Cambustion

M²AS

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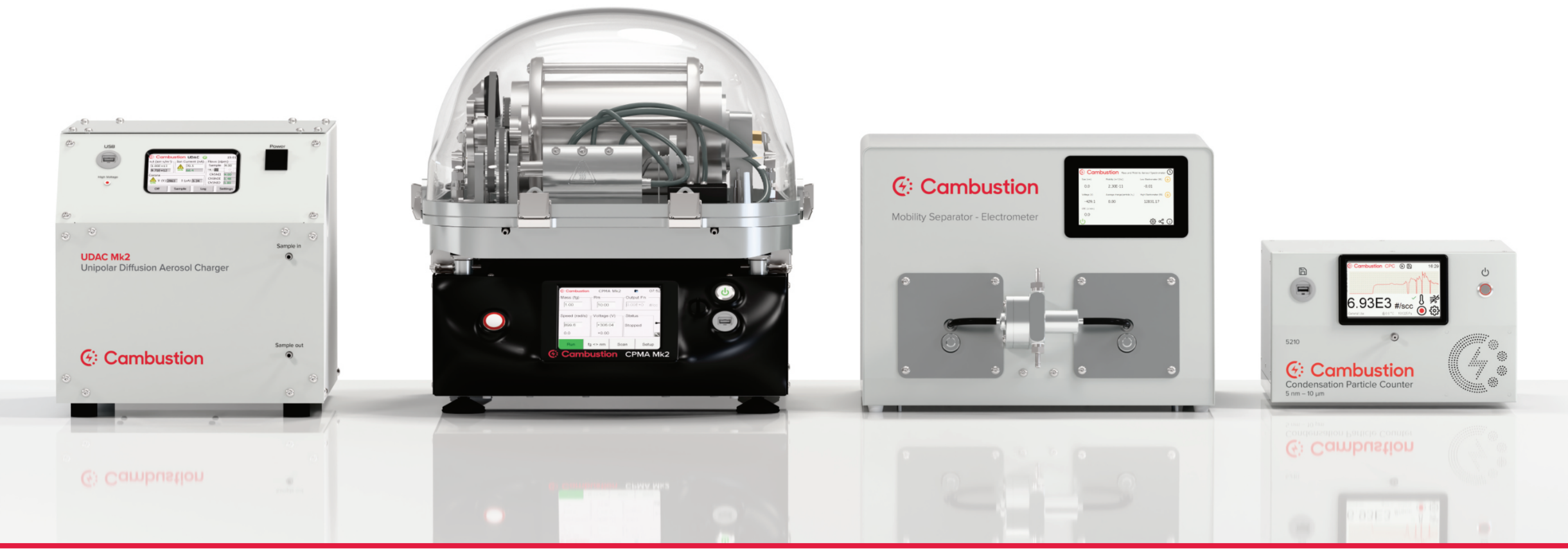
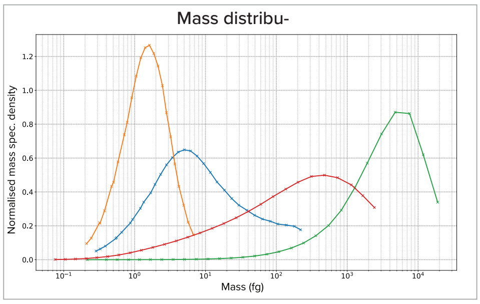
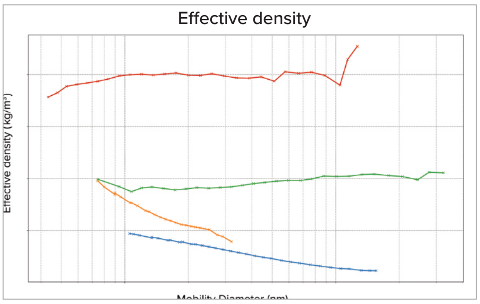
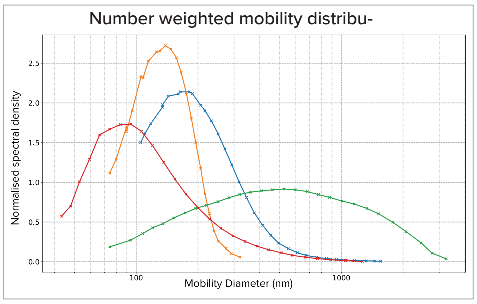


Aerosol mass, mobility and density distributions

The M²AS combines existing UDAC, CPMA and CPC instruments with a novel Mobility Separator. In a single scan, the M²AS measures particle mass, mobility diameter, charge state and concentration over a wide measurement range of ~50nm - 3µm.



