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The density and cloud point of diesel oil mixtures with the straight vegetable oils (SVO): Palm, cabbage palm, cotton, groundnut, copra and sunflower

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ABSTRACT

The densities and cloud points of six vegetable oils mixed in variable proportions to diesel oils (commercial vehicle fuels) are measured. Simple correlations are reported between these properties and the fatty acids vegetable oil composition. A simple modelling summarises experimental data informations.

1. Introduction

The direct use of vegetable oils in diesel engines has been known for a long time [1]. Described as Straight Vegetable Oil (SVO) to avoid confusion with either methyl esters of vegetable oils (biodiesel) or petroleum diesel, their physical characteristics are quite different from petroleum diesel oils. For direct use in engines generally the slow and medium speed diesels can accommodate SVO, and high speed road engines of certain classes can be modified to operate on SVO subject to some purity of SVO constraints [2]. In our study we have chosen the alternative route of blending SVO directly with mineral diesel and here we determine the range of blends that would be available for use in Tropical countries. Concerning the origin of these SVOs: Palm, Cabbage palm, Cotton and Copra are from Ivory Cost, Groundnut is from Senegal and Sunflower is supplied in a supermarket in Paris.

Three physical properties are major formulation targets when fitting a fuel to a diesel engine: viscosity versus

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Table 1 – Comparison of the density and the cloud point of some SVOs.

Characteristics	Summer diesel oil	Palm	Cabbage palm	Copra	Groundnut	Cotton [12]	Sunflower [12]
Density at 20 °C (kgm^{-3})	0.83	0.91	0.91	0.92	0.91	0.92	0.92
Cloud point (°C)	0	32.7	20	20	2.6	0.5	−5

Table 2 – Palm oil (PO)/diesel oil blends (% mass); specific mass measurements versus temperature.

Temp (°C)	Gasoil	5% PO	10% PO	15% PO	20% PO	30% PO	40% PO	50% PO	100% PO
10	0.8387	0.8390	0.8431	0.8470	0.8503	0.8577	0.8668	0.8771	0.9255
20	0.8314	0.8319	0.8361	0.8399	0.8433	0.8503	0.8598	0.8693	0.9145
30	0.8244	0.8249	0.8290	0.8327	0.8363	0.8437	0.8529	0.8609	0.9043
40	0.8172	0.8179	0.8219	0.8256	0.8293	0.8369	0.8459	0.8519	0.8975
50	0.8101	0.8108	0.8149	0.8186	0.8223	0.8300	0.839	0.8444	0.8907
60	0.8029	0.8038	0.8071	0.8116	0.8149	0.8231	0.8321	0.8372	0.8839
70	0.7957	0.7967	0.8008	0.8046	0.8080	0.8161	0.8251	0.8295	0.8772
80	0.7884	0.7924	0.7955	0.7990	0.8030	0.8100	0.8192	0.8219	0.8705

temperature, cloud point and the fuel's density. These properties can be measured case by case. But within defined climatic and oil feed constraints, it would be of course much easier to identify the optimal formulation window using simple models. As a matter of fact, for engineering purpose such models are only asked to correlate experimental information, even just empirically. Screening the fatty acids that are most widely observed in the SVOs, it comes that natural possibilities are quite restricted. Thus, measuring the SVO blend properties for varied major available oils, it can be expected the most significant correlations with the fatty acids composition will merge. This is the purpose of this study. A study focused on viscosity has already been carried out [3]. This study will thus focus on densities and cloud points.

1.1. *Density*

SVOs densities vary between 0.9 and 0.93, whereas from 0.81 to 0.87 for diesel oil [4]. Given the injection pressure, thus the injection jet speed, SVOs have a greater inertia compared to gasoil. Consequently, one may expect the fuel jet to go deeper in the combustion chamber. Many researchers studied the effects of using pure SVOs in diesel engines [5–9]. They conclude the high viscosity of SVOs to reduce atomization efficiency, and the higher density to increase the length of fuel jets.

1.2. *The cloud point*

Mirante and Coutinho [10] suggested that the ability to predict the SVO cloud points would be determining for an economic optimization of these fuels production. At low temperatures, the diesel oil paraffins partly turn to solid gels. This phenomenon defines the minimal temperature at which a diesel oil can be used [11], also called the cloud point. When using SVO, either alone or blended with diesel oil, generally triglycerides are expected to turn to gels at higher temperatures than the diesel oil paraffins. The cloud point of SVOs is thus expected to be a most serious restriction to their use. Table 1 reports data for the different SVOs used here.

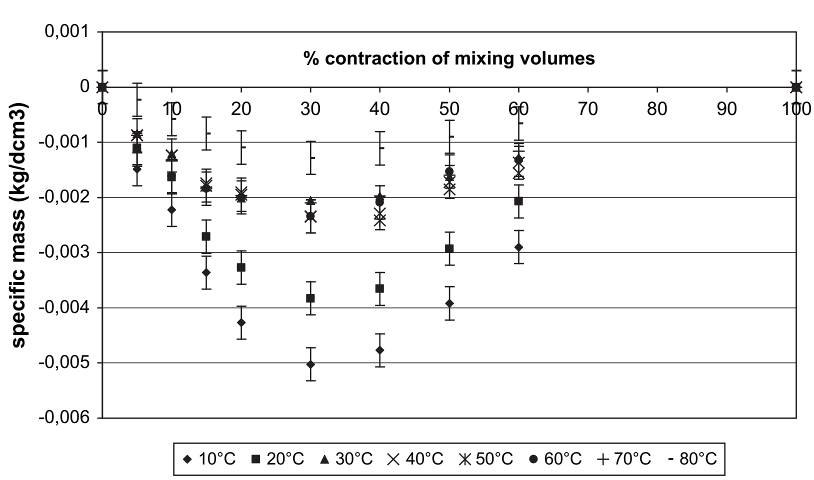

Fig. 1 – Volume contraction when blending palm oil.