Depletion of Phospholipid Matrix Interference when Dealing with Small Volume Plasma Samples

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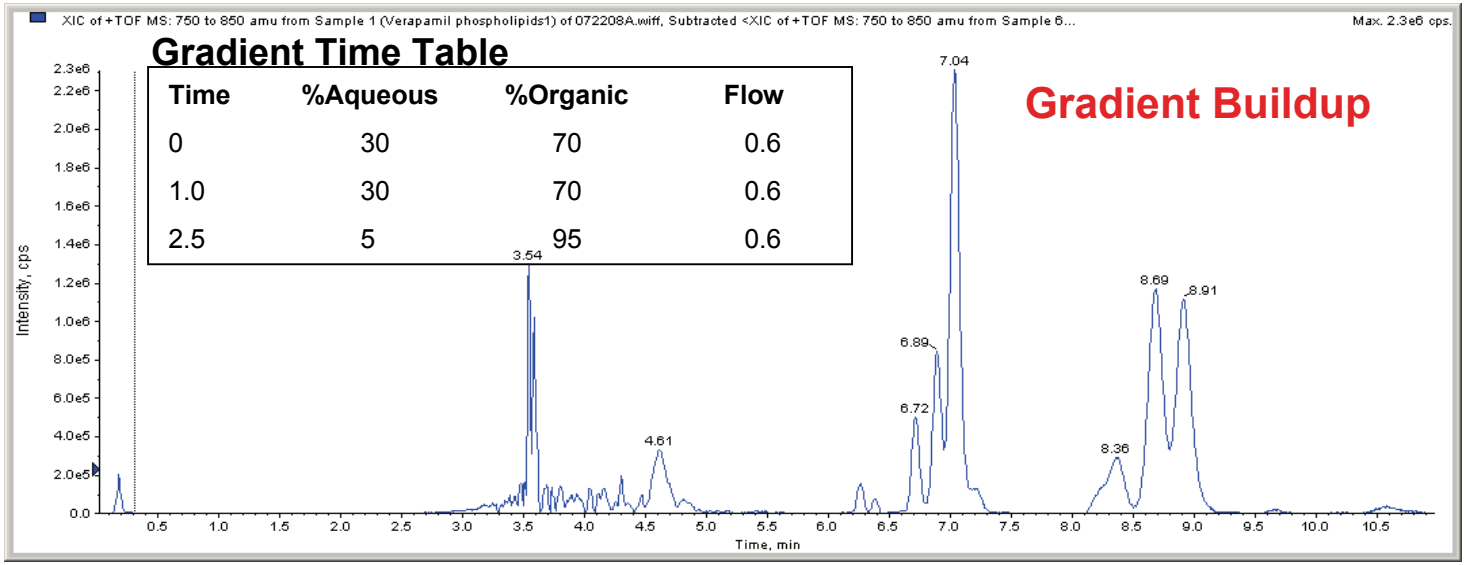
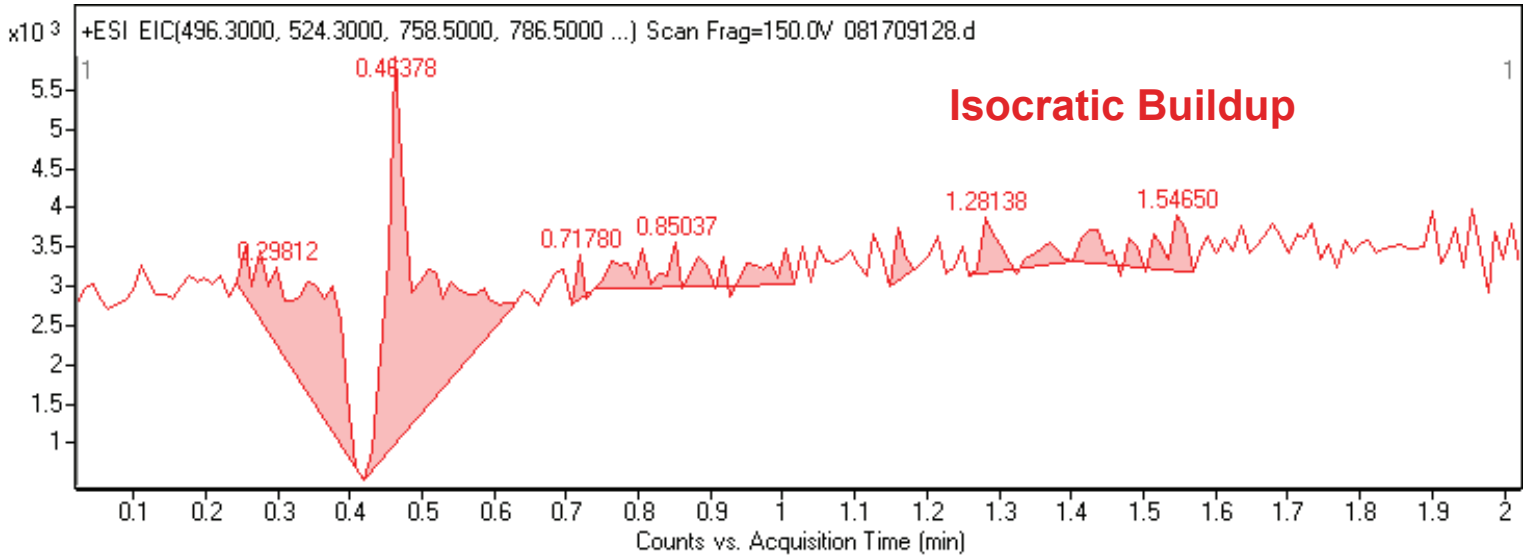
Introduction

