NIMS got talent

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A team of US scientists has shown that a novel form of imaging mass spectrometry (MS) is not only able to analyse both solid and liquid samples, but can even be used to separate the various analytes in those liquid samples. This means that the novel MS technique can perform dual analytic roles: identifying analytes separated by chromatography or electrophoresis, or separating analytes prior to identification by tandem MS or Fourier transform MS.

As their name suggests, imaging MS techniques are able to produce spatial ionisation images of a sample. As such, unlike conventional MS techniques, they are able to work with solid samples rather than just liquid samples.

The most commonly used imaging MS technique is matrix-assisted laser desorption/ionization (MALDI), which involves covering a solid sample with a liquid or solid matrix. Scanning the sample with a laser beam causes the matrix molecules to vibrate rapidly, transforming the individual biomolecules within the sample into ions. A more recently-developed technique is known as desorption electrospray ionization (DESI), which transforms biomolecules into ions by spraying the solid sample with electrically-charged water droplets.

In 2007, scientists led by Gary Siuzdak from the Scripps Research Institute in La Jolla, California, unveiled the latest imaging MS technique. Known as nanostructure initiator MS (NIMS), it involves coating a thin section of biological tissue onto surfaces covered with 10nm-wide nanopores filled with an 'initiator' molecule. So far, Siuzdak and his team have favoured silicon-based surfaces and fluorinated siloxanes as the initiator molecule.

Scanning a laser over the sample rapidly heats the initiator molecules in the pores underneath, vaporising them. This produces a tiny explosion that ionises the biomolecules in the sample above. As a first test of NIMS, Siuzdak and his team showed that it could produce ionisation images of single cells and mouse embryo tissue at higher resolutions than either MALDI or DESI.

They have now gone on to show that NIMS is also more

sensitive, able to detect the antipsychotic drug clozapine in specific areas of a rat brain at lower levels than either MALDI or DESI. At the same time, they have shown that the talents of NIMS extend beyond just imaging solid samples, as it is equally adept at analysing biofluids such as blood or urine.

To analyse biofluids with NIMS, Siuzdak developed a method that involves depositing droplets of the biofluid directly onto the surface with a pipette. The droplets are left for 30-60 seconds, giving molecules in the droplets enough time to adsorb onto the surface, and then sucked up by a pipette or blown off by a stream of nitrogen. The adsorbed molecules are then ionised in the same way as solid samples.

But in studying these adsorbed molecules with NIMS, Siuzdak came upon another unexpected talent: the ability of NIMS to separate the adsorbed molecules via a kind of gradient elution. For Siuzdak discovered that he could ionise more of the adsorb molecules by first extracting them from the surface with a solution of an organic solvent such as methanol. Furthermore, increasing the concentration of the organic solvent caused different molecules to be extracted from the surface and then ionised. In this way, Siuzdak found that he could identify drug molecules such as nicotine and diazepam in samples of urine at levels as low as 50-100ng/mL.

These findings show that NIMS could be placed at either end of an analytical system. 'NIMS could be used in conjunction with chromatography or electrophoresis, and we demonstrated the chromatographic coupling a couple of years ago with another surface-based technology,' Siuzdak told ***separationsNOW***. 'But we really like the on-plate separation; [its] very quick and the results have been quite good.'

Related links:

- ***Analytical Chemistry*, 2009, 81, 2969 - 2975**: "Nanostructure initiator mass spectrometry: tissue imaging and direct biofluid analysis"
- ***Nature*, 2007, 449, 1033 - 1036**: "Clathrate nanostructures for mass spectrometry"

Article by Jon Evans