Analysis of Personal Care Products (PPCP) in Water Samples by Way of Large Volume Sample Injections

Lower Detection Limits With Large Injection Volumes

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Overview

A series of Pharmaceuticals and Personal Care Products (PPCP) were determined in surface waters using Liquid Chromatography tandem Mass Spectrometry (LC-MS/MS). Water samples were injected directly into the LC-MS/MS to quantify PPCP at parts-per-trillion levels (ng/L). Multiple Reaction Monitoring (MRM) was used on a SCIEX QTRAP® 4500 system equipped with a 2000 µL sample loop to obtain the maximum sample loading and sensitivity. Accuracy and reproducibility was increased by employing the *Scheduled* MRM™ algorithm to maximize dwell times for each analyte.

Introduction

PPCP have become important emerging contaminants, due to their presence in environmental waters (following incomplete removal in wastewater treatment or diffuse-source contamination), threat to drinking water, and concern about possible estrogenic and other adverse effects, both to wildlife and humans. It is estimated that approximately 3000 different substances are used as pharmaceutical ingredients, including painkillers, antibiotics, antidiabetics, betablockers, contraceptives, lipid regulators, antidepressants, and impotence drugs. However, only a small subset of these compounds has been investigated in environmental studies so far.[1]

The diversity of chemical properties make method development a challenge. LC-MS/MS is able to analyze polar, non-polar, and thermally labile compounds without time consuming and extensive sample preparation. When coupled to an LC system capable of injecting large sample volumes, MRM offers the selectivity and sensitivity to quantify PPCP reproducibly at trace levels.

A method is outlined showing the analysis of 40 PPCP compounds using LC-MS/MS. The method employs a large sample injection technique and high flow rates to provide identification of PPCP with excellent sensitivity.

Experimental

Sampling and Sample Preparation

More than 20 water samples from different types of waters, including drinking water, ponds, creeks, rivers, and lakes were collected and kept refrigerated until analysis. Water samples were acidified with formic acid at a level of 0.1% and injected directly after filtration without additional cleanup.

LC Preparation

A SCIEX UltraLC 110 System was equipped with a 1000 µL sample syringe, a 2000 µL buffer tubing line, and a 2000 µL sample loop. A Supelco core-shell PFP column (Ascentis Express F5, 10 x 4.6 mm, 2.7µm) and a fast gradients of water and methanol with 0.1% formic acid at a nominal flow rate of 1.2 mL/min was used. The flow rate was varied from 200 µL/min. during injection to 1500 µL/min. during elution to improve peak shape. Injection volumes of 100-1000 µL were used without evidence of breakthrough.

MS/MS Detection

A SCIEX QTRAP® 4500 LC-MS/MS system with Turbo V™ source and Electrospray Ionization (ESI) probe was used. The mass spectrometer was operated in MRM mode using the *Scheduled* MRM™ algorithm. The *Scheduled* MRM™ algorithm monitors transitions automatically during a short retention time window only. This allows many more transitions to be monitored in a single LC run, while maintaining maximized dwell time and optimized cycle time.

Data Processing

Data was processed in PeakView® software version 2.1 and MultiQuant™ software version 3.0.

Results and Discussion

The combination of a small fused core particle size (2.6 µm), high flow rate (1.5 mL/min), and a large injection volume (1000 µL) with high sensitivity MS/MS detection on a QTRAP® 4500 instrument allowed the direct injection of waters samples and detection of PPCP with Limits of Detection (LOD) in the low parts per trillion range. Two MRM transitions were monitored for each of the 40 analytes to quantify and identify using the ratio of quantifier and qualifier MRM.

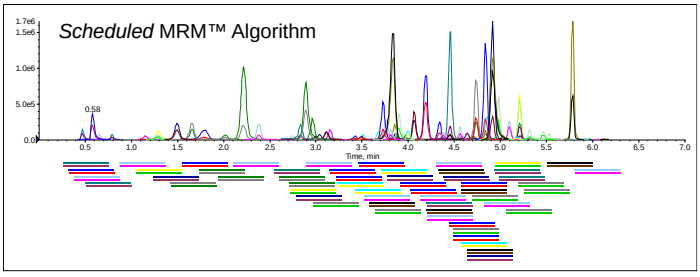

Figure 1. The *Scheduled* MRM™ algorithm uses the knowledge of the elution of each analyte to monitor MRM transitions only during a short retention time window. This allows many more MRM transitions to be monitored in a single LC run, while maintaining maximized dwell times and optimized cycle time.

An LC-MS/MS example chromatogram of 40 PPCP at a concentration of 0.1 µg/L (100 ppt) is shown in Figure 2.