- Sample preparation of small volume plasma samples can be restrictive due to the limited volume of available plasma.
- Mouse studies, plasma samples are limited to 30 µL or less.
- Traditional solid phase extraction techniques limited due to large hold up volumes.
- Often limited to liquid-liquid protein precipitation resulting in a high degree of matrix interference.
- Major concern in developing bioanalytical methods is addressing matrix effects
- The impact of matrix effects in bioanalysis has been well documented.
- Co-extracted interferences directly affect the quantitation of analytes.
- Matrix build up that leads to irregularities in quantitation.
- Gradient elution often required for matrix elution…time consuming

Figure 1. Phospholipid Chromatographic Buildup





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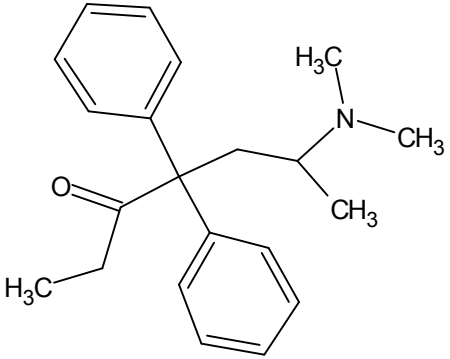
Experimental

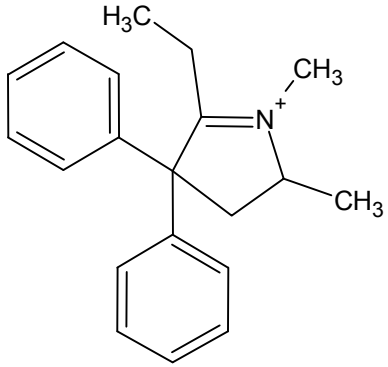
- In this study, comparisons are made between standard protein precipitation methods along with sample preparation by HybridSPE-PPT™ small volume technique for the recovery of methadone and metabolites from plasma samples along with effective matrix removal.
- Spiked Rat plasma samples with methadone and metabolites EDDP and EMDP processed by standard protein precipitation compared against HybridSPE-Small Volume 96well plate
- The analysis was conducted on an Agilent 1200SL Rapid Resolution system coupled to an Agilent 6210 TOF LC/MS. Chromatographic separation was performed on the Ascentis Express RP-Amide.
- The high sensitivity of methadone and metabolites enable for direct small volume injection of the processed sample with out the need for evaporation or reconstitution.

