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Combustion of Hydrotreated Vegetable Oil and Jatropha Methyl Ester in a Heavy Duty Engine: Emissions and Bacterial Mutagenicity

Götz A. Westphal,*[,†] Jürgen Krahl,[‡] Axel Munack,[§] Nina Rosenkranz,[†] Olaf Schröder,[§] Jens Schaak,[§] Christoph Pabst,[§] Thomas Brüning,[†] and Jürgen Bünger[†]

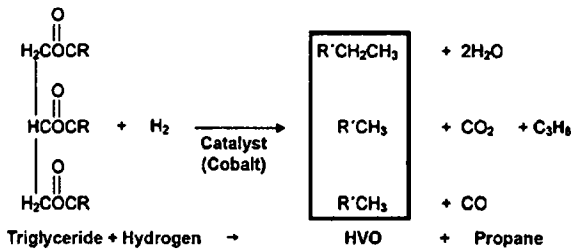
[†]Institute for Prevention and Occupational Medicine of the German Social Accident Insurance - Institute of the Ruhr-University Bochum (IPA), Bürkle-de-la-Camp-Platz 1, 44789 Bochum, Germany

[‡]Coburg University of Applied Sciences and Arts, Friedrich-Streib-Strasse 2, 96450 Coburg, Germany

[§]Thünen Institute of Agricultural Technology, Bundesallee 50, 38116 Braunschweig, Germany

Supporting Information

ABSTRACT: Research on renewable fuels has to assess possible adverse health and ecological risks as well as conflicts with global food supply. This investigation compares the two newly developed biogenic diesel fuels hydrotreated vegetable oil (HVO) and jatropha methyl ester (JME) with fossil diesel fuel (DF) and rapeseed methyl ester (RME) for their emissions and bacterial mutagenic effects. Samples of exhaust constituents were compared after combustion in a Euro III heavy duty diesel engine. Regulated emissions were analyzed as well as particle size and number distributions, carbonyls, polycyclic aromatic hydrocarbons (PAHs), and bacterial mutagenicity of the exhausts. Combustion of RME and JME resulted in lower particulate matter (PM) compared to DF and HVO. Particle numbers were about 1 order of magnitude lower for RME and JME. However, nitrogen oxides (NO_X) of RME and JME exceeded the Euro III limit value of 5.0 g/kWh, while HVO combustion produced the smallest amount of NO_X. RME produced the lowest emissions of hydrocarbons (HC) and carbon monoxide (CO) followed by JME. Formaldehyde, acetaldehyde, acrolein, and several other carbonyls were found in the emissions of all investigated fuels. PAH emissions and mutagenicity of the exhausts were generally low, with HVO revealing the smallest number of mutations and lowest PAH emissions. Each fuel showed certain advantages or disadvantages. As proven before, both biodiesel fuels produced increased NO_X emissions compared to DF. HVO showed significant toxicological advantages over all other fuels. Since jatropha oil is nonedible and grows in arid regions, JME may help to avoid conflicts with the food supply worldwide. Hydrogenated jatropha oil should now be investigated if it combines the benefits of both new fuels.



INTRODUCTION

The limited fossil oil resources urge the research for renewable fuels for the transport sector. Biodiesel (fatty acid methyl esters, FAME) was introduced to the market in the 1980s as a suitable alternative and was supposed to be environmentally friendly. Compared to petrol diesel fuel, the combustion of biodiesel results in a reduction of greenhouse gas emissions.[1] Biodiesel is mainly produced by transesterification of rapeseed oil in Europe (rapeseed methyl ester, RME) and soybean oil in the USA (soy methyl ester, SME). In Asia, palm oil serves as the major source for biodiesel production (palm methyl ester, PME).

Increasing research activities are focused on use of nonedible plant oils for biodiesel production, since the extensive use of edible vegetable oils raises concern due to the competition between fuel and food production resulting in rising prices of vegetable oils.[1,2] *Jatropha curcas* has gained attention as a source for biodiesel production in tropical and subtropical countries and has spread beyond its center of origin, because of its hardiness, easy propagation, drought endurance, high oil content, rapid growth, adaptation to wide agro-climatic conditions, and multiple uses of the plant as a whole.[3] A recent study reported a general reduction in the global warming potential and the nonrenewable energy demand by use of *Jatropha curcas* biodiesel compared to fossil diesel. On the other hand, environmental impacts on acidification, ecotoxicity, eutrophication, and water depletion showed increases.[4] We included jatropha methyl ester (JME) in this study as an alternative to RME, SME, and PME.

Hydrotreated vegetable oil (HVO) was introduced to the market as a new alternative biogenic diesel fuel. HVO can be produced by the catalytic hydrogenation of plant oils. Its physicochemical properties are similar to petroleum derived diesel fuel (DF). Blends (mixtures) of DF and HVO did not result in elevated CO_2 emissions or fuel consumption.[5,6]

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