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Technical Report

Compatibility study of high density polyethylene with bioethanol–gasoline blends

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A R T I C L E I N F O

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A B S T R A C T

In order to evaluate the compatibility of high density polyethylene (HDPE) in E5 (5% v/v bioethanol, 95% v/v gasoline) and E10 (10% v/v bioethanol, 90% v/v gasoline), immersion tests have been performed in fuel blends at 45 °C during 2000 h. Different mechanical and physical–chemical properties of HDPE have been assessed before and after the execution of these tests.

Additional information about biofuels–HDPE interaction has been obtained by infrared spectroscopy and solubility tests. Although a slight variation of mechanical properties has been observed, no effects on the chemical structure and physical properties of this polymer, which could be attributed to the E5 and E10 blends, have been detected.

1. Introduction

Biofuels (including ethanol, biodiesel and several other liquid and gaseous fuels) represent an important renewable fuel resource to displace petroleum-derived transport fuels. Increasing biofuels use would bring some benefits such as a reduction in oil demands and greenhouse gas emissions and waste, an increase of air quality, an enhancement of rural economic development and an improvement of vehicle performance [1]. Moreover, gasoline–bioethanol blends have a slightly higher octane number than standard gasoline, which lowers temperature and shortens burning time. They also have a higher oxygen content and burn more completely which results in reduced emissions of some pollutants [2,3].

We can currently find in the market cars known as flexy-fuel that can use fuels with high bioethanol content (85% bioethanol). These cars present significant changes in the engine, which raise the final price of the vehicle.

Another strategy to increase the consumption of biofuels is to gradually increase the percentage of bioethanol so as to achieve minimal changes in the vehicle. In Spain, as in some other countries, the use of E5 is only allowed as the first stage in a short-term plan before the use of a 10% bioethanol blend can be fully established.

Materials compatibility is a major concern whenever the fuel composition is changed in the fuel system. Changes in fuel composition and the introduction of alternative fuels often create problems of corrosion and degradation in metallic and polymeric materials.

Being bioethanol a hygroscopic fuel, it is more problematic than biodiesel with regard to metal corrosion and besides, unlike gasoline, it presents some electrical conductivity. In addition, it can be oxidized to acetic acid thus lowering the fuel pH. Several studies of the corrosive behaviour on metals of bioethanol and bioethanol–gasoline blends have been carried out [4–10] though electrochemical and immersion test. Kabasakaloglu et al. [4] carried out studies about the influence of ethanol acidity on the passivity of carbon steel. Rossi et al. [5] reported the Al–Si alloy to show better corrosion behaviour than grey iron in hydrated ethanol (H_2O:1.5%). Nie et al. [6] found out that variable bioethanol content (E30, E85, and E100) did not influence the corrosion behaviour of stainless steel AISI 304. Recent findings [7,8] confirm that, under certain conditions, bioethanol can cause stress corrosion cracking in carbon steels. Finally, the use of coatings [9] and anti-corrosion additives [10] has been proposed as a means to minimize the effect of bioethanol corrosion on the metallic components in vehicles.

Moreover, as the biofuel is also in contact with polymers, it is necessary to check the compatibility of polymers with the new biofuels. The possible degradation of plastics can be due to several physical and chemical phenomena: permeation (solvent ingress driven by chemical activity gradient), swelling (interaction between the solvent and the polymer matrix) and plasticizer extraction (loss antioxidants, fillers, heat stabilizers, plasticizers due to the solvent permeation). Few works have been published regarding the compatibility of polymers with new biofuels. Moreover, most of the work that has been published in this area has focused on the degradation of elastomeric materials.

Frame and McCormick [11] tested five elastomers (N1059 peroxide-cured nitrile rubber, V747 fluorocarbon filled with carbon black, V884 fluorocarbon without carbon black, N674 general

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