Structures of Methadone and Metabolites



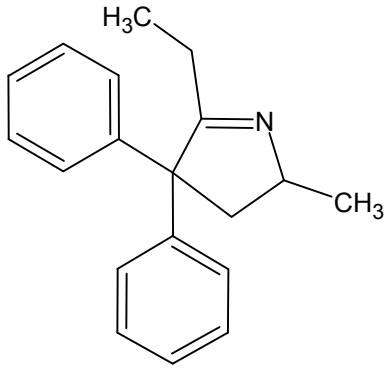
Methadone

Monoisotopic Mass = 309.209264 Da



EDDP

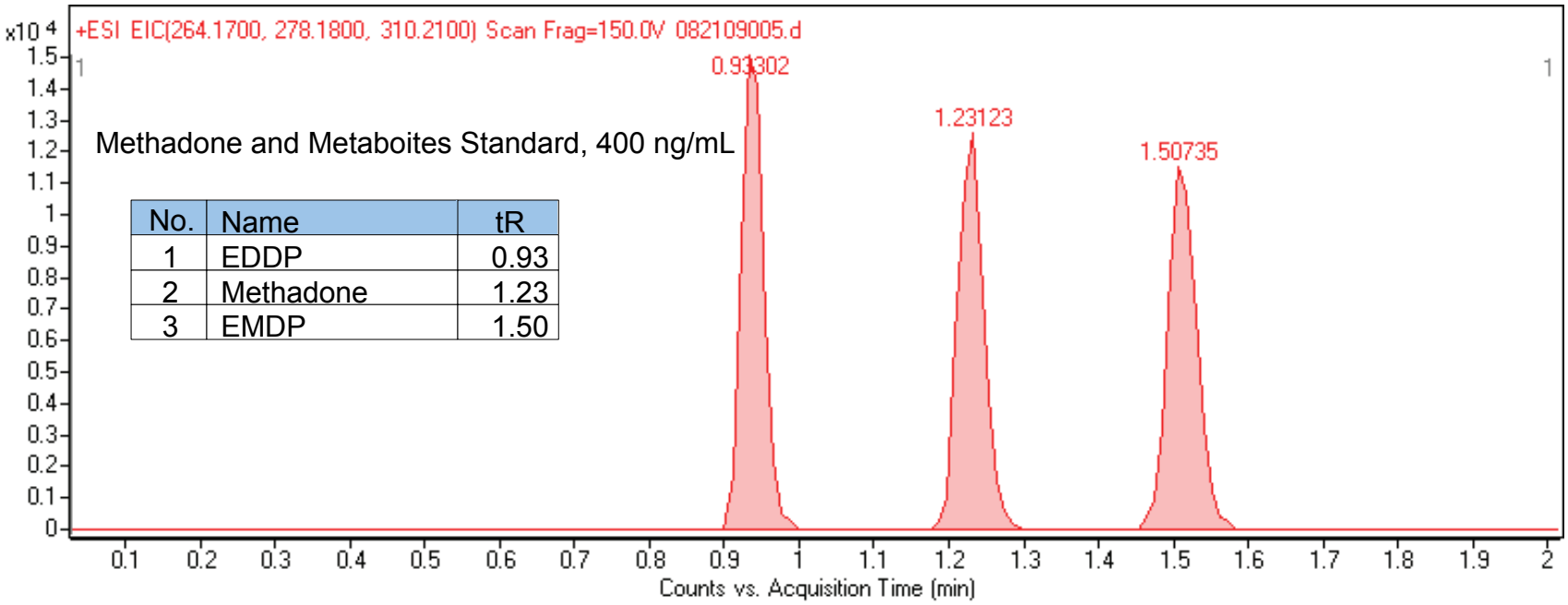
Monoisotopic Mass = 278.190326 Da



EMDP

Monoisotopic Mass = 263.1674 Da

Figure 2. Chromatographic Conditions



column:	Ascentis Express RP Amide 10 cm x 2.1 mm, 2.7 µm (53913-U)
mobile phase:	10 mM ammonium formate (65:35 water:acetonitrile) pH 3.6
flow rate:	0.4 mL/min.
temp.:	35 °C
det.:	ESI+, 1.5 spectra/sec, 6309 transients/spectra
injection:	0.5 µL
system pressure:	275 bar
instrument:	Agilent 1200SL Rapid Resolution, Agilent 6210 TOF LC/MS

Phospholipid Monitoring

Lysophosphatidylcholines:	m/z
1-palmitoyl-2-hydroxy-sn-glycero-3-phosphocholine	496.3
1-stearoyl-2-hydroxy-sn-glycero-3-phosphocholine	524.3

Glycerophosphocholines:	m/z
1-hexadecanoyl-2-(9Z,12Z-octadecadienoyl)-sn-glycero-3-phosphocholine	758.5
glycerophosphocholine 36:2	786.5
1-(9Z,12Z-octadecadienoyl)-2-(5Z,8Z,11Z,14Z-eicosatetraenoyl)-sn-glycero-3-phosphocholine	806.5
1-stearoyl-2-arachidonoyl-*sn*-glycero-3-phosphocholine	810.5

Sample Preparation

Standard Solutions: Standard solutions were prepared from a stock standard in (3:1) 1% formic acid acetonitrile:water at a level of 1, 10, 20, 50, 100, 200, 500 ng/mL.

