Particulate emissions produced from gas CAST, liquid fuel CAST, and ship diesel engine

L. Mueller[1,2], J. Schnelle-Kreis[1], G. Jakobi[1], B. Stengel[3], L. Jing[4], and R. Zimmermann[1,2]

[1]Joint Mass Spectrometry Centre, Cooperation Group Comprehensive Molecular Analytics, Helmholtz Zentrum München, 85764 Neuherberg, Germany

[2]Joint Mass Spectrometry Centre, Chair of Analytical Chemistry, University of Rostock, 18051 Rostock, Germany

[3] Fakultät für Maschinenbau und Schiffstechnik Lehrstuhl für Kolbenmaschinen und Verbrennungsmotoren, University of Rostock, 18059 Rostock, Germany

[4]Jing Ltd, Zollikofen, BE, Switzerland

Keywords: soot, particulate matter, emission, diesel fuel, aerosol mass spectrometry

Presenting author email: laarnie.mueller@helmholtz-muenchen.de

Combustion processes of fossil fuels dominate energy conversion mechanisms (Chu and Majumdar, 2012) which can be found in major economic activities such as transportation, industrial, and commercial as well as in residential activities. In this work, the behavior, physical and chemical properties of particulate emissions produced from combustion aerosol standards (CAST) using propane and DF with or without additives and ship diesel engine using HFO and DF were studied by using aerosol online instrumentation techniques.

Combustion aerosol particles produced from ship diesel diesel engine by using HFO 180 or diesel fuel (DF, EN 590) (Mueller et al., 2015a) were compared to those produced from propane flame mini-CAST using $\Phi = 0.89$ and 1.13 (Mueller et al, 2015b), as well as the particles from DF with or without metal additives (Fe, Al, V) that were generated using a DF CAST prototype burner generated at $\lambda = 10.4$ and 5.4 (Mueller et al., 2016). The high resolution aerosol mass spectrometry (HR-ToF-AMS), scanning mobility particle sizer (SMPS), and aethalometer were applied to measure the resulting emissions online.

Figure 1 shows the different contributions of the organic matter (OM) families depending on the fuel type and the combustion condition. The combustion particles from the engine produced a lesser degree of mixing of OM families consisting mainly of hydrocarbon families. But depending on the engine setting the mixing state of the organic becomes less homogenous. Contributions of oxygenated organic compounds increased at 75% engine load for HFO and 25% engine load for DF. For the DF burned in CAST burner, the contribution of oxygenated hydrocarbons is higher compared to the engine generated DF combustion particles. Interestingly, the mixing of organic families increased with the addition of metal additive to the DF. For Al additive, the increase of oxygenated and N-containing organics increased as well for DF + Fe. This shows that the mixing state of the organic fraction of the combustion aerosols can be tuned depending on the fuel, combustor, and the combustion setting.

From these results, insights regarding the formation of particulates from different combustion setups can be learned. The mini-CAST particles seemed to be dominated by the PAH/BC formation only. The DF CAST particles seemed to be formed via PAH/BC, incomplete combustion via the HCO route, and metal-catalyzed formation mechanisms which is the same for HFO with the addition of unburned fuel route. DF particles from the ship diesel engine were formed via PAH/BC and incomplete combustion routes. The DF CAST particles can be compared with the engine combustion aerosol particles at efficient combustion engine setting only due to the limitation in vaporizing and diffusing the higher molecular weight species into the flame in the DF CAST.

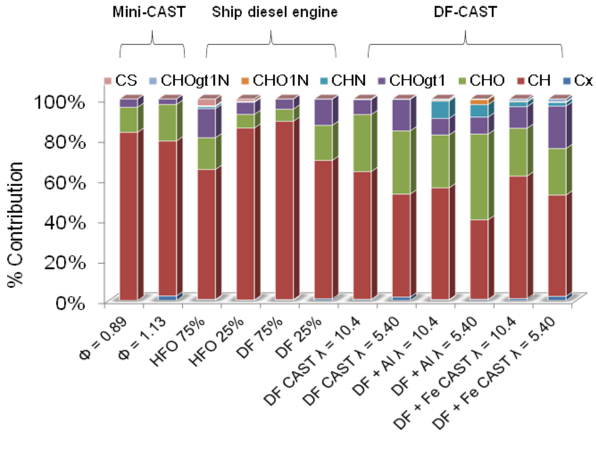

Figure 1. Comparison of the contribution of each OM family between the different combustion setups: mini-CAST, DF CAST and ship diesel engine at different combustion conditions.

This work was supported by the Helmholtz Virtual Institute for Complex Molecular Systems in Environmental Health.

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