Chemical characterization of lubricant oil droplets emitted by an airplane engine

I.K. Ortega[1,2], C. Irimiea[2], D. Delhaye[1], Y. Carpentier[2],X. Vancassel[1] and C. Focsa[2]

[1]Onera-The French Aerospace Lab, F-91761 Palaiseau, France
[2]Laboratoire de Physique des Lasers, Atomes et Molécules (UMR CNRS 8523), Université de Lille 1 Sciences et Technologies, 59655 Villeneuve d'Ascq, France
Keywords: Particulate Matter, airplane emissions, Mass spectrometry.
Presenting author email: Ismael.ortega@onera.fr

Airplane gas turbine engine emissions and their potential impact on air quality and climate have drawn extensive attention during recent years. Most of the studies linked to these emissions have been focus on gas phase (mainly CO_2 and NO_X) and particulate matter (soot) emissions.

Airplane lubrication system are not considered as source of particulate matter emissions, but a recent work by Yu et al. (2012) reported the presence of lubricant oil droplets in the exhaust of the engine of different aircraft in Chicago Midway Airport and O'Hare International Airport. Yu et al. used a High Resolution Aerosol Mass Spectrometer (HR-AMS) to analyse the plume of airplanes on ground, thus with near idle engine operations. They found that the contribution from lubricant oil to the particulate matter measured in airplane plumes ranged from 5% to 100%.

In the present work, we have used Time of the Flight Secondary Ion Mass Spectrometry (ToF-SIMS) to characterize the lubricant oil droplets found in the exhaust of a SAM146 engine. This campaign was performed in the framework of MERMOSE project (http://mermose.onera.fr/).

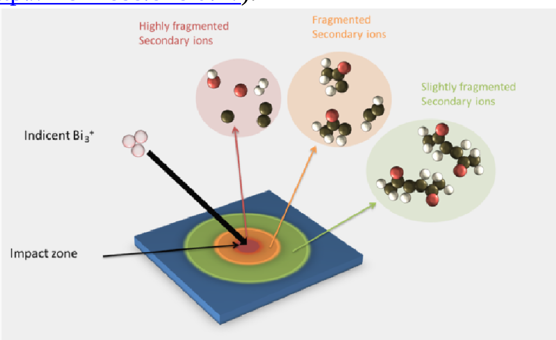

Figure 1. Ion beam desorption/ionization performed in ToF-SIMS instrument

ToF-SIMS uses a pulsed primary ion beam (Bi_3^+) to desorb and ionize species from a sample surface. The resulting secondary ions are accelerated into a mass spectrometer, where they are mass analysed by measuring their time-of-flight from the sample surface to the detector (Fig. 1). In addition to the mass spectra acquired form the molecular species on the sample surface, this instrument is able to provide an image of the sampled surface, allowing to visualize the distribution of individual species on the surface of the sample.

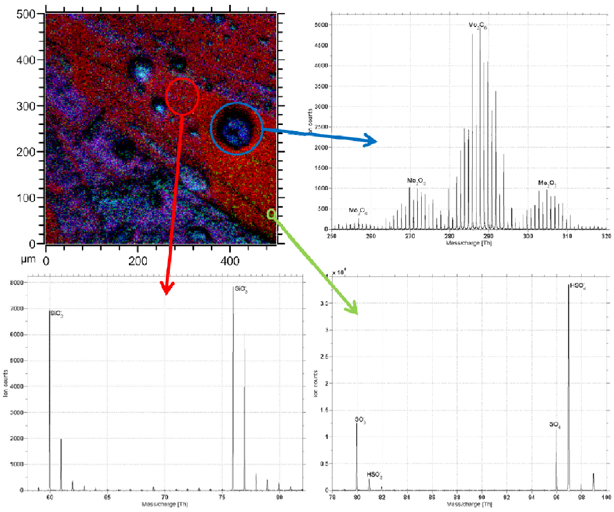

Figure 2. Top left: Mapping of a sample collected over silicon wafer, red areas indicate the presence of SiO_2^- ion (bottom left spectra), blue areas indicate the presence of $Mo_2O_6^-$ (top right spectra) ion and green areas indicate the presence of HSO_4^- ion (bottom right).

Fig. 2 show an example of the oil droplets found in the samples collected at 70% engine regime. In addition to different carbon containing fragments linked to the fatty acids present in the lubricant oil, we found different heavy metals in the droplets, including iron, copper, silver, aluminium and molybdenum. The most abundant one was in all cases molybdenum. Though molybdenum can be included in high pressure lubricant oils as an additive, an analysis of clean lubricant oil used during the campaign did not show any amounts of this metal. Thus most probably, the source of the observed molybdenum is the motor gear, were molybdenum doped stainless steel is used in several pieces.

This work was supported by the CORAC MERMOSE project, funded by French Civil Aviation Authority (DGAC) and by the French National Research Agency (ANR) through the PIA (Programme d'Investissement d'Avenir) under contract ANR-10-LABX-005 (LABEX CaPPA - Chemical and Physical Properties of the Atmosphere).

Yu, Z., Herndon S.C., Ziemba, L.D., Timko, M.T., Liscinsky, D.S., Anderson, B.E. and Miake-Lye R.C. (2012) *Environ. Sci. Technol.* **46**, 9630-9637.