ABSTRACT:

Name of Responsible Researcher:	Jorge Omar Contreras Rodríguez
Project Title:	Understanding the soot reactivity and toxicity in the exhaust gases released from internal combustion engines fuelled with blends of diesel and biofuels

Abstract

Combustion processes not only produce useful energy to sustain our daily life, but also produce several pollutants such that Particulate Matter (PM) that have harmful effects on health and ecosystems. The toxicity of exposure to the particulate matter (PM_{10}, $PM_{2.5}$) and ultra-fine particles with diameters below 100 nm ($PM_{0.1}$) also called soot, have been studied in the case of animals and humans finding major health problems such as cardiovascular diseases, cancer and respiratory diseases. The transportation sector is one of the main contributors to the global emissions of PM since its propulsion systems are mostly based on internal combustion engines (ICE) using conventional fuels, mainly diesel. For this reason, emissions in transport are limited all over the world through regulations, and the limits have become more stringent with time. Two approaches can be used to address this issue, upstream and downstream. The former is the utilization of novel biofuels to reduce soot mass produced by combustion process. The latter, is the control of exhaust soot nanoparticles using filters, such as Diesel Particulate Filters (DFP) where trapped soot particles undergo an oxidative reaction called regenerative process to form CO_2.The performance of these regenerative filters is linked with oxidation soot reactivity that in turn is associated with particle nanostructure and composition. It is known that the utilization of biofuels along with conventional fossil fuels reduce PM mass production and increase the oxidative soot reactivity. In the other hand, recent studies about changes in emission profile of these biofuels compared to various historic conventional fuels have shown that PM mass may not the best metric to assess toxicity. For example, different biofuels types and blends that reduced PM mass concentrations have been reported to have increased toxicity on a per unit mass basis. Therefore, it is important to study how soot is produced by using biofuels to better understand the real implications of utilization of these alternative energy sources. To validate the promising perspectives of utilization of biofuels to reduce PM amount and increase soot oxidation reactivity changes on biofuels soot emissions profiles that include physicochemical properties, morphology and nanostructure must be assessed in terms of their soot reactivity and toxicity. These properties are associated with the concept of soot maturity, that refers to the age of soot, that changes constantly inside the flame where competing formation/oxidation mechanisms are present and after the flame, i.e. in the exhaust stream of an ICE where changes still can occur. However, *in-situ* measurements in an ICE is a very challenging task requiring modification of high cost equipment. For that reason, most studies about soot formation in ICE used "mature" soot collected at exhaust stream. To overcome the drawbacks of ICE, well established burners can be used to study the transition of "young" to" mature" soot characteristics with *in-situ* techniques providing the history of soot evolution from early stages. In that way, a stable laminar diffusion flames, as a coflow burner, along with an ICE could be used to better understand the mechanisms by which the fuel and biofuel blends affect the aging process of soot particles from its birth into the flame to the exhaust into atmosphere. To have a complete history of soot evolution, we are going to study transition from "young" to "mature" soot in a coflow burner where *in-situ* measurements, such as laser induced incandescence (LII), can be done to assess soot concentration and morphology. These results will be compared with *ex-situ* analysis for mature soot from the exhaust of an ICE using similar biofuels blends to provide insights of soot production processes to connect soot formation conditions with soot reactivity and toxicity in the exhaust stream of an ICE. *Ex-situ* techniques proposed to be used here are transmission electron microscopy, RAMAN spectroscopy and thermogravimetry analysis (TGA). The toxicology of the soot collected at the exhaust of the ICE will be assesses through a *Vibrio fischeri* bioluminescence inhibition assay (VFBIA). Carrying out these analyses we expect to show first, that changes on reactivity oxidation of soot collected from engine exhaust along with nanostructure and morphology studies could be linked to oxidation processes that soot particles undergo inside the flame, in the high temperature zone. And second, that there is a biofuel blend composition that provides a good compromise between reduction of PM mass, increase of soot reactivity and toxicity.