Plasma: Rat plasma stabilized with K_2EDTA was acquired from Lampire Biological Laboratories, (Pipersville PA). Plasma was spiked directly from stock standard to a level of 20, 50, 100, 400, 300 ng/mL.

Standard Protein Precipitation: apply 20 µL of plasma to centrifuge vial, followed by 60 µL of 1% formic acid acetonitrile. Agitate via vortex for 1 minute, place into centrifuge for 2 minutes at 15000 rpm. Collect supernatant and analyze directly.

HybridSPE-small volume Plasma Samples: apply 20 µL of plasma to plate, followed by 60 µL of 1% formic acid acetonitrile. Agitate via vortex for 1 minute, place on vacuum manifold and apply 10”Hg vacuum for 2 minutes. Collect filtrate and analyze directly.

Collection Plate: Eppendorf 150 µL conical with mylar cover.

Figure 3. Phospholipid Interaction with Zirconia-Coated Particle of HybridSPE

- The high selectivity towards phospholipids achieved utilizing Lewis acid/base interaction between the phosphate group of the phospholipids and the zirconia surface.
- The zirconia-coated particle is not as Lewis “acidic” as pure zirconium oxide, enabling highly efficient extraction of phospholipids while remaining non-selective towards a broad range of basic, neutral and acidic compounds.
- Utilize high surface area of silica particle to increase capacity.

