

Forensic applications of DART-MS: A review of recent literature Executive Summary

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Future Forensics Subcommittee

Review Reference

E. Sisco, T.P. Forbes **Forensic applications of DART-MS: A review of recent literature** *Forensic Chemistry*, 22 (2021) 100294.

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This review article covers applications of direct analysis in real time mass spectrometry (DART-MS) from 2015 – 2020. Also discussed in the article are the fundamentals of DART-MS, approaches for sample analysis, and data analysis trends.

Seized Drug Analysis

- Seized drug analysis is the most widely researched forensic application of DART-MS
- Research has shown DART-MS is capable of detection of nearly all novel psychoactive substances even in the presence of complex matrices, beverages, and plant material
- The use of in-source CID and neutral loss spectra can be leveraged for identification of new NPSs [29]
- Analysis of e-liquids appears to be an emerging area of research, focusing on both commercially available and illicitly made liquids
- Multi-variate statistics have proven useful for the identification of psychoactive plant species
- A number of papers have demonstrated the use of nitrogen as the DART source gas for drug analysis. This may be critical in addressing field-ability and helium conservation concerns. Spectra are, generally, similar though some notable differences are observed.
- The use of thermal desorption (TD)-DART-MS may allow for screening of drug evidence without having to open the packaging [67]

Toxicology

- A relatively small body of work exists for toxicological applications of DART-MS
- Mixed results have been obtained for detection of drugs in biological matrices
- The use of sample pre-treatment steps, such as SPME, appear to be ideal for analysis within these complex materials [72]

Explosives

- DART-MS allows for detection of trace explosives residues on a range of different surfaces. The use of a dopant, such as dichloromethane, may assist in detection of the more-traditional military grade explosives.
- Detection of volatile homemade explosives (peroxides and nitrate esters) is possible using DART-MS
- Combining DART-MS with high temperature thermal desorption can unlock detection of inorganic homemade explosives like ammonium nitrate and potassium chlorate [19]

Gunshot Residue

- Detection of the organic fraction of GSR is easily achieved with DART-MS
- Similar classification results have been obtained from DART-MS and GC-MS results
- Sample collection techniques such as capillary micro-extraction can be coupled with DART-MS for detection of oGSR [90]

Fire Debris

- Analysis of neat and weathered fuels has been completed and distinctions based on additives and weathering rates are observable [92]
- Analysis of ignitable liquids from matrices is also possible and is enhanced when using a temperature programmed thermal desorption front-end.

Inks and Paint

- A large-scale study of inks showed that DART-MS provides a similar level of discriminating power as SEM for ink analysis – although LA-ICP-MS is still superior [95]
- For paint analysis, as with ink analysis, fusion of DART-MS data with other data (in this case FTIR) was found to be superior to analysis by a single technique
- Compared to py-GC-MS, analysis of paints by DART-MS provides a similar discriminating power

Lubricants

- Analysis of personal lubricants and lotions by DART-MS is a budding area of research
- The different chemical compositions of lubricants allow for differentiation and classification based on the DART-MS spectra
- Detection of lubricant compounds in a post-coital environment was also shown to be possible [105]
- Using temperature programmed thermal desorption allows for a more complete chemical profile of lubricants along with a higher discriminating power

Other Applications

- Wood species identification using DART-MS spectra has been demonstrated for several different genera
- Analysis of insect extract to classify and identify flies in different life stages has been demonstrated [113]
- Fiber and polymer analysis have also been demonstrated – typically when coupled with temperature programmed thermal desorption
- Other applications include adulterated beverages, stains, hair, latent fingerprints, and DNA extracts

Resources for Forensic Chemists

- A number of resources were highlighted for forensic chemists using DART-MS. These include validation and operating manuals [124], textbooks [126], and databases [130].

Research Needs and the Potential Future of DART-MS

- One of the biggest outstanding questions for many applications is how well does this technique work on real casework?
- The need for large datasets is becoming increasingly important with the rapid adoption of chemometrics and other statistical analysis approaches
- It is important to fully understand the effects of using nitrogen as a source gas
- Simplified data extraction processes, enhanced spectral searching capabilities, and up-to-date spectral libraries are critical for wide-scale adoption of the technique
- DART-MS may prove extremely useful as a forensic intelligence tool because of its ability to provide rapid, near-complete, chemical profiles

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