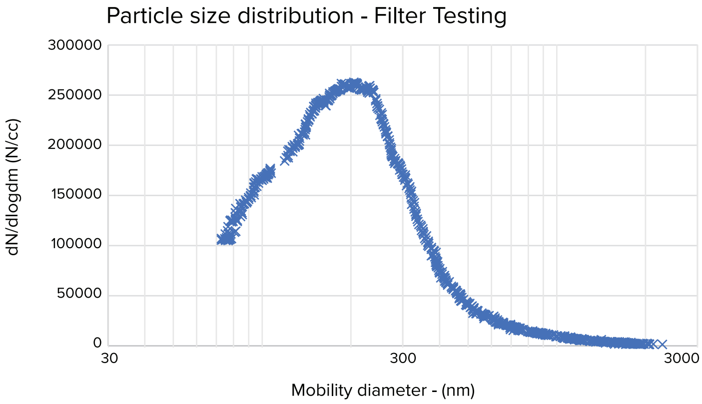




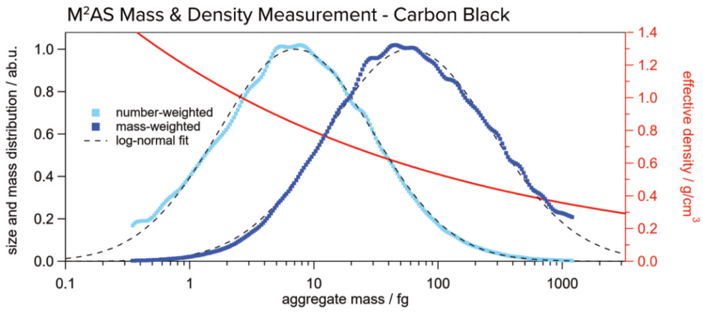
For measurements of:

Technique Video - Mass & Mobility Aerosol Spectrometer:

- Aerosol mass and number concentration
- Aerosol particle density
- Mobility Diameter
- Fractal dimension / mass - mobility exponent
- Spherical particles
- Combustion agglomerates
- Nanomaterial characterisation
- Carbon Black & flame pyrolysis production



The interaction between aerosols and filter materials, particularly the initial formation of a cake layer, is strongly dependent on the large particle tail of the size distribution. This is often difficult to resolve with conventional instruments due to multiple charging issues. The M^{2}AS measures beyond 1 micron with explicit correction for the particle charge.



By dispersing powders and nanomaterials into the aerosol phase, they can then be measured by the M^{2}AS. Particle mass and the distribution of this mass across the particle sizes is the best metric for determining the effect of particle size on the material performance.

Typically these materials have complex morphologies

Cambustion CPMA

Centrifugal Particle Mass Analyser

The Cambustion CPMA selects particles of a desired mass : charge ratio by balancing centrifugal and electrical forces in a spinning annular classifier with an applied electric field.

The CPMA is used for a wide range of particle mass experiments and as a calibration standard for other instruments.

The standard method for determining sub-micron particle mass and density uses the CPMA in combination with a DMA and CPC but this requires a long experiment with a DMA scan at each CPMA setpoint. The M^{2}AS extends this measurement to larger size ranges (approximately 3 micron, depending on density) and makes the size, mass and density measurement in a single scan.

Cambustion UDAC

Unipolar Diffusion Aerosol Charger

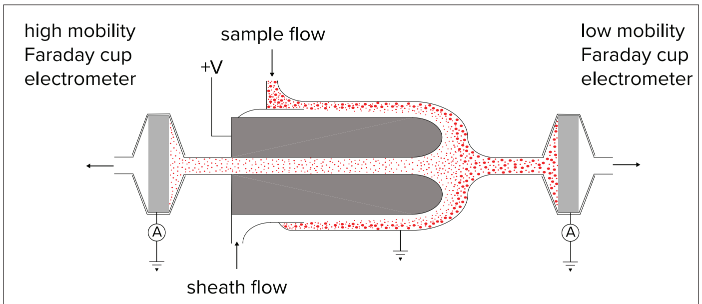
The UDAC uses a corona discharge to apply a particle charge by a unipolar diffusion charging process. The charging chamber incorporates sheath flows and an AC charging field to provide high levels of charge with minimum particle losses.

