The influence of chemical composition on the hygroscopic properties of particulate matter ($PM_{2.5}$) collected in Metro Manila, Philippines

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ABSTRACT

Aerosol hygroscopicity or the ability of suspended particles to absorb and release water to and from the atmosphere, has been known to have direct impact on atmospheric visibility, cloud formation and aerosol radiative forcing. Humidified particles have greater effects than their dry counterparts. This study involved the determination of hygroscopic growth of water-soluble components of $PM_{2.5}$ and investigated the correlation with aerosol chemistry.

Samples were collected in roadside of Katipunan Avenue, Quezon City, defined as Quezon City road side (QCRS) in this study. Growth factors were measured using the humidified tandem differential mobility analyzer (HTDMA) with an initial particle diameter of 100 nm which were then exposed at increasing relative humidity (5%-90%). The measured growth factor at 85% RH ranged from 1.23 to 1.37 (mean: 1.28 $\pm$ 0.05) and at 90% RH, growth ranged from 1.33 to 1.58 (mean: 1.42 $\pm$ 0.07) which were, expectedly, lower than sea water (2.1) and pure NaCl (2.42). Hygroscopicity parameter (kappa) which relates particle growth to cloud condensation nuclei (CCN) activity measured 0.16 to 0.30 at 90% RH (mean: 0.21 $\pm$ 0.05) which conforms to the characteristic of a multi-component atmospheric particulate matter ($0.1 < \kappa < 0.9$). Results were compared with Quezon City urban background site sample (QCUBS) where mean g(85%) was measured as 1.28 $\pm$ 0.04 and mean kappa was computed as 0.23 $\pm$ 0.05 at 90%. Comparison between sites showed no significant difference in both hygroscopic growth and kappa values at α=0.05. To assess the link between aerosol hygroscopicity and chemistry, correlation analyses were performed between growth factors and (a) ion concentrations, (b) mass fractions and (c) reconstructed salt concentrations. Results showed consistent association of the former with [Cl^-] (0.65), Cl^- mass fraction (0.54), and NaCl, (0.64), respectively.

Since Cl^-/Na^+ ratio of sample ranged from 0.04 to 0.60 (mean: 0.27 $\pm$ 0.03) which is much lower than Cl^-/Na^+ ratio for seawater (1.18), NaCl possibly underwent acid displacement process that have depleted available chlorine in the atmosphere which resulted to lower Cl^-/Na^+ molar ratio and reduced particle growth. The decline in g(85%) due to chloride depletion via acid displacement was further supported with the positive correlations between g(85%) and Cl^-/SO_4^{2-} (0.50) and Cl^-/NO_3^- (0.54) which favored the formation of lesser hygroscopic salts, Na_2SO_4 or $NaNO_3$, respectively. Positive correlation was also found between g(85%) and Cl^-/WSOC (0.65) which indicates further suppression

of growth by WSOC. It can be concluded that hygroscopic growth of particles was mainly affected by Cl^- concentration but atmospheric processes that led to chloride depletion as well as presence of WSOC suppressed the growth of particles.

Growth factors obtained in this study can provide useful information to accurately model climate simulations and improve estimates on visibility degradation and aerosol radiative forcing as most models and calculations generally simplify hygroscopic properties of particles to unity and do not account for the effect of relative humidity.