

Elemental and ionic analysis of aircraft engine smoke number filter samples with micro-PIXE and IC

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Abstract

Smoke number (SN) is the measure of exhaust plume visibility of a jet engine, which correlates with non-volatile PM mass concentration in the exhaust. Usually, SN filter samples have not been used for any quantitative analysis of PM on the filter. Here, we have attempted to extract information on elemental composition and ionic species components and PM characteristics from the SN filters using elemental analysis by micro-PIXE and ion component analysis by ion chromatography. The SN filter samples were collected from in-service commercial aircraft turbine engines in the test cell at SR Technics, Zurich airport in 2019 and 2020. The elemental composition analyses of the SN filter samples were carried out using two X-ray Si(Li) detectors microbeam PIXE system at Tohoku University. Ionic species in the SN filter samples were determined using an ion chromatography.

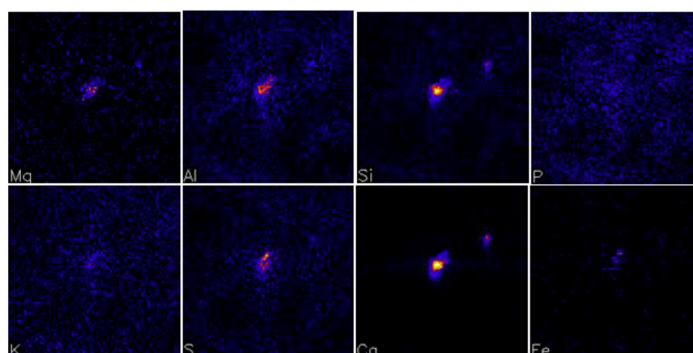


Figure 1 Elemental map of a gray-colored filter, analytical scanning area: $100 \times 100 \mu\text{m}$.

Particles formed from Mg, Al, Si, P, K, S, Ca and Fe have been confirmed from a gray-colored filter (high soot loading at high engine thrust) (Figure 1). In addition, some particles composed mainly of S and Ti have been found. For the elemental compositions, Na, Mg, Al, Si, Cl and Ca are major elements in a gray-colored filter. These elements make up 90% of the total mass of the measured elements. Although the concentration levels are different, major ionic species are F⁻, Cl⁻, Na⁺, K⁺ and Ca²⁺ in both the gray filter and the white filter (low loading at low engine thrust).

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