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PARTICULATE MATTER CHEMICAL CHARACTERISTICS FROM A LIGHT-DUTY DIESEL ENGINE FUELED WITH PODE/DIESEL BLENDS

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ABSTRACT–To evaluate the influence of polyoxymethylene dimethyl ethers (PODE) on particulate matter (PM) chemical features, PM samples emitted from diesel fuel and PODE/diesel blends at volume ratios of 10 %, 20 %, and 30 % (P10, P20, and P30) were characterized using gas chromatography-mass spectrometry, X-ray photoelectron spectroscopy (XPS), and Fourier transform infrared spectroscopic (FT-IR). Results showed that adding PODE in diesel fuel could increase the proportions of the lower carbon-atom-number components and the contents of oxygen-containing compounds in the soluble organic fractions extracted from PM samples. The ratio of oxygen to carbon (O/C), the functional groups, and the nanostructure of dry soot obtained from XPS showed that the O/C rose as the PODE volume ratio increased. The graphitization degree of dry soot decreased in the order: diesel fuel > P10 > P30 > P20. The relative content of hydroxyl functional groups exhibited the same trend, while the relative content of carbonyl functional groups exhibited an opposite trend with the graphitization degree. Moreover, according to FT-IR, both the branching degree and the relative content of hydrocarbon functional groups of aliphatics are influenced by the graphitization degree of dry soot. A turning point at P20 observed by analysis results above indicated that the chemical characteristics of PM could be affected not only by fuel properties but also by the process of fuel combustion and PM formation.

KEY WORDS : Diesel engine, Polyoxymethylene dimethyl ethers, Particulate matter, Soluble organic fractions, Surface functional groups

1. INTRODUCTION

Diesel engines are extensively applied in industry, modern farming, traffic, and freight transportation according to their higher thermal efficiency, economy, and durability (Roy *et al*., 2016). More than 90 % of particulate matter (PM) emitted from diesel engines is distributed at 10 nm ~ 1 μm of particle size, a kind of micro-nano scaled particle (Bagheri and Baar, 2018; Bermúdez *et al*., 2015). Also, diesel pm harms the atmospheric environment and mankind's health (Pirjola *et al*., 2017). The increasingly stringent emission legislations raise higher requirements for pm emissions of diesel engines. Besides, energy security issues are incredibly urgent all over the world, leading to the development of alternative fuels. Oxygenated fuels are considered to be promising alternative fuels, which play autonomous oxygen providing roles in the combustion and reduce pm emission of diesel engines (Zhang *et al*., 2020; Liu *et al*, 2019; Jamrozik *et al*., 2018).

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In recent years, oxygenated fuels such as methanol, ethanol, dimethyl carbonate (DMC), biodiesel, dimethyl ether (DME) have been extensively investigated as alternative fuels for diesel engines (Jamrozik *et al*., 2018; Alptekin, 2017; Suhaimi *et al*., 2018). Employing the oxygenated fuels above can promote the reduction of diesel PM, while there are some imperfections for their use. Compared with diesel fuel (DF), the lower boiling point and cetane number of methanol, ethanol, and DMC lead to air resistance and unstable combustion of diesel engines (Sun *et al*., 2013; Zhang, 2009; Sukjit *et al*., 2012). Biodiesel is perishable and corrosive (Weng *et al*., 2008). DME is gaseous at ambient temperature, and its greater vapor pressure and reduced viscosity, result in an alteration in the fuel feeding and the injection system of diesel engines (Wang *et al*., 2000). Polyoxymethylene dimethyl ethers (PODE) has a higher oxygen content and cetane number but a lower vapor pressure than DF, which is considered to be an ideal diesel additive (Burger *et al.*, 2010; Liu *et al*., 2016).

PODE is a kind of acetal polymer synthesized from methanol, Methylal, DME, trimeric formaldehyde, etc. with