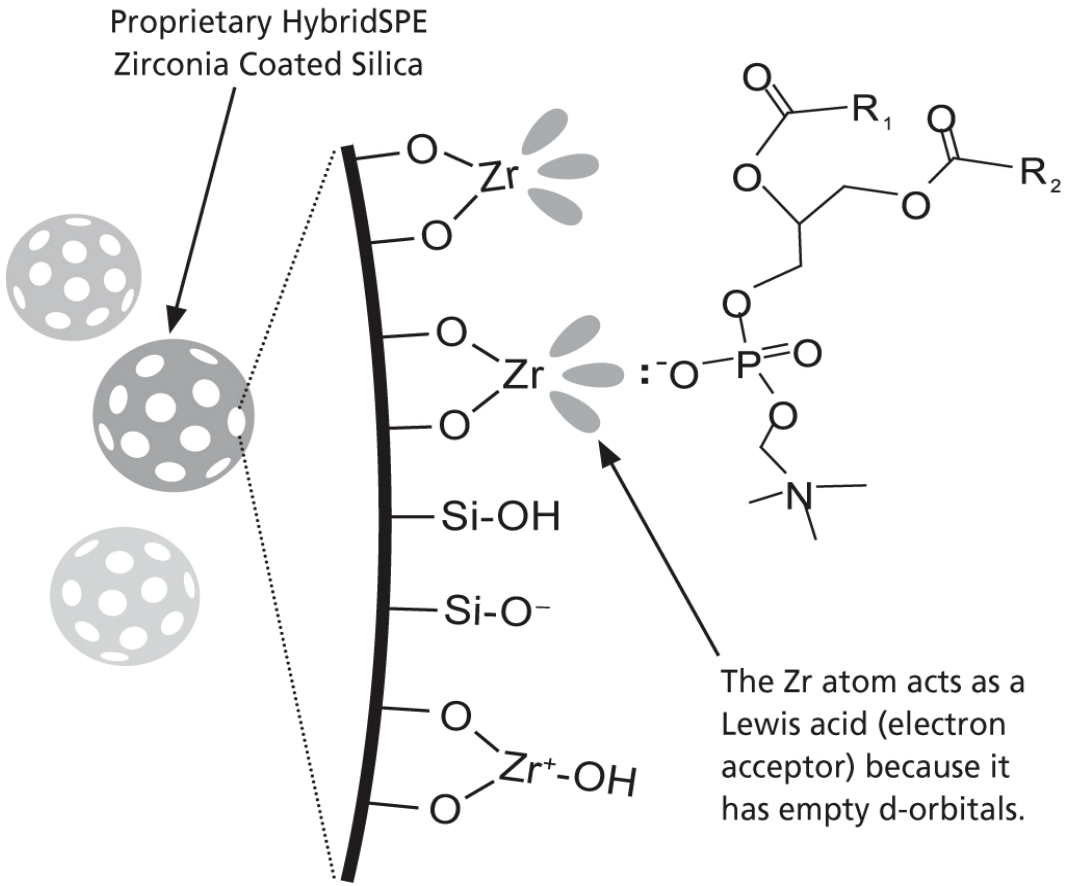
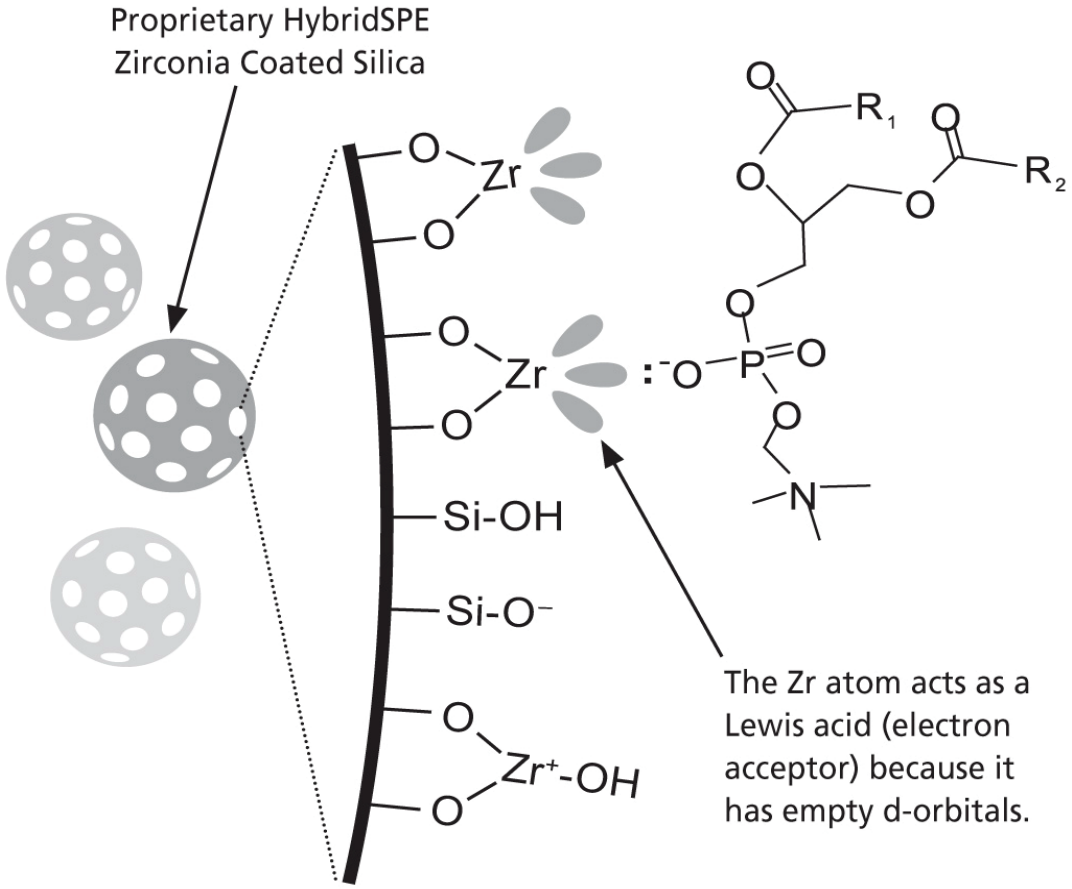


Figure 4. Lewis Acid Base Strength Scale

Lewis Base	rel. Strength on Zirconia
Hydroxide	Strongest
Phosphate	
Fluoride	
Citrate	
Sulfate	
Acetate	
Formate	
Chloride	Weakest

