REAL-TIME MEASUMENT OF THE MASS AND COMPOSITION OF PARTICLES

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Over the past decade, aerosol science has strived to characterize smaller and smaller particles while the field of mass spectrometry has strived to characterize larger and larger molecules. We will discuss how to merge the two disciplines using a quadrupole mass spectrometer with an essentially infinite mass range.

The mass limit of most mass spectrometers is currently under 100kDa. In terms of aerosols, this mass limit corresponds to particles less than 7nm in diameter. To move quadrupole MS beyond this limit three main problems must be overcome. (1) Particles acquire an enormous amount of kinetic energy, when transferred into vacuum, that must be reduced before trapping or mass analysis can be preformed. (2) A technique to detect such massive ions must be developed. (3) The quadrupole's frequency must be rapidly switched or scanned in order to effectively cover the entire mass range of particles/ions from 0.1nm to 10μm. We have solved these problems and are developing a mass spectrometer that will open new frontiers in mass spectrometry and be capable of real-time particle mass analysis.

The problems outlined above are being solved using the following methods: (1) A reverse jet of gas is being used to reduce the kinetic energy of a collimated particle beam. The same forces that first accelerated the particles are used by the reverse jet to slow them down again thus effectively slowing all masses simultaneously. (2) The quadrupoles used for mass analysis are driven with square waves (digitally) using pulse generators whose frequency can be rapidly switched or scanned to generate an optimal well-depth for any mass range. (3) Detection of the charged species is accomplished by pyrolytic vaporization and electron impact ionization of the evolving vapor with subsequent detection with a channeltron electron multiplier.

After experimentally confirming that the reverse jet slows incoming charged particles, the pyrolytic detector system was tested and optimized. Currently, single 41nm latex beads are easily detected. Of course, when used with a quadruple trap many charged species will be pulsed to the detector at once so this detector will be sensitive to much smaller particles. Recently, a linear quadrupole was used to control the transmission of particles. With this enabling technology in place, a complete mass spectrometer is currently being evaluated and its performance will be presented.

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