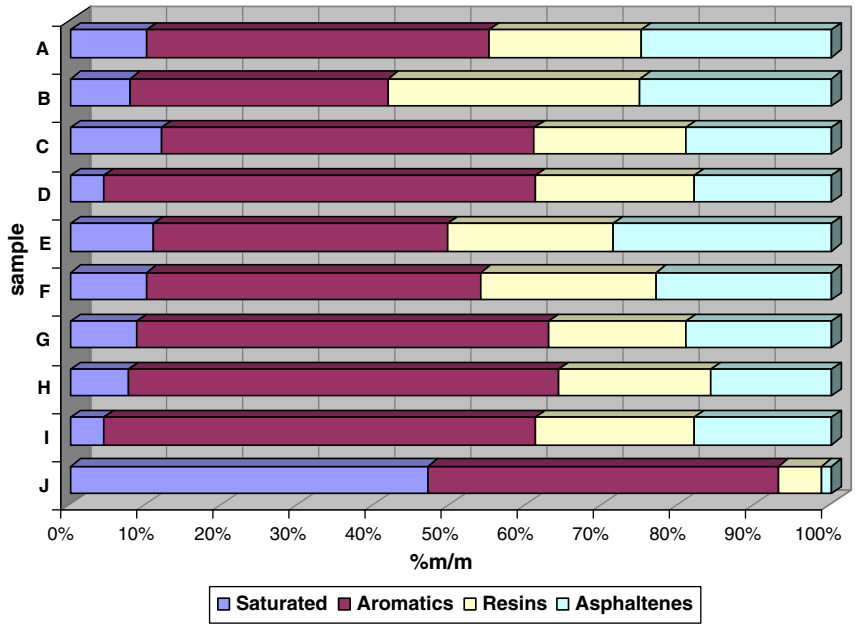

Fig. 2. Composition of RMG 380 samples.