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Low molecular weight dicarboxylic acids in background atmospheric aerosol

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1. Introduction

Dicarboxylic acids, ubiquitous in the troposphere, are important organics resulting from the marine pathway, fossil fuel and biomass burning, cooking, forest biosources and anthropogenic emissions. Low molecular weight dicarboxylic acids (low-M_w DCAs) are late products in the photochemistry of hydrocarbons. In this paper, in addition to water-soluble inorganic composition, the presence and characteristics of low-M_w DCA in background atmospheric aerosol in Taiwan are investigated.

2. Experimental

Background atmospheric $PM_{2.5}$ aerosol was collected in Ali Mountain in central Taiwan on 7 and 25 September 2005 using a Versatile Air Pollutant Sampler (VAPS, URG-3000K) with a calibrated flow of 15.0±0.1 L min^{-1}. The low-M_w DCA and water-soluble inorganic ionic concentrations of the aqueous extracts were determined by ion chromatography (IC, Dionex). Laboratory and field samples were analyzed by a slightly modified version of the method of Hsieh et al (2007).

3. Results and discussion

The results (Table 1) show that oxalic acid was the most abundant low-M_w DCA, followed by succinic acid and malonic acid and that their concentrations in a background location were less than in a polluted one. These three DCAs comprised >85 % of the total diacid concentration (260 ng m^{-3}), with oxalic acid alone comprising 57 % of the total. They also comprised 0.959 % of the $PM_{2.5}$ aerosol mass, of which tartaric acid was the most minor species (0.05 % of $PM_{2.5}$ mass) and sulfate was the major species (15.1 % of $PM_{2.5}$ mass). Indeed, concentration of SO_4^{2-} in background atmospheric aerosol reached roughly 15.8 times that of oxalic acid.

The mass concentration ratio of malonic acid / succinic acid (M:S mass ratio) of 0.3-0.5 indicates an overwhelming contribution from a traffic emissions origin for these dicarboxylic acids whereas a ratio > 1.0 indicates an origin from photochemical reactions associated with elevated concentrations of oxidants and therefore a sourcing from secondary reactions. The M:S mass ratio in this background study was 0.44 (Table 1), indicating that the background mountain aerosol was probably affected by long-distance primary vehicle exhaust. Typical backward trajectories for air parcels that affected this aerosol (Fig. 1) supported this, showing that air passing through significant sources of urban vehicular exhaust – Taipei (with a population of approximately 4.2 million) and Taichung (with a population of approximately 1.5 million) – subsequently travelled to the site of background aerosol collection.

Table 1. Mean sulfate and low-M_w DCAs of background atmospheric $PM_{2.5}$ aerosol

Species	Mean		SD	Ratio
$PM_{2.5}$ mass (μg m^{-3})	15.34		5.57	
Sulfate (μg m^{-3})	2.32	(15.1 %)[a]	1.23	
Succinic acid (ng m^{-3})	52.86	(0.345%)	16.24	
Malonic acid (ng m^{-3})	23.25	(0.152%)	5.51	
Maleic acid (ng m^{-3})	14.76	(0.096%)	5.63	
Tartaric acid (ng m^{-3})	7.51	(0.049%)	3.08	
Malic acid (ng m^{-3})	14.75	(0.096%)	7.25	
Oxalic acid (ng m^{-3})	147.1	(0.959%)	39.8	
Sulfate/Oxalic acid				15.77
Malonic acid/Succinic acid				0.44

a. Estimated av. % by $PM_{2.5}$ mass

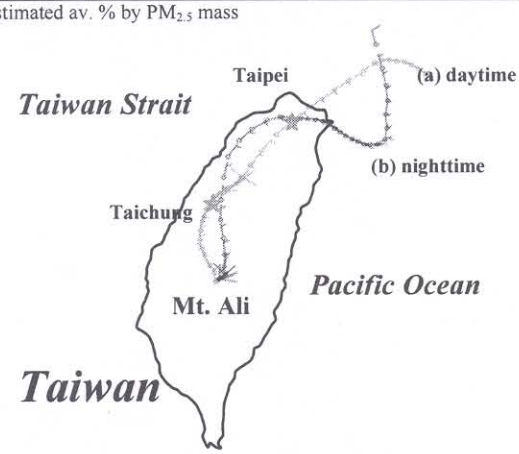

Figure 1. Backward trajectories for air parcels that affected the Mt. Ali. (a) daytime; (b) nighttime.

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References

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