Emissions from gas flaring

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Abstract

Worldwide flared volumes exceed 140 billion m^3 annually. Flaring is a major source of CO_2, black carbon (BC) and other air toxic emissions. Flarenet Strategic Network aims to provide a quantitative understanding of flare-generated pollutant emissions enabling science-based regulations and pollutant inventories, understanding climate and health impacts and mitigation strategies for the energy production sector.

First phase of this project involved investigation of emissions from a large scale laboratory flare. Soot particles were generated at the Flare Test Facility within the Energy & Emissions Research Laboratory at Carleton University. Flares up to 80 mm in diameter with turbulent flames up to 3 m tall were tested. Effects of fuel mixture, burner diameter, and effluent velocity on emissions were investigated. Experiments consisted of several gas and particulate analyzer; however this poster only focuses on the effective density, morphology, and Raman characterizations.

In these experiements, fuel mixtures with heavier hydrocarbons produced larger particles in size and higher number of particles per unit mass of fuel. Transmission Electron Microscopy (TEM) showed that the average primary particle diameter varied between 13 to 24 nm, while its geometric standard deviation varied between 1.3 and 1.7. No clear correlation was observed between the primary particle diameter and burner diameter and effluent speed. Similarly, effective density of particles for all test conditions did not change significantly. Average primary particle diameter was found to increase substantially with the size of the aggregates, regardless of the operating condition. Recent investigations showed that the primary particle diameter and mass-specific absorption cross section (MAC) increase with the aggregate size, even in a single operating condition (Dastanpour & Rogak, 2014; Dastanpour et al. 2017). This elaborates the need to investigate the size-ependency of the optical properties of flaring emissions.

The analysis of the spectra generated by Raman spectroscopy is a common method to obtain the chemical composition of soot nanoparticles. By analyzing the ratio of the characteristic peaks of soot, the degree of graphitization, the crystal sizes in disordered carbon, and the amount of amorphous carbon can be estimated. Furthermore, comparins Raman spectra allow to detect any difference in chemical composition among soot generated with different burining conditions.