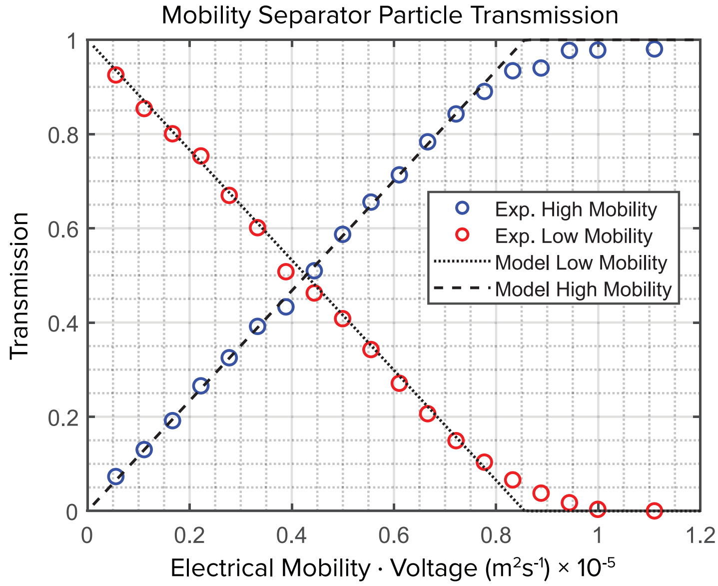
It can be used in a range of experiments and is used alongside the CPMA as a particle mass standard for the calibration of other instruments.

For the M^{2}AS application, the UDAC has been further optimised and can now achieve an ion density - residence time product of 10^{14} ions s·m^{-3}, far exceeding other instruments of this type.

Mobility Separator

The mobility separator is a new instrument for real-time measurement of the electrical mobility of a monodisperse aerosol. Used downstream of a classifier selecting particles by mass : charge ratio, this allows calculation of the particle mobility diameter and thus effective density, and allows calculation of the full classifier transfer function which is often dependent on the particle mobility.

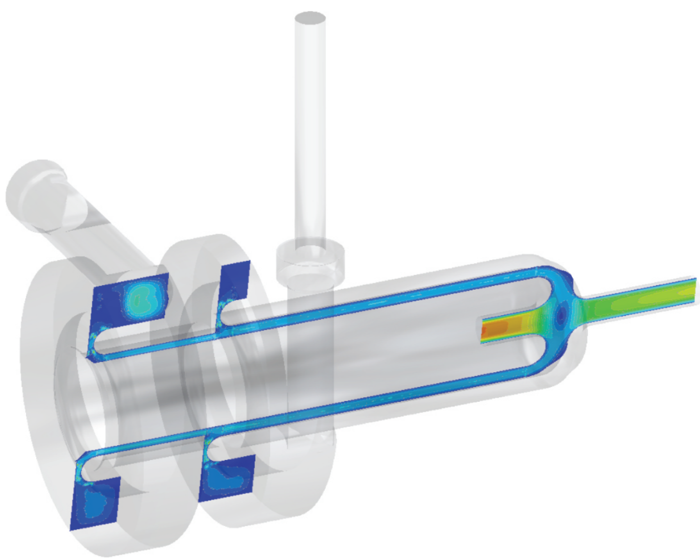




The mobility separator consists of an annular flow channel with a centre electrode, two concentric inlets and two outlets, and two outlets which effectively split the flow in concentric streams. Particles introduced in the sample flow inlet flow to the ‘low mobility’ outlet unless dragged across by the electric field into the ‘high mobility’ outlet. Each outlet feeds an integrated aerosol electrometer.

This is similar to a Differential Mobility Analyser but operating at a very low equivalent resolution and measuring both the particles in the normal monodisperse outlet and the sheath excess outlet. In this way, particles with higher electrical mobility are predominantly detected in one outlet and higher mobility particles predominantly in the other. Particles of an intermediate mobility are detected in both outlets in a ratio dependent on the mobility. The voltage required to maintain this ratio gives a continuous and highly linear measurement of average particle electrical mobility.

The mobility separator communicates with a range of Condensation Particle Counters from various manufacturers. This allows it to calculate the average charge per particle from the ratio of the sum of the aerosol electrometer signals and the particle count concentration. It thus calculates the particle mechanical mobility and hence mobility diameter.



