

The influence of butanol blending on the ignition properties of gasoline

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Introduction

The EU Fuel Quality Directive [1] targets 10% of renewable energy in the transport sector by 2020. Currently the most widely used biofuel is bioethanol, accounting for 90% of total biofuel usage [2]. Ethanol can be used in a blend with gasoline within modified engines, or in its pure form within specially designed spark-ignition engines. It has a high octane number and heat of vaporisation, making it a favourable choice for use in high compression ratio engines [3]. However, ethanol cannot be used in standard spark ignition engines because of its potential to cause corrosion of fuel lines and engine seals. It also has other disadvantages, including a high oxygen/carbon ratio, high hygroscopicity, full miscibility in water, and low energy density. Using ethanol blends >10% often requires modifications and at present not all countries within the EU have the infrastructure in place to support this. As the regulations for carbon emissions become stricter, for example in accordance with the UK 2050 target of 80% carbon emissions reductions, higher blending ratios may become mandatory if there is a continued reliance upon fossil fuels or internal combustion engines. This has resulted in increasing interest for the development of other alcohol based biofuels, since higher alcohols have lower hygroscopicity and corrosivity, higher energy density, and can be readily blended with hydrocarbon fuels in fueling systems [4].

Butanol provides a promising alternative to ethanol since it can be formulated from bioenergy sources and can be mixed with gasoline in much higher proportions than ethanol without the need for significant technology changes due to its higher energy content, more closely resembling that of gasoline [5]. In addition, *n*-butanol is more hydrophobic and less corrosive than ethanol, which means that the current fuel distribution infrastructure could be used, while the fuel can be used in conventional internal combustion engines without the need for modification [6]. Although butanol does have some drawbacks, such as difficulties in cold weather, lower octane number, currently higher production costs and a lack of existing facilities for the production of significant quantities of fuel to facilitate widespread use, research and production is taking place to overcome these difficulties and to determine the true potential of butanol as a fuel for the future. It is therefore timely to explore the combustion properties of butanol particularly when blended with gasoline.

Results

The paper will present ignition delay studies of butanol and a butanol gasoline blend at high pressures (~20 bar) from a Rapid Compression Machine (RCM). It will be shown that for stoichiometric conditions and a blending fraction of 20% butanol that the ignition de-

lay times for the blends fall between those measured for stoichiometric mixtures of pure butanol and pure gasoline in air over a range of temperatures between 677-857 K.

The complexity of gasoline makes modelling its combustion properties particularly difficult. Surrogates are commonly used within modelling studies in order to overcome this issue. A commonly used gasoline surrogate is TRF (toluene reference fuel) which has demonstrated an ability to behave like gasoline from an auto-ignition point of view [7]. This study also aimed to test the ability of TRF to represent gasoline with respect to ignition delays times within the RCM for the representation of 100% gasoline and also for the butane blends. The relative components (iso-octane, n-heptane, toluene) of the TRF were calculated to match specific properties of the gasoline; the Research Octane Number (RON), the H/C and air fuel ratios.

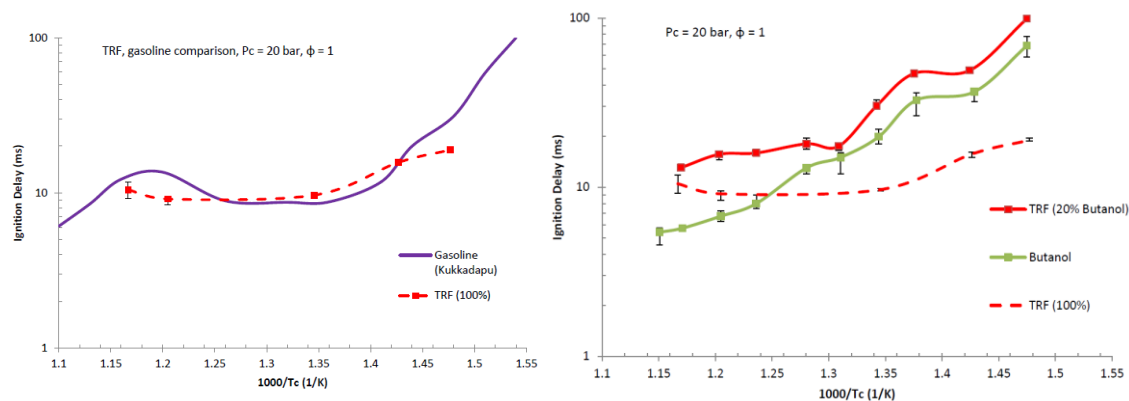


Figure 1 – Ignition delay times for a) the TRF compared with those of gasoline [8] b) the 20% butanol blends compared to pure butanol and pure TRF.

The ignition delay times for 100% TRF were very similar across the tested temperature range to previous data for a gasoline with similar properties to that used here (see Fig. 1a). However, the 20% n-butanol, 80% TRF mixtures exhibited ignition delay times that were longer than either pure butanol or pure TRF (Fig 1b). The behavior of the surrogate when blended was therefore not a good representation of the gasoline it was aiming to represent. The paper will explore the possible reasons for such differences in response on blending.

References

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