

Role of the ionic and carbonaceous fractions in aerosol conductivity

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Particles deposited on electronics can be a potential source of failure for electronic equipment. In particular, they can cause corrosion, mechanical effects such as overheating and electrical bridging between components that would normally be electrically insulated in a printed circuit (Dai *et al.*, 2012). Hygroscopic dust is believed to be the major responsible of electrical bridging caused by deposited aerosol particles, because ionic components spontaneously pass in solution when their DRH (Deliquescence Relative Humidity) is exceeded (Comizzoli *et al.*, 1986; Tencer, 2008). In this work the synergy between ionic components and other common atmospheric aerosol conductive species, such as elemental carbon, in electrical bridges formation has been investigated.

An electrical conductivity method (Ferrero *et al.*, 2014) in an Aerosol Exposure Chamber (AEC) was used to measure the hygroscopicity of 56 PM_{2.5} samples from the urban site of Milan 'Torre Sarca' (MI-TS) and the rural site of 'Oasi Le Bine' (OB), both in northern Italy. Moreover, atmospherically relevant pure saline aerosol samples were generated in the laboratory with an Aerosol Generator ATM 220 (Topas), together with mixed saline and soot aerosol samples. Soot was obtained with an acetylene non-premixed diffusion flame. All the environmental and generated samples were deposited on PTFE filters and they were exposed to humidification-dehumidification cycles (from 30 to 90% RH and again down to 30%, 1% steps, DMA672 LSI-Lastem probe). The electrical response of samples was measured at each RH step (3421A D.A.U., Hewlett-Packard; 0-30.1 MΩ measured resistance range). The inorganic ionic content of environmental PM_{2.5} samples was quantified with ion chromatography (anions: F⁻, Cl⁻, NO₃⁻, SO₄²⁻, AS14A-5µm column, Dionex; cations: Na⁺, NH₄⁺, K⁺, Ca²⁺, Mg²⁺, CS12A-5µm column, Dionex). Elemental Carbon (EC) and Organic Carbon (OC) content was derived by previously determined average seasonal percentages for both sites (Perrone *et al.*, 2013).

36% of the environmental PM_{2.5} samples showed no electrical response. Therefore their surficial mass loading as well as their chemical composition was considered in order to explain this behavior (Table 1). Unexpectedly, the detected samples had a lower ionic content (35.3±2.1% on average on the overall mass) than the not detected ones (43.7±2.6%), even if their total PM_{2.5} masses were quite higher (199.3±8.6 and 128.4±5.9 µg/cm² respectively). Therefore, the prospect that the presence of ionic hygroscopic compounds is not the only necessary factor to determine aerosol conductivity was investigated. The dataset was split in MI-TS and OB samples. Only 25% of OB samples

showed an electrical conductivity response (3 out of 12), while this percentage was 75% for MI-TS samples (33 out of 44), even if the two subsets of samples have very overall similar PM_{2.5} mean masses and similar ionic content. This result can be explained comparing the different surficial EC distributions (Figure 1): the poor estimated EC content for rural samples is responsible for the different results obtained for the two sampling sites.

Laboratory generated samples provided further proof that a synergy between the ionic components and EC need to be established in order to detect aerosol conductivity. In effect, none of the pure saline samples showed any conductivity response even if their surficial loading (116.584 - 857.716 µg/cm²) was comparable much higher than the environmental samples. On the contrary, electrical conductivity curves were measured for all the mixed saline and soot samples.

		PM _{2.5} (µg/cm ²)	Ionic fraction (%)
Detected samples	Mean	199.3	35.3%
	<i>S_{mean}</i>	8.6	2.1%
Not detected samples	Mean	128.4	43.7%
	<i>S_{mean}</i>	5.9	2.6%

Table 1: PM_{2.5} surficial loading on filter and ionic fraction percentages for detected (electrically conductive) and not detected samples.

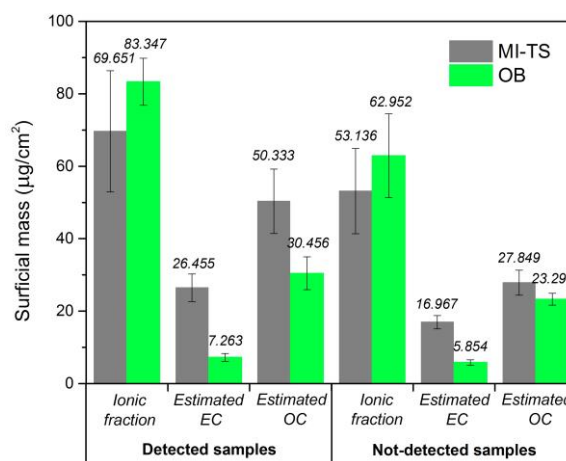


Figure 1. Surficial mass on filter of the ionic fraction, EC and OC for detected and not detected samples (MI-TS: urban site, OB: rural site).

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