Aerosol hygroscopicity as the function of the size and the chemical composition

K. Imre[1], A. Molnár[2] and D. Benkő[1]

[1]Department of Earth and Environmental Sciences, University of Pannonia, Egyetem 10, 8200, Veszprém, Hungary
[2]Air Chemistry Group, Hungarian Academy of Sciences, Egyetem 10, 8200, Veszprém, Hungary

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The hygroscopic behavior of the particles is determined by the inorganic as well as by the organic species. Although the organic fraction of the aerosol particles is rather high, our knowledge on their role in aerosol hygroscopicity is limited. The aim of this work is to study the hygroscopic growth of the particles as the function of their size and chemical composition, and to estimate the effect of organic compounds on the aerosol hygroscopicity.

In summer of 2001 and 2002, 13 size-selected ambient aerosol samples were taken at K-puszta station, Hungary. The sampling site is located on a forest clearing on the Great Hungarian Plain. The air was sampled by a 9-stage Berner impactor. Gravimetric method was applied for the determination of the aerosol particle mass under different relative humidities. The relative humidity was controlled by saturated solutions of different inorganic salts. Finally, the samples were chemically analyzed; the concentrations of inorganic ions and total carbon were measured.

Beside measured mass growth, on the basis of the inorganic composition of the aerosol, the mass growth of the particles in different size ranges were calculated by means of Aerosol Inorganic Model (AIM) (Clegg *et al.*, 1998): Then, the measured and calculated mass growth factors were transformed to diameter growth factors considering volume mixing rule for dry particle mass and absorbed water mass.

Particle growth *G(RH)* is generally estimated as the function of relative humidity (*RH*) (Zhou *et al.*, 2001):

$$G(RH) = 10^c \cdot \left(\frac{1-RH}{100}\right)^{-\gamma}$$

Table 1: γ exponents in different particle sizes for both measured and calculated data sets.

Geometric particle diameter (μm)	γ exponent measured	calculated
0.088	0.185	0.273
0.18	0.096	0.164
0.35	0.078	0.206
0.71	0.182	0.268
1.4	0.178	0.205
2.8	0.201	0.192
5.7	0.196	0.092
11.3	0.147	0.140

The growth rate is mostly governed by γ, since 10^c varies around 1. In Table 1 the summary of fitted γ exponents are given for both the measured and for the calculated data sets. The results show that the particle growth (γ exponent) strongly depends on the particle size. One can suppose that γ is mainly controlled by the chemical composition of the particles. We assumed that the measured γ exponent (γ_m) – the growth factor (G) – can be estimated by the inorganic ion and the total carbon concentrations of the aerosol particles. We considered that the hygroscopic behavior of the inorganic compounds is well estimated by the AIM model, i.e. the hygroscopic effect of inorganic ions is correctly described by the "calculated" γ exponent (γ_c). On the other hand we also supposed that the hygroscopic effect of carbonaceous compounds can be estimated by the TC concentration. As a first approximation, linear function of two variables is considered:

$$\gamma_m = m_1 \cdot \gamma_c + m_2 \cdot TC + b$$

The calculation is based on multilinear approach, where parameter "b" could be interpreted as the hygroscopic effect of other constituents which are not determined. The results for fine and coarse mode aerosol show statistically significant relationship among the parameters considered:

Fine mode: $\gamma_m = 0.78 \cdot \gamma_c + 0.07 \cdot TC - 0.01$

Coarse mode: $\gamma_m = 0.58 \cdot \gamma_c + 0.12 \cdot TC - 0.13$

The results indicate that in the fine mode γ_m can be estimated by the inorganic and the total carbon concentrations, since the unknown constituents ("b") do not play important role (<10%) in the control of γ_m. On the other hand, for coarse mode aerosol same conclusion cannot be drawn because of the high contribution of non-defined compounds (the share of "b" is > 70%).

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