LABORATORY INVESTIGATION OF THE EFFECT OF WATER AND SULPHURIC ACID VAPOUR ON THE FORMATION AND GROWTH OF IODINE OXIDE NANOPARTICLES IN THE ATMOSPHERE

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Introduction

Recent studies have shown that new particle formation via a secondary gas-to-particle process at coastal regions (see review articles of Kolb, 2002 and von Glasow, 2005) originates from biogenic emissions (Carpenter, 2003) of iodine-containing vapours such as CH$_2$I$_2$ and I$_2$. These species undergo rapid photo-chemical reactions to produce condensable iodine oxides which, in turn lead to the nucleation and growth of new particles (O'Dowd and Hoffmann, 2005).

These particles may be ubiquitous in the Earth’s atmosphere if open ocean sources are also significant. They may influence the global radiation budget directly i.e. they can scatter and absorb solar radiation to some extent and may therefore affect climate. In terms of an indirect effect, a significant fraction of these particles have the potential to grow into cloud condensation nuclei (CCN). Changes in the number concentration of CCN may affect the number concentration and size of cloud droplets, and therefore the optical properties and the lifetime of clouds (Curtius, 2006).

Despite the recent studies, uncertainty still remains regarding the composition of newly formed particles from photo-oxidation of iodine-containing species. According to Saunders & Plane (2005), the most likely composition of particles is I$_2$O$_5$ while studies of particle formation from photolysis of CH$_2$I$_2$ (Jimenez et al., 2002; O’Dowd and Hoffmann, 2005) have suggested the I$_2$O$_4$ form. However, a thorough knowledge of atmospheric particle composition and properties requires a description of how they interact with other gases (H$_2$O and H$_2$SO$_4$ in particular) in the marine boundary layer (MBL).

To achieve this, we have carried out additional laboratory studies to investigate the following aspects of iodine oxide particle growth;

- Vapour pressure (water activity) measurement of aqueous I$_2$O$_5$ solutions
- Deliquescence of I$_2$O$_5$ particles
- Hygroscopic growth of dry particles
- Uptake of H$_2$SO$_4$ vapour and subsequent growth of particles

The vapour pressure measurements were performed on a number of prepared solutions, using an AquaLab water activity meter: Series 3TE at the University of Manchester, whilst particle deliquescence was studied using a set-up designed and constructed in our laboratory in Leeds.
Hygroscopic growth and acid uptake behaviour were studied using a modified version of an aerosol-generation system used in previous studies here. In these experiments, particles can be generated in both dry and humidified conditions in a flow cell and H₂O or H₂SO₄ vapours added downstream in a secondary cell in order to study the effects on the detected particle size distributions. An electrical mobility spectrometer (EMS), comprising a differential mobility analyser (DMA) and Faraday cup electrometer (FCE), was employed to detect particles of sizes from ~ 0.8 nm up to 40 nm and study the effects of vapour uptake at the earliest detectable stages of particle growth.

In this paper, we will communicate in detail the results of these various experiments and discuss the likely implications for the presence of such particles in the MBL.

References


