Emission characteristics of methanol-in-canola oil emulsions in a combustion chamber

Shreyas Bhimani\textsuperscript{a}, Jorge L. Alvarado\textsuperscript{b,\textdagger}, Kalyan Annamalai\textsuperscript{a}, Charles Marsh\textsuperscript{c,d}

\textsuperscript{a} Department of Mechanical Engineering, Texas A\&M University, College Station, TX 77843, USA
\textsuperscript{b} Department of Engineering Technology and Industrial Distribution, Texas A\&M University, 118 Thompson Hall, 3367 TAMU, College Station, TX 77843-3367, USA
\textsuperscript{c} US Army, Engineer Research and Development Center, Construction Engineering Research Laboratory, 2902 Newmark Drive, Champaign, IL 61822-1076, USA
\textsuperscript{d} Department of Nuclear Plasma and Radiological Engineering at the University of Illinois at Urbana–Champaign, 104 South Wright Street, Urbana, IL 61801, USA

Highlights

- Stable canola oil emulsions were made using Span 80, canola oil, and methanol.
- Emulsions produced lower NO\textsubscript{x}, CO and unburned HC emissions than pure canola oil.
- Higher amount of methanol in the emulsions led to lesser NO\textsubscript{x}, UHC and CO emissions.
- Increased vorticity at higher swirl angle led to better mixing and lower emissions.

Article info

Article history:
Received 13 January 2013
Received in revised form 28 April 2013
Accepted 29 April 2013
Available online 28 May 2013

Keywords:
Canola oil
Methanol
Swirler
Emulsion
Twin-fluid atomizer

Abstract

This paper focuses on the emulsification and combustion characteristics of different methanol-in-canola oil blends subject to different conditions including swirl number and equivalence ratio. Exhaust emissions data such as nitrogen oxides (NO\textsubscript{x}), unburned hydrocarbons (UHC’s), carbon monoxide (CO) and carbon dioxide (CO\textsubscript{2}) emission levels were measured and analyzed thoroughly. Stable methanol-in-canola oil emulsions were made by using a combination of Span 80 and Tween 80 surfactants. The three different fuels studied were: pure canola oil, 89-9 emulsion [9% methanol – in – 89% canola oil emulsion with 2% surfactant (w/w)] and 85-12.5 emulsion [12.5% methanol – in – 85% canola oil emulsion with 2.5% surfactant (w/w)]. All the experiments were conducted in a 30 kW combustion chamber equipped with a twin fluid atomizer and a radial vane swirler. The swirler vanes were positioned at 60° and 51° angles (with respect to vertical axis) in order to achieve swirl numbers (SNs) of 1.40 and 1.0, respectively. The fuels were tested at equivalence ratios ($\phi$) of 0.83, 0.91, 1.0, 1.05 and 1.11.

Ultimate analysis, higher heating value (HHV), kinematic viscosity and density were used to characterize the fuel properties. Experimental results showed that fuel type and swirl number had a major influence on emission levels. All the emulsions produced lower NO\textsubscript{x}, CO and unburned hydrocarbon emissions than pure canola oil at both swirl numbers and all equivalence ratios. The emulsions also produced higher CO\textsubscript{2} emissions than pure canola oil. On comparing the performance of the emulsions, it was seen that the addition of methanol to the blend had a definite positive impact on the combustion characteristics. It was observed that higher percentage of methanol in the emulsions led to lesser NO\textsubscript{x}, UHC and CO emissions. The vorticity imparted to the secondary air by the swirler also affected emission levels considerably. Increased vorticity at higher swirl angle led to better mixing of air and fuel, minimizing emission levels specifically at swirl number of 1.4.