The Use of a Novel Quadrupole Time-of-Flight Instrument for the Quantitative and Sensitive Analysis of Drugs of Abuse in Hair Samples

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Background

The detection and quantification of drugs in hair present significant analytical challenges, particularly with respect to sensitivity and matrix effects. Tandem quadrupole mass spectrometers are typically employed for targeted analyses due to their high sensitivity and the specificity afforded by multiple reaction monitoring (MRM). However, high-resolution mass spectrometry (HRMS) instruments offer additional advantages, including enhanced selectivity for compounds with similar *m/z* values and improved discrimination against background interferences.

Objectives

The objective of this study was to expand upon our previous work (1), in which a panel of drugs in hair was analyzed using a tandem quadrupole mass spectrometer. In the present study, a novel quadrupole time-of-flight (QTof) mass spectrometer was evaluated for the accurate identification and quantification of a panel of commonly encountered drugs of abuse. The developed method readily met the confirmation cutoff criteria recommended by the Society of Hair Testing (SoHT).

Methods

Decontaminated hair samples were pulverized, weighed into vials (20 mg), and incubated in a proprietary solvent mixture for 2 hours. Samples were subsequently extracted using mixed-mode cation exchange solid-phase extraction plates (Waters Oasis™ MCX Plates), as previously described (1) with minor modifications. LC–MS/MS analysis was performed using a Waters ACQUITY™ Premier system coupled to a Waters Xevo™ MRT Mass spectrometer operated in Tof MRM mode, in which precursor ions are fragmented and analyzed by the time of flight analyzer, leading to highly specific quantitation. For this proof of concept method, 15 drugs and metabolites including natural and synthetic opiates, amine stimulants, benzodiazepines and hypnotics were analyzed.

Results

The modified extraction procedure enabled a substantial reduction in final sample volume without compromising extraction recovery or overall method performance, resulting in a corresponding increase in analytical sensitivity. Calibration curves encompassed the cutoff

concentrations recommended by the Society of Hair Testing and the European Workplace Drug Testing Society. Quantitative results demonstrated acceptable accuracy and precision for all analytes.

Conclusion

A sensitive and reliable method was developed for the quantitative analysis of drugs of abuse in hair using Tof MRM on a novel high-resolution time-of-flight mass spectrometer. The method demonstrated excellent accuracy and precision and met SoHT cutoff criteria, highlighting the applicability of high-resolution mass spectrometry for targeted forensic hair analysis.

1-Danaceau et al. Extraction and Analysis of a Definitive Drug Panel in Hair Samples by UHPLC-MS/MS for Forensic Toxicology Waters Application note, 2025 720008769en.

Key words: Mass spectrometry, Sample preparation, Time of Flight, Drugs of abuse, quantification