Fuel 209 (2017) 132–140

Contents lists available at ScienceDirect

Fuel

journal homepage: www.elsevier.com/locate/fuel

Full Length Article

The effect of pentanol addition on the particulate emission characteristics of a biodiesel operated diesel engine

Ke Yang[a,b], Long Wei[a], C.S. Cheung[a,*], Chenglong Tang[b], Zuohua Huang[b]

[a] Department of Mechanical Engineering, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong
[b] State Key Laboratory of Multiphase Flow in Power Engineering, Xi'an Jiaotong University, Xi'an 710049, PR China

ARTICLE INFO

Keywords:
Diesel engine
Biodiesel
Pentanol
Particulate emissions
OC
EC
PAHs

ABSTRACT

In the present study, combustion performance and the physical and chemical characteristics of soot particles from a DI diesel engine were studied. The engine was fueled with *n*-pentanol mixed with biodiesel at 15% and 30% by volume and operated at 1800 rpm under three engine loads (20%, 50% and 80% load). In comparison with pure biodiesel, the pentanol-biodiesel blends lead to delayed start of combustion and shortened combustion duration. The particle number concentrations of all size groups are reduced for biodiesel-pentanol blends in all the tested conditions, due to longer ignition delay time, lower viscosity and boiling point, and higher oxygen content of pentanol. The brake specific elemental carbon (EC) emissions of biodiesel were found to be lower compared to diesel and after adding pentanol in biodiesel, the EC emissions further decrease. While for organic carbon (OC) emissions, biodiesel and diesel are at similar level under the tested engine loads, and the blends show a higher fraction of OC at low and medium engine loads. The blended fuel with higher proportion of pentanol gives lower total particle-phase PAHs emissions and also a lower benzo[a]pyrene equivalent (BaP_{eq}) compared to pure biodiesel under the tested engine loads.

1. Introduction

The search of alternative fuels, such as biodiesel and alcohols, for diesel engines has attracted significant research interest since they have the potential to reduce our reliance on fossil fuels, and restrain the life-cycle CO_2 emissions [1,2]. Biodiesel is renewable and non-toxic without sulfur and aromatic compounds, and also has similar fuel properties with diesel [3,4]. Previous engine emission test show that with the use of biodiesel in a diesel engine, unburned hydrocarbon (HC), carbon monoxide (CO) and particulate matter (PM) emissions are decreased, while nitrogen oxides (NO_x) emission is increased inevitably [5]. However, higher NO_x emissions and poor cold flow properties [6] are major disadvantages for biodiesel.

Some studies have proved that the use of small alcohols/diesel fuel blends, mainly methanol and ethanol, could help to reduce the PM and NO_x emissions [3,7]. In spite of this, some properties of alcohols with short carbon chain length, such as the lower calorific values and high latent heat, restrict their use in diesel engines. Additionally, miscibility and stability problems arise when high percentage of alcohol is blended in addition to the low cetane number, poor autoignition behavior and inappropriate lubricating properties of these small alcohols [8–10]. To solve these problems, many technologies comprising modified and unmodified engines operating on alcohol-diesel blends have been proposed. Double injection of diesel fuel and alcohol, blending diesel with alcohol with stabilization additives and cetane enhancers, and emulsions are among the mostly used approaches [11,12]. Due to favorable thermophysical properties and higher energy density, the use of alcohols with longer carbon chain length such as butanol and pentanol as alternative fuels for diesel engines has received more and more attention [13–17]. However, there are still many issues regarding to the fuel properties including lubricity and cetane number of higher alcohols-diesel blends [18] that need to be enhanced.

Blends of biodiesel and low/high alcohols do not have the above-mentioned drawbacks for the diesel-alcohol blends. Moreover, the addition of alcohol in biodiesel can solve the problems of increased NO_x emissions. Various experimental works have been conducted on the use of low alcohols blending with biodiesel in diesel engines [19–23].From those previous studies, it is shown that biodiesel-ethanol/methanol blends could reduce PM and NO_x emissions, however there exist different findings on CO and HC emissions with different concentration of methanol or ethanol in the blends. Recently, Yilmaz et al. [9] and Rakopoulos [24] found that compared to pure biodiesel, butanol-biodiesel blends result in lower NO_x and smoke opacity but higher unburned HC emissions.