Why Mass?

Various techniques are used for measuring the 'size' of micron-sized aerosol particles. Mobility analysis with an SMPS measures particle drag; optical techniques measure the propensity of a particle to scatter or absorb light; inertial techniques measure the drag : mass ratio. These techniques result in measurements of diameter which differ according to the shape, density or optical properties of the particle and so 'diameter' is difficult to define, especially for non-spherical particles.

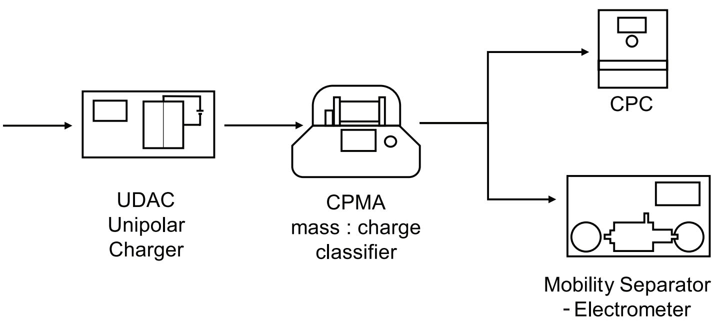
By contrast, mass is a rigorously defined metric, not dependent on the measurement technique. In many cases, such as doses for health effects, or nanomaterial production, the particle mass is also the most important attribute of the aerosol.

The M²AS is the first system which can measure the particle mass distribution simply with a single scan.

How the M²AS Works

The CPMA classifier is the heart of the M²AS system. It selects particles within a narrow range of mass : charge ratios. This is the key component in a system to scan the mass distribution of particles: we simply need to know the particle charge. In existing techniques particle charge is typically assumed from a model, but this introduces errors and this is even more difficult for a mass measurement than for mobility derived from electrical mobility, because the particle density is an additional uncertainty in the relationship between the classifier setpoint and particle charge.

In the M²AS, the particle charge is explicitly measured by taking the ratio of a CPC concentration measurement and the measurement of total charge in an aerosol electrometer. The measurement is therefore valid even for non-spherical aerosols where the particle morphology affects the charging behaviour.

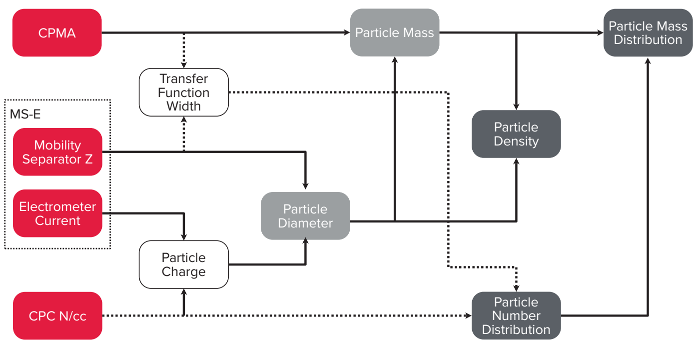


The M²AS furthermore addresses the practical difficulty caused by uncharged particle penetration in the CPMA: small uncharged particles can pass through the classifier and thus be confused with those of the desired mass. In the M²AS, strong unipolar charging is used so that practically all particles larger than around 20 nm are charged — uncharged particles smaller than this can be ignored by adjusting the diameter detection limit of the particle counter. This is made possible by the performance of the Cambustion UDAC which has been optimized for use in the M²AS system so it can operate at an unrivalled ion density product of 10^{14} s.m^{-3}.

The use of unipolar charging also ensures a pseudo-continuous charge distribution, required for the mean charge measurement to be meaningful.

The final aspect of the full characterization of the aerosol, is measurement of the electrical mobility without a further scan by the newly developed Mobility Separator. This allows calculation of the mobility diameter effective density giving insights into both the particle material and morphology. It also allows full determination of the CPMA transfer function and thus accurate calculation of total particle concentration.

Mass, mobility, concentration and effective density distributions are therefore measured in a single scan.



The measurable particle size range of the M²AS is approximately 30 nm to 3 microns, dependent on particle density.

Cambustion is an independent, privately owned company with headquarters in Cambridge, UK.

Cambustion continue to research & develop novel instrumentation, and now also offer Measurement Consultancy; helping our global clients to solve a wide range of particle and gas measurement issues.

Cambustion

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