Effect of water-containing butanol addition to diesel–biodiesel blend on PAHs emissions emitted from a diesel-generator

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Diesel engine exhaust has been of great concern in many countries owing to its adverse health effects. Diesel engines are commonly known to be a major source of polycyclic aromatic hydrocarbons (PAHs) emission. Biodiesel is one of the most promising, clean, alternative fuels that are generated from renewable resources. However, the viscosity and cetane number of biodiesel are higher than those of conventional fossil diesel. Blends with an excessively high percentage of biodiesel are unfavorable for engine operation. Therefore, “biodieselhol” (which is a blend of biodiesel, solvent, and fossil diesel) with an oxygen agent from ethanol, butanol or acetone, usually has a lower viscosity than biodiesel to provide better engine fuel combustion efficiency and lower PM emissions (Chang *et al.*, 2014; Tsai *et al.*, 2014a, 2014b). Butanol has a lower volatility and auto-ignition temperature than methanol and ethanol, so it can be ignited more easily when burned in diesel engines (Sarathy *et al.*, 2009). It is also less corrosive and can be blended with diesel fuel without phase separation. To explore the impact of biodieselhols containing water-containing butanol on engine exhaust emissions, pure petrochemical diesel and different tested biodieselhols were used as fuels in this study.

Different blended fuels were tested at the stable energy output (110 V/60 Hz, 1800 rpm) of a generator under 3 kW load. The tested biodieselhols consisted of 10–50 vol% pure (or dehydrated) butanol (denoted as B) or 10–40 vol% water-containing butanol (2% and 5% water content, denoted as B' and B", respectively), 20 vol% waste-edible-oil-biodiesel (WEO-biodiesel, denoted as W20), and 30–80 vol% conventional diesel. An auto-detector flow sampling system equipped with quartz fiber filters was installed on the downstream side of the diesel generator tailpipe to determine suspended particles and particulate-phase PAHs in exhaust. Gas-phase PAHs were collected by two connected cartridges (filled with XAD-16 resins). Each sample was extracted in a *Soxhlet* extractor with a mixed solvent (n-hexane and dichloromethane 1:1 vol/vol) for 24 hr. The extracts were then concentrated by gently purging with ultra-pure nitrogen, and cleaned-up with a silica gel column. The effluents were re-concentrated to exactly 1 mL. Twenty-one PAH congeners were detected with a gas chromatograph/mass spectrometer (GC/MS).

Experimental results showed that the use of W20 and pure-butanol/water-containing-butanol biodieselhols reduced the emitted concentrations of LMW-, MMW-, HMW-, and Total-PAHs as well as Total-BaP_{eq} below those obtained when D100 was used (Fig. 1). When the amount of added pure-butanol/water-containing-butanol was at least 30%, the reductions of emitted PAHs and BaP_{eq} increased as the addition percentage increased. The largest reductions of PAHs and BaP_{eq} were observed when the blended fuels contained 30%-pure-butanol/water-containing-butanol (W20B30, W20B'30, and W20B"30). The emission reductions were 51% for Total-PAHs and 48% for Total-BaP_{eq} using W20B30, 59% for Total-PAHs and 55% for Total-BaP_{eq} using W20B'30, and 58% for Total-PAHs and 52% for Total-BaP_{eq} using W20B"30. The reductions of emitted PAH and BaP_{eq} concentrations achieved using biodieselhols with water (2% or 5%)-containing butanol exceeded those achieved using biodieselhols with dehydrated butanol, except for the BaP_{eq} when W20B"40 was used.

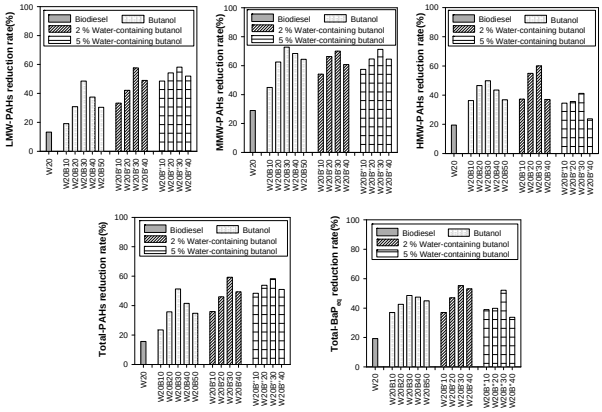

Figure 1. Reduction of PAHs emissions emitted from the diesel-generator fuelled with biodieselhols when operating at 3 kW.

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