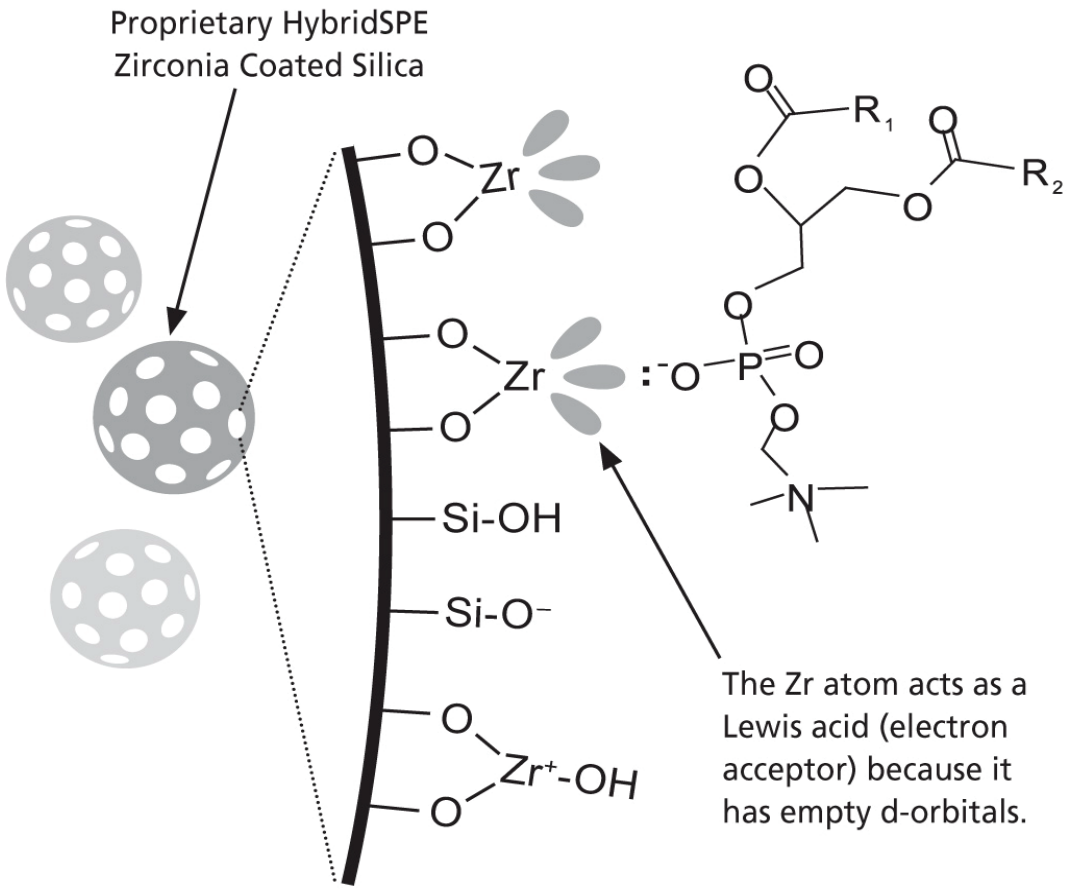


Interaction between a representative phospholipid and the zirconium surface of the HybridSPE-PPT particle via Lewis acid-base interaction[3].

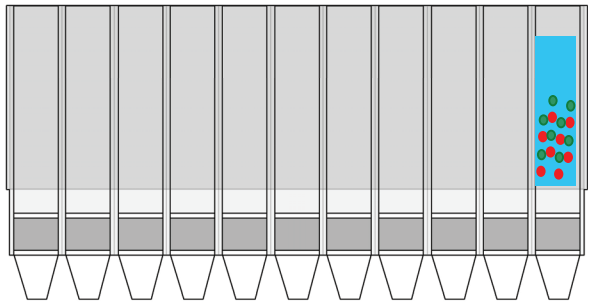
Figure 5. Crash Solvents and Additives

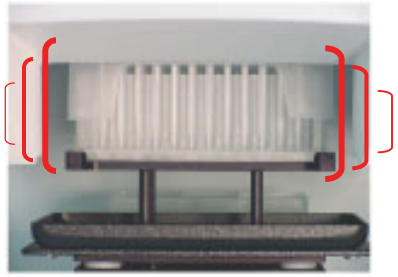
Precipitated Plasma Sample Composition

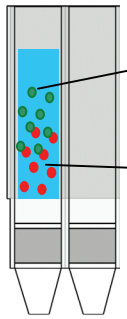
- Modifier (1% formic acid) mitigate lewis-acid base interaction between chelation/ acidic compounds
- Modifier (formic acid, ammonium formate) acts to disrupt ion-exchange with surface silanols
- High organic content (75%+) acts as strong solvent when related to hydrophobic retention (acetonitrile, methanol).
- Aqueous content (25%) is strong solvent when related to HILIC retention.



