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Full Length Article

Effects of dispersed multiwalled carbon nanotubes on the micro-explosion and combustion characteristics of 2-methylfuran – diesel mixture droplets

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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

Isolated droplet combustion experiments have been carried out on neat diesel, a 15 vol% 2-methylfuran – 85 vol % diesel mixture (MF15), and nanofuels made from MF15 base fuel with addition of multiwalled carbon nanotubes (MWCNTs) at 25 ppm, 50 ppm, and 100 ppm concentrations (referred to as MF15C25, MF15C50, and MF15C100). Compared to MF15, the nanofuels displayed increased micro-explosion intensity and reduced micro-explosion occurrences, both effects being more pronounced at higher MWCNTs loadings. This behavior is attributed to the higher surface tension and viscosity of the nanofuels compared to that of MF15. The ignition delay decreased from 2.33 s to 1.71 s, the combustion rate constant increased from 0.82 $mm^2 s^{-1}$ to 1.01 $mm^2 s^{-1}$, and the combustion period reduced from 5.31 s to 4.54 s when going from pure MF15 to MF15C50. The improved combustion characteristics can be related to the superior thermal conductivity and large specific surface area of the dispersed MWCNTs in the nanofuels. The combustion characteristics of the nanofuel deteriorate at the highest MWCNTs dosing investigated here, possibly due to nanoparticle agglomeration. Overall, the present results suggest that dosing of MWCNTs at optimum levels improves the thermal efficiency and reduces the NO_x emissions upon combustion of MF-diesel blends.

1. Introduction

Diesel has been one of the widely used non-renewable energy sources for transportation over the past several decades. The ever-increasing usage of diesel in internal combustion engines leads to major problems such as emission of harmful particulate matters (PMs) and nitrogen oxides (NO_x), fossil fuel depletion, and environmental degradation due to oil exploration activities and processing. Biodiesels could address some of these problems as they are considered renewable with carbon-neutrality because plants – the biodiesel raw materials – absorb carbon dioxide (CO_2) as they grow [1]. Biodiesels, however, are generally more expensive and have lower fuel economy compared to conventional diesel [2]. Furthermore, biodiesels could damage rubber hose lines of automobile fuel systems and are not suitable for use in cold countries owing to their higher pour point compared to that of traditional diesel. The higher cloud point of biodiesels could also cause clog up in fuel rails and fuel filter. Therefore, biodiesels cannot be used directly in commercial diesel engines and the required major diesel engine modifications would lead to increased capital and operational costs in the short term [3].

Recently, furan-based fuels with better physicochemical properties compared to those of biodiesels have attracted significant attention. 2-methylfuran (MF) and 2,5-dimethylfuran (DMF) are commonly produced from fructose – an abundant and renewable material – allowing large-scale production of MF and DMF [4–5]. Unlike biofuels such as ethanol, MF and DMF are insoluble in water but soluble in diesel. MF and DMF can be mixed with diesel to produce homogenous single phase solutions [6], and are thus are good candidates for combustible biofuel-diesel blends. The renewability and possible large-scale availability of MF and DMF make them favorable diesel blends to reduce fossil fuel consumption.

The effects of MF on the combustion and emission characteristics of a diesel engine have been reviewed recently, and issues including fuel consumption efficiency, prolonged ignition delay, and increased carbon monoxide (CO) and NO_x emissions were identified [6]. For example, longer ignition delay and shorter combustion duration of MF-diesel blends compared to that of neat diesel was observed in a rapid-

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