AOT-100
Aerosol Optical Tweezers
Application Note

Sampling and Analysis of Aerosol Particles using the AOT-100

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In many aerosol sampling and analysis projects the target particles are likely to be small (<1µm diameter), non-spherical, solid and opaque. The interest in such particles often relates to the fact that they act as nucleation sites for water condensation and can then be subject to heterogeneous chemical reactions with the gases and vapours in which they are suspended. The Aerosol Optical Tweezers (AOT) technique, which can trap a particle in the focus of a laser beam for indefinite periods, is the ideal tool for the detailed study of such effects under carefully controlled conditions. However, to trap a particle in an AOT it must be relatively large (5µm - 20µm diameter), be spherical and be transparent to the light being used to trap it. Most often it is a liquid droplet and these have been extensively studied using the technique, particularly in fields such as hygroscopicity and heterogeneous chemistry. Recently however it has been recognised that the trapping requirements apply only to the primary particle and so a trapped droplet can act as a collection volume for smaller particles that could not be trapped directly. It has been demonstrated that collecting such particles does not cause the droplet to be lost from the trap. The Cavity Enhanced Raman Spectroscopy (CERS) and optical microscopy techniques, developed for droplet analysis, can then be used to measure and monitor the parameters of the particles during the collection process. This provides a highly sensitive, time-resolved analysis of the collected particles, together with any chemical reactions they undergo, that could not be obtained by any other technique.

Measurement of the Quantity Collected

Changes in the size of a trapped droplet can be monitored with exceptional sensitivity by using the Whispering Gallery Modes (WGM) in the Cavity Enhanced Raman Spectroscopy (CERS) of the droplet. A change in radius of 2nm can be reliably measured and any changes can be monitored with a time resolution of 1s. This is a simple and robust means of monitoring the volume of all insoluble particles collected by the droplet.

If the particles collected are soluble in the droplet liquid they will cause a change to the refractive index and this can also be measured by the WGM analysis. If the chemical nature of the soluble particles is known this is a sensitive technique for monitoring the quantity collected.

Chemical Analysis of the Collected Material

If the collected particles dissolve in the droplet liquid or react with it then they can potentially be identified either by changes to the refractive index or in the Raman spectrum. Changes caused by a single type of soluble or reactive particle will of course be easiest to quantify but there is potential to find signatures generated by different proportions of reactive particles by challenging the instrument in the laboratory with known mixtures.

If the requirement is to identify and quantify a particular component in a mixed aerosol then it may be possible to develop a specific assay for that component. This could be achieved by adding a reagent to the droplet that reacts specifically with the target component to produce an easily identifiable change to the Raman spectrum. If a suitable reagent can be identified that has a unique reaction with the target particle then this could be the basis of an extremely sensitive assay.

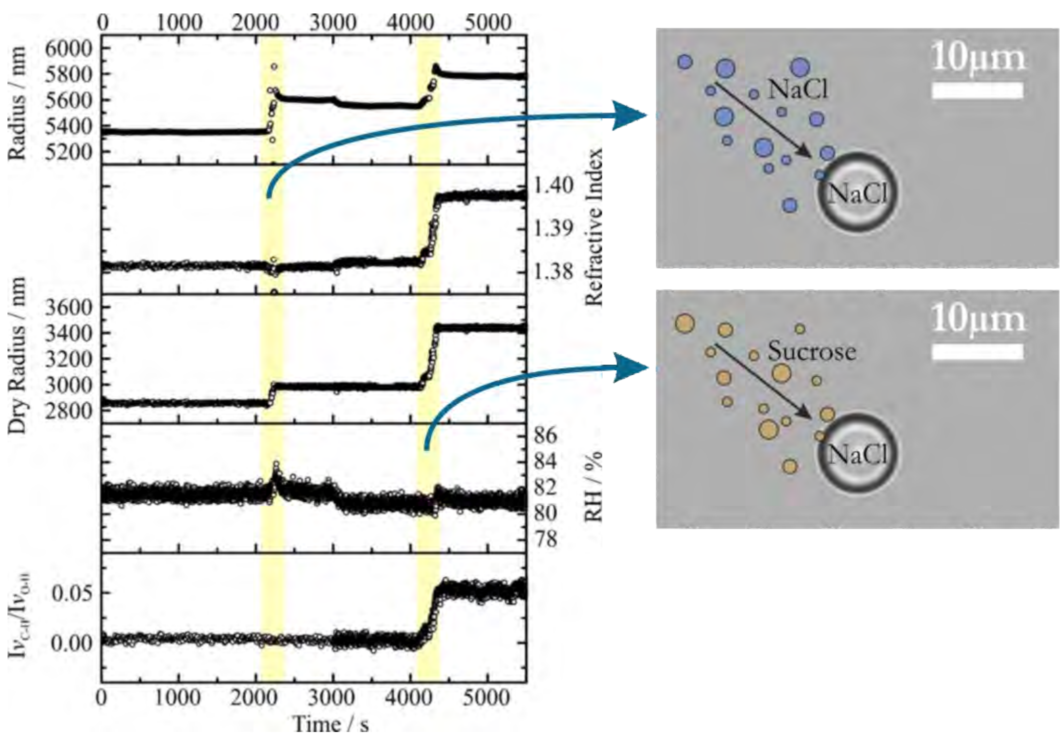
If the collected particle is insoluble in the droplet it will be more difficult to determine its composition. In some cases, such as microorganisms, it may be possible to use the AOT100s microscopy facility to identify the particles, at least generically. Alternatively, if a specific type of particle is being monitored then it may be possible to add a reagent that dissolves or reacts with the surface of the collected particles in a way that is identifiable by the instrument's analysis techniques.

Progress to date

This is a very new field of application for aerosol optical tweezers and only one paper is known to have been published on it (1). However this has generated a great deal of interest from those with highly diverse research objectives. For anyone who would like to explore the feasibility of using this technique in their research Biral is very happy to discuss how best their objectives could be achieved with the instrument.

References:

1 Allan E. Hadrell, Rachael E.H. Miles, Bryan R. Bzdek, Jonathan P. Reid, Rebecca J. Hopkins and Jim S. Walker. Coalescence Sampling and Analysis of Aerosols using Aerosol Optical Tweezers. Anal. Chem. 2017, 89, 2345 – 2352.



About the Author

Don joined Biral in 2005 following his retirement from Dstl, Porton Down where he had been the leader of aerosol science and biological detection research groups. His initial work for Biral involved the development of instruments for biodetection, a field in which Biral was a world leader. Don is now active in the development of the AOT 100, the world's first aerosol optical tweezers instrument and is looking at applications for the AOT 100, as well as researching new opportunities in aerosol characterisation and climate research.