

Atmospheric particles above the North Sea: new insights using recent technology

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Electron microscopy, combined with electron-induced X-ray spectrometry, is a fast and powerful technique to analyse huge numbers of individual microparticles. Recent developments in X-ray detector technology now have made it possible to detect the signals from elements with low atomic numbers. The determination of these light elements, such as carbon, nitrogen and oxygen, in atmospheric aerosol particles is important to study the chemical behaviour of atmospheric pollution. E.g. the majority of marine nutrients are nitrogen-rich materials: their atmospheric deposition to the sea and the knowledge of their distribution in atmospheric particles could enhance our knowledge on eutrophication and algal bloom. The semi-quantitative determination of light and heavier elements in individual atmospheric particles could give additional and useful chemical information to marine aerosol studies. Their concentrations not only give us molecular information (speciation), but could also result in an enhanced knowledge on their reactivity and transport in the air (going to or coming from the sea).

The electron probe microanalyzer (EPMA) in our research facility has been equipped with a new thin-window detector, which can detect elements starting from carbon (atomic number $Z > 5$). A quantification method based on reverse Monte Carlo calculations, combined with iterative simulations, has been developed in our group. This method was standardised and tested earlier by measurements on single particles with known chemical compositions. The shape and size of the particles, which are important for the simulations, were determined using high-magnification secondary electron images. Elemental concentrations were afterwards calculated, combining the obtained morphological properties with the X-ray spectra taken from each individual particle.

Special care was also taken of beam-sensitive particles, such as ammonium-sulphate and ammonium-nitrate, which were analysed using a liquid-nitrogen-cooled sample stage. These types of particles are very volatile and their structure is unstable under vacuum conditions or electron bombardment, causing evaporation of the irradiated particles. Cooling down the samples with liquid nitrogen drastically reduces the beam damage effect which also opens up new perspectives on the study of volatile particles.

Individual marine aerosol particles collected using a nine-stage Berner cascade impactor were analysed with thin-window EPMA, after which our new quantification method was applied to study the light element content of the particles. Five sets of marine aerosol samples were collected over the North Sea during a cruise of the Belgian oceanographic research vessel Belgica. One aerosol sample was also collected at the Belgian coast at Blankenberge, around 8m above sea level. Preliminary results on these samples (about 5000 particles) show that the new concentration calculation method can be used to study e.g. the

modification of sea-salt particles in the troposphere. For obtaining information on the possible sources of the aerosol and the possible chemical interactions between gaseous and particulate pollutants, the particles were classified into representative groups using the chemical and morphological data obtained with EPMA. The semi-quantitative knowledge of light element concentrations leads to a more relevant particle classification; therefore the possible sources and interactions occurring in the troposphere can be traced by analysis of large numbers of individual particles.