“In-well Precipitation” for HybridSPE 96-well format





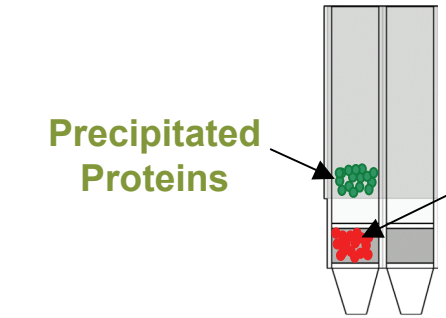


1a) Precipitate Proteins:
100 µL plasma/serum + 300 µL
1% formic acid in ACN (& I.S.)

! PTFE frit keeps plasma from dripping through packed-bed prematurely.

1b) Mix by vortexing HybridSPE plate or by aspirating/dispensing with 0.5-1 mL pipette tip

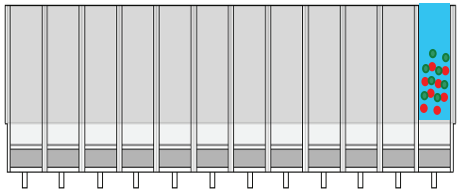
2) Apply vacuum. Packed-bed filter/frit assembly acts as a depth filter



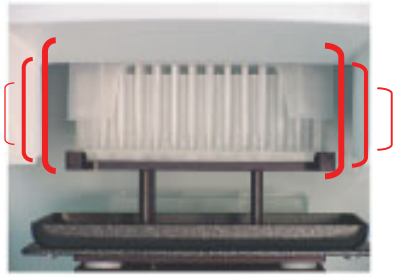
3) Resulting filtrate/eluate
free of proteins and phospholipids
Ready for ananlysis

Figure 6. *In-Well* Protein Precipitation Schematic

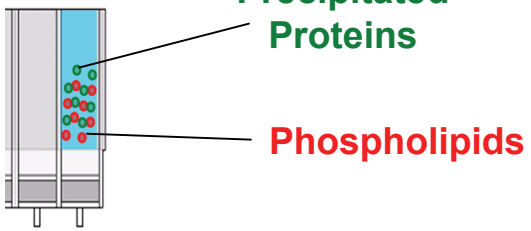
15 mg Zirconia-Coated Silica Bed



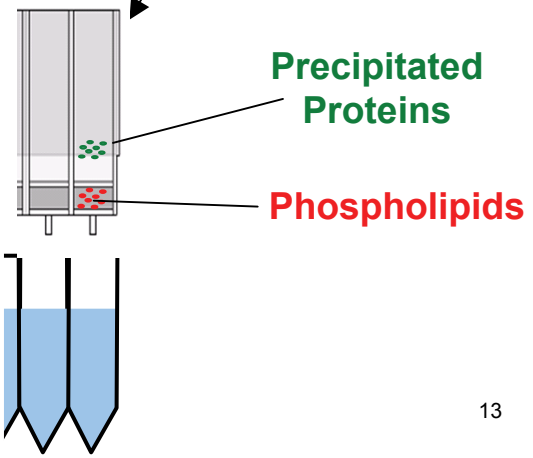
1) Precipitate Proteins: Add 20 µL plasma/serum followed by 60 µL 1% formic acid in acetonitrile. Add I.S. as necessary. Note: the upper PTFE frit keeps plasma from dripping through packed-bed prematurely.



2) Mix by vortexing HybridSPE plate or by aspirating/dispensing pipette tip..