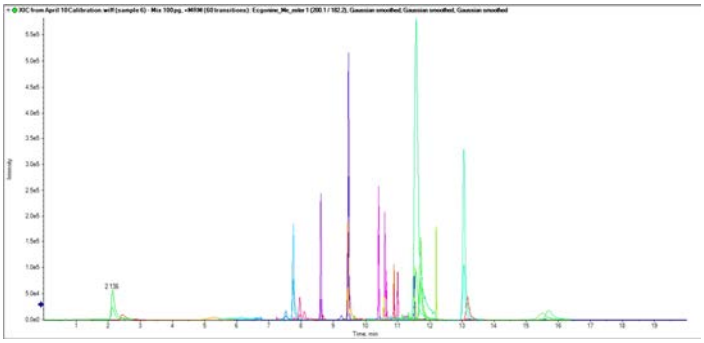

Figure 2. LC-MS/MS Detection of 40 PPCP at 0.1 µg/L (100 ppt) using an injection volume of 1 mL

Two MRM transitions were monitored for each analyte, the most sensitive MRM transition was used for quantitation while the second MRM transition was used for qualitative identification based on the automatic ion ratio calculation in MultiQuant™ Software.

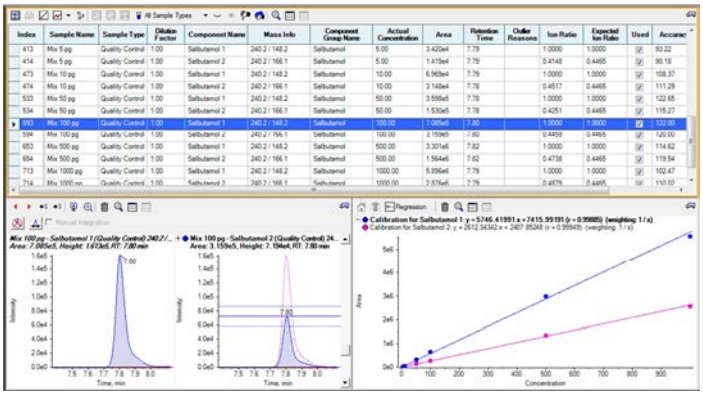

Figure 3. Identification of 100 ppt Salbutamol based on MRM ratio calculation with a tolerance levels of 20%

The sensitivity and signal-to-noise (S/N) gain using a large volume sample injection on the QTRAP® 4500 system is highlighted in Figure 5.

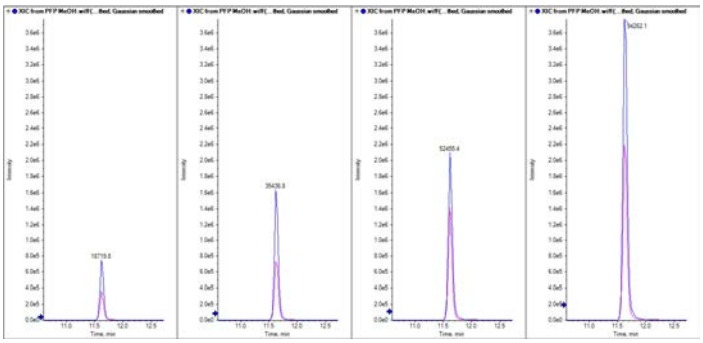

Figure 4. Sensitivity and S/N gain for Salbutamol when injecting 100, 250, 500, and 1000 µL (The S/N was automatically calculated in PeakView® Software using 3 times the standard deviation of the adjacent noise.)

Example chromatograms of 12 selected analytes at a concentration of 5 ng/L (5 ppt) are presented in Figure 5

Such low Limits of Detection (LODs) allows for the use of less sensitive mass spectrometers for the determination of PPCP in water samples by simples changes to the syringe and sample loop injection volumes of the ultraLC 110 system.

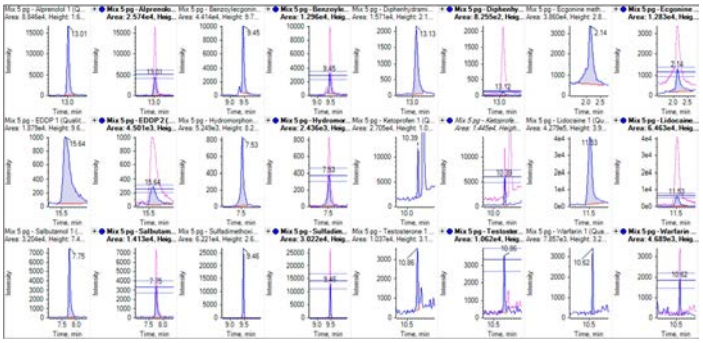

Figure 5. Example chromatograms of 12 selected PPCP at a concentration of 5 ng/L (top left to bottom right: Alprenolol, Benzoylecgonine, Diphenhydramine, Ecgonine methyl ester, EDDP, Hydromorphone, Ketoprofen, Lidocaine, Salbutamol, Sulfadimethoxine, Testosterone, Warfarin)

The detection of PPCP at low ppt levels can now be accomplished without additional cleanup or time consuming and extensive sample concentration.

Summary

Large sample injection using 1000 µL or larger sample loops provides an easy and effective way to expand the analytical capabilities of the SCIEX UltraLC 110 system with a mid-range mass spectrometers such as the SCIEX QTRAP® 4500. In this example we are able to achieve very low detection limits of many common pharmaceuticals and personal care products. Even in the absence of any extensive sample preparation, LOD in the ppt range (ng/L) were routinely achieved. The large sample injection procedure provides an effective mechanism to screen drinking and surface waters for PPCP.

References

1 S. Richardson and Th. Ternes: 'Water Analysis: Emerging Contaminants and Current Issues' Anal. Chem. 86 (2014) 2813−2848

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