* Corresponding author.
E-mail address: mmcsc@polyu.edu.hk (C.S. Cheung).

http://dx.doi.org/10.1016/j.fuel.2017.07.093
Received 27 May 2017; Received in revised form 22 July 2017; Accepted 24 July 2017
Available online 28 July 2017

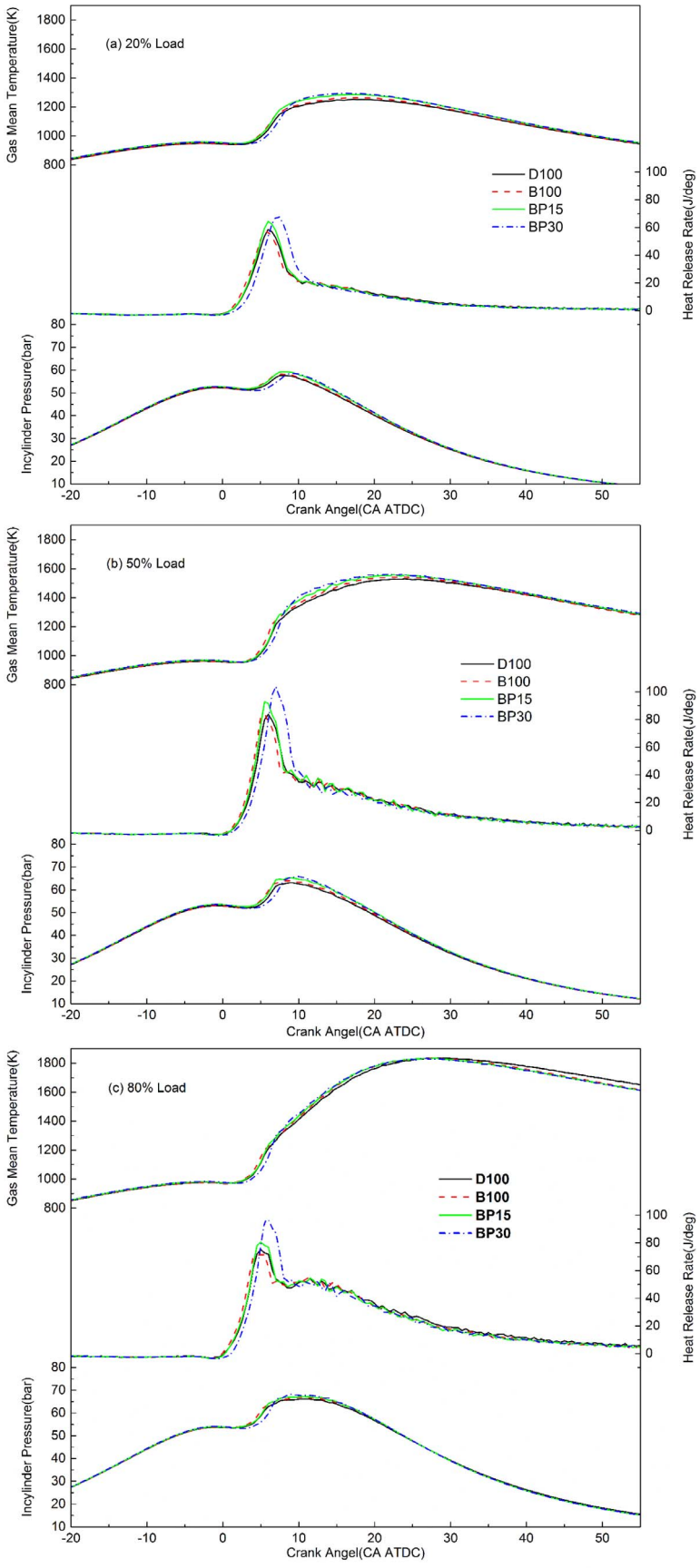

Fig. 1. In-cylinder pressure, gas mean temperature and heat release rate at three engine loads.