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Sequential Collective Microanalysis (SCM) Applied on the Characterization of Atmospheric Carbonaceous Particulate Materials Collected in the Metropolitan Area of Monterrey, in México

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This research presents the characterization by the Sequential Collective Microanalysis (SCM) of atmospheric particulate material (PM). This technique involves the *ex-situ* analysis of a single particle by different microprobe techniques such as scanning electron microscopy coupled with and energy dispersive X-ray spectrometer detector (SEM-EDS), micro-Raman spectroscopy (MRS), and photoluminescence microscopy (PLM). Additionally, the proposed technique overcomes the necessity of acquiring or modifying the common characterization equipment regularly found in the laboratories [1]. The PM was collected during the winter season of 2017 in four sampling zones of the Metropolitan Area of Monterrey (MAM), in the northeast of México.

Figure 1 shows the SCM of a carbon-rich particle. The SEM micrograph (figure 1a) showed a particle with spherical morphology and smooth surface. The EDS analysis (figure 1b) showed the presence of C, O, S, and P. Both, the composition and morphology are characteristic of carbon black (CB) particles. From the PLM, the optical micrograph obtained with the polarized light (figure 1c) showed the appearance of the particle as light blue color, suggesting the presence of polyaromatic compounds that are believed to be photoluminescent. The optical micrograph and corresponding Raman spectrum (figures 1d and 1e) showed the vibration modes at 1350 and 1560 cm^{-1} (D, and G bands), attributed to carbonaceous materials. These bands were deconvoluted for determining the I_{D3}/I_G ratio, and setting the potential emission source [2, 3]. The calculated ratio was 0.97, which corresponded to particles produced from the combustion of diesel soot [3]. Figure 2 shows the SCM of a Fe-rich particle. The SEM image and EDS analysis (figures 2A, and 2B) showed an irregular shape particle composed of Fe, O, and C. This type of particles have been associated with the wear of automotive parts. However, the PLM with polarized light did not showed the typical reddish color observed in iron oxide particles, but a bluish appearance [4]. The optical micrograph acquired with regular light (figure 2d) showed a reddish halo around the particle, and a dark appearance on the surface. This suggested that a carbonaceous material might be covering the particle. The Raman spectra acquired with different beam intensities (figure 2e) showed the D, and G bands. The subsequent deconvolution and I_{D3}/I_G ratio showed a value of 1.1, suggesting that possibly, the burning of fuels such as diesel or gasoline originated the carbonaceous material covering the Fe-rich particle [3].

The SCM methodology proposed herein, allowed to individually characterize and identify the carbonaceous particles found in the PM, and even to relate their physicochemical characteristics with the potential source of emission.

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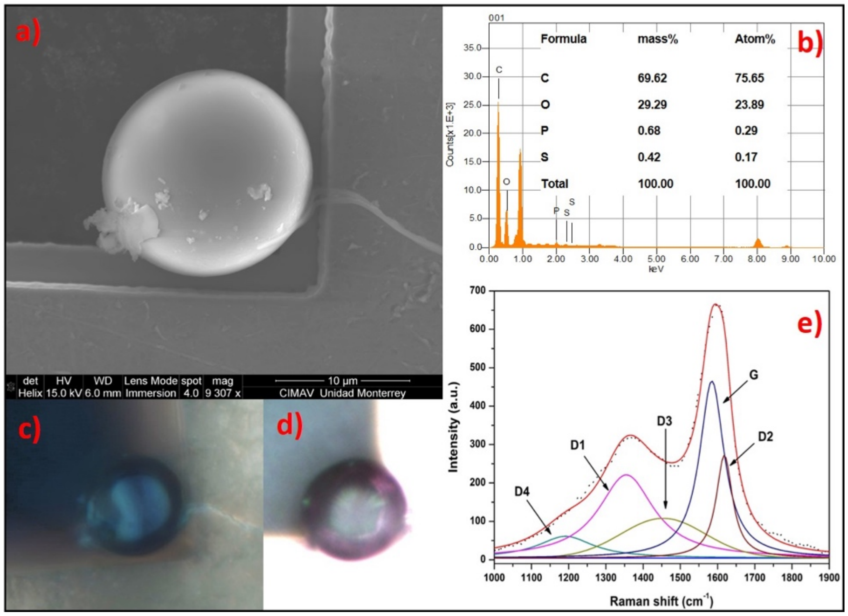

Figure 1. SCM of a C-rich particle. (a) SEM image, (b) EDS analysis, (c) PLM micrograph with light polarized, (d) optical micrograph, and (e) Raman spectrum.

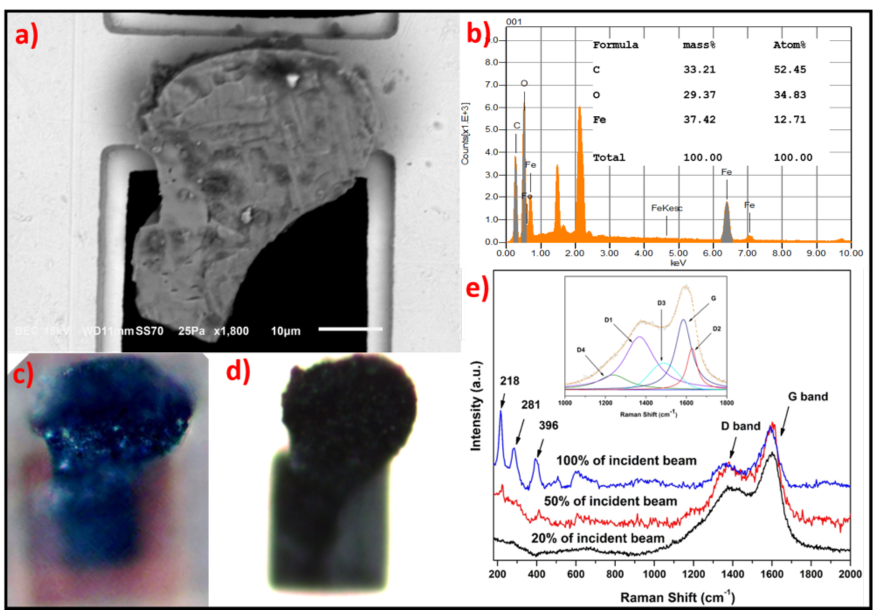

Figure 2. SCM of a Fe-rich particle. (a) SEM image, (b) EDS analysis, (c) PLM micrograph with light polarized, (d) optical micrograph, and (e) Raman spectra.

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