Diurnal variation of small and large ion concentrations in an urban location

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A Neutral cluster and Air Ion Spectrometer (NAIS) was used to monitor the concentration of airborne ions on 258 full days between Nov 2011 and Dec 2012 in Brisbane, Australia. The air was sampled from outside a window on the sixth floor of a building close to the city centre, approximately 100 m away from a busy freeway. The NAIS detects all ions and charged particles smaller than 42 nm. It was operated in a 4 min measurement cycle, with ion data recorded at 10 s intervals over 2 min during each cycle. The data were analysed to derive the diurnal variation of small, large and total ion concentrations in the environment. We adapt the definition of Horrak et al (2000) and classify small ions as molecular clusters smaller than 1.6 nm and large ions as charged particles larger than this size.

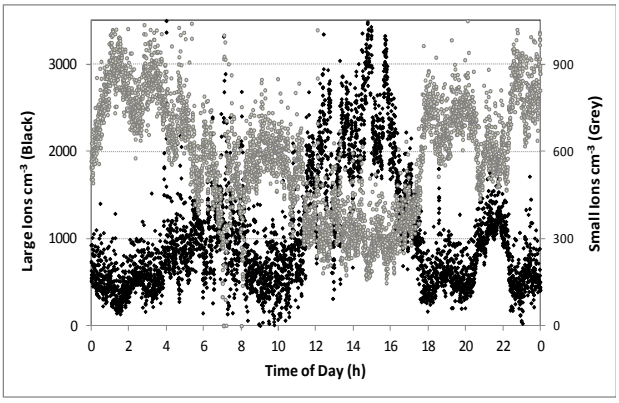

Figure 1: Diurnal variation of large and small ion concentrations on 3 February 2012 in Brisbane.

Fig 1 shows the large and small ion concentrations on a typical day. The large ion concentration generally peaked during the middle of the day, especially when there was secondary particle formation due to nucleation of organic precursors from motor vehicle emissions. On this day, a condensation particle counter showed a particle number concentration (PNC) of about 2 x 10^4 cm^{-3} between 12h and 14h. It is well known that small ions rapidly attach to particles in the air. There is an apparent negative correlation between the large and small ion concentrations in Fig 1. The maximum small ion and minimum large ion concentrations generally occurred between midnight and 4 am when the air was relatively clean (PNC of about $3x10^3$ cm^{-3}), while the maximum large ion and minimum small ion concentrations were observed soon after mid day when the PNC was a maximum (1-$3x10^4$ cm^{-3}).

Fig 2 shows the mean hourly total ion concentrations over the entire measurement period. The error bars show the corresponding standard deviations. The total ion concentration was fairly constant between $1x10^3$ and $2x10^3$ cm^{-3} right through the night and showed maximum concentrations of between $3x10^3$ and $4x10^3$ cm^{-3} shortly after mid day.

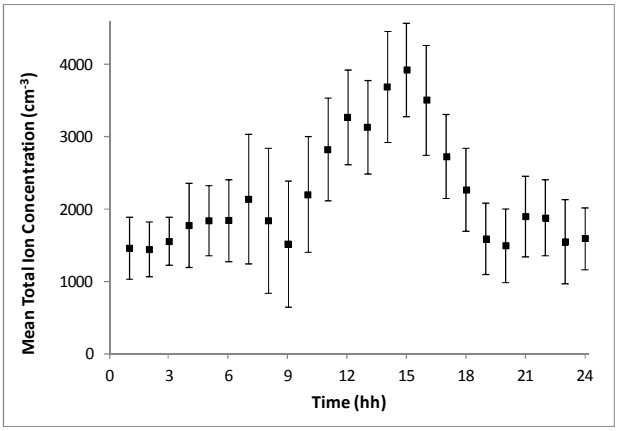

Figure 2: Mean hourly values of the total ion concentration with standard deviations.

The health effects of ions and charged particles are still largely unknown. Some studies have shown that, during inhalation, charged particles are more likely to be deposited in the human lungs than similarly sized uncharged particles (Cohen et al, 1998). While there have been several reports of small ion concentrations in urban environments (Retalis et al, 2009, Ling et al, 2010), there have not been many similar studies dealing with large ions and charged particles (Hirssiko et al, 2007, 2011). We believe that this is the first study of charged particles in an urban environment in the Southern Hemisphere.

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