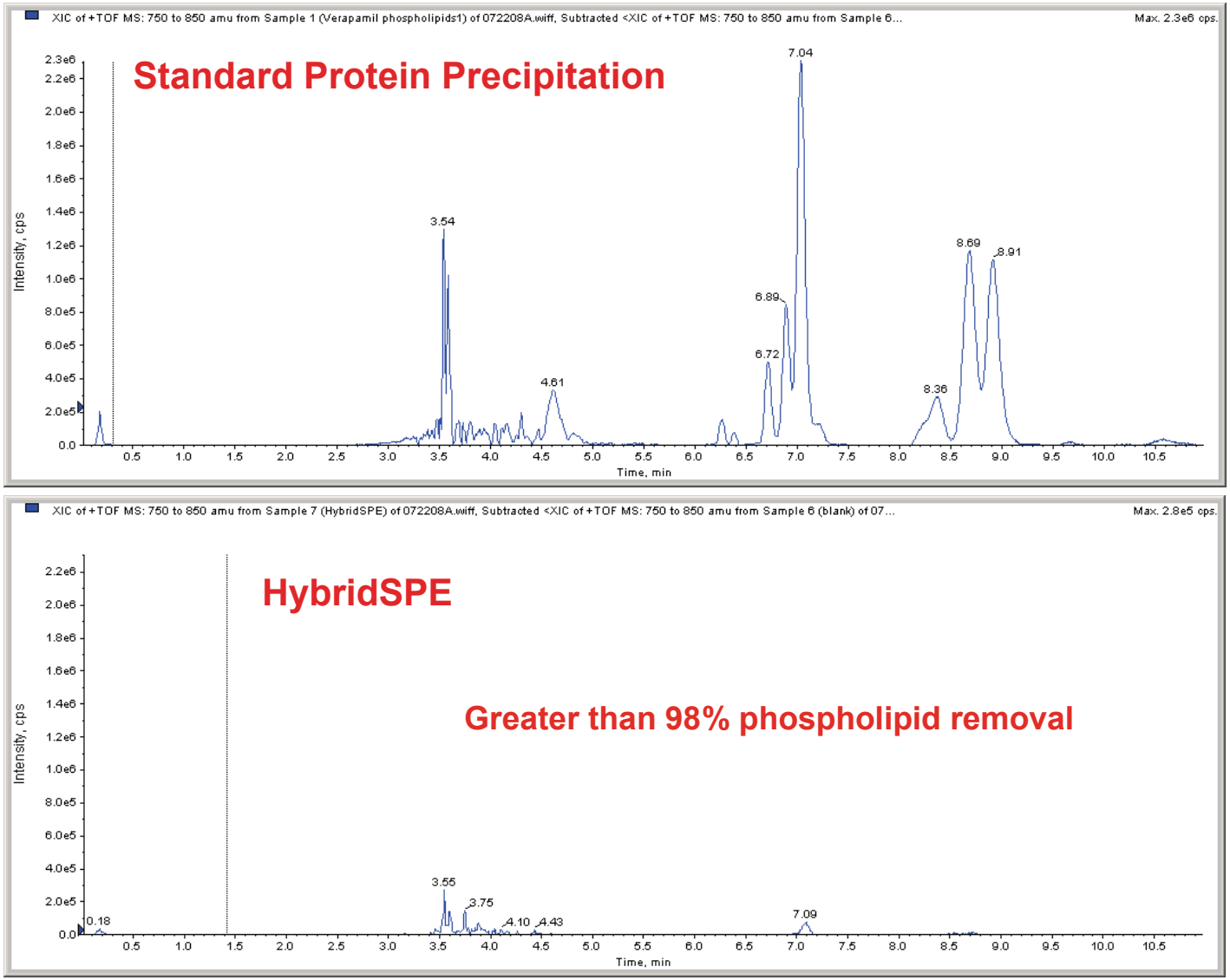
3) Apply vacuum. Packed-bed filter/frit assembly acts as a depth filter for the concurrent physical removal of precipitated proteins and chemical removal phospholipids.



Recovery volume 40-50 µL

4) Resulting filtrate/eluate is depleted of proteins and phospholipids and ready for immediate LC-MS/MS analysis.

Figure 7. Gradient Elution, Phospholipid Removal Comparison



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- Each spiked level sample was prepared n=8 for both sample prep techniques.
- Samples processed using the HybridSPE-Small Volume technique were collected directly into an Agilent low volume 96 well collection plate, average sample volume recovery from the plate was 40 µL.
- To ensure sufficient sample was drawn up by the injector, the auto sampler was set for bottom well sensing.
- Samples were assayed for content of methadone and metabolites along with matrix monitoring for phospholipids.
- Lyso and glycerophospholipids were monitored as a representative phospholipids matrix ions.

Injection Series

First Series: Calibration Standards

Level 1, 10, 20, 50, 100, 200, 500 ng/mL, n=8 for each level

Second Series: Spiked Plasma Samples HybridSPE

Level of 20, 50, 100, 200, 300 ng/mL, n=8 for each level

Third Series: Spiked Plasma Samples Protein Precipitation

Level of 20, 50, 100, 200, 300 ng/mL, n=8 for each level

Injections made in order of increasing concentration, blank injection performed between sample prep techniques.

Figure 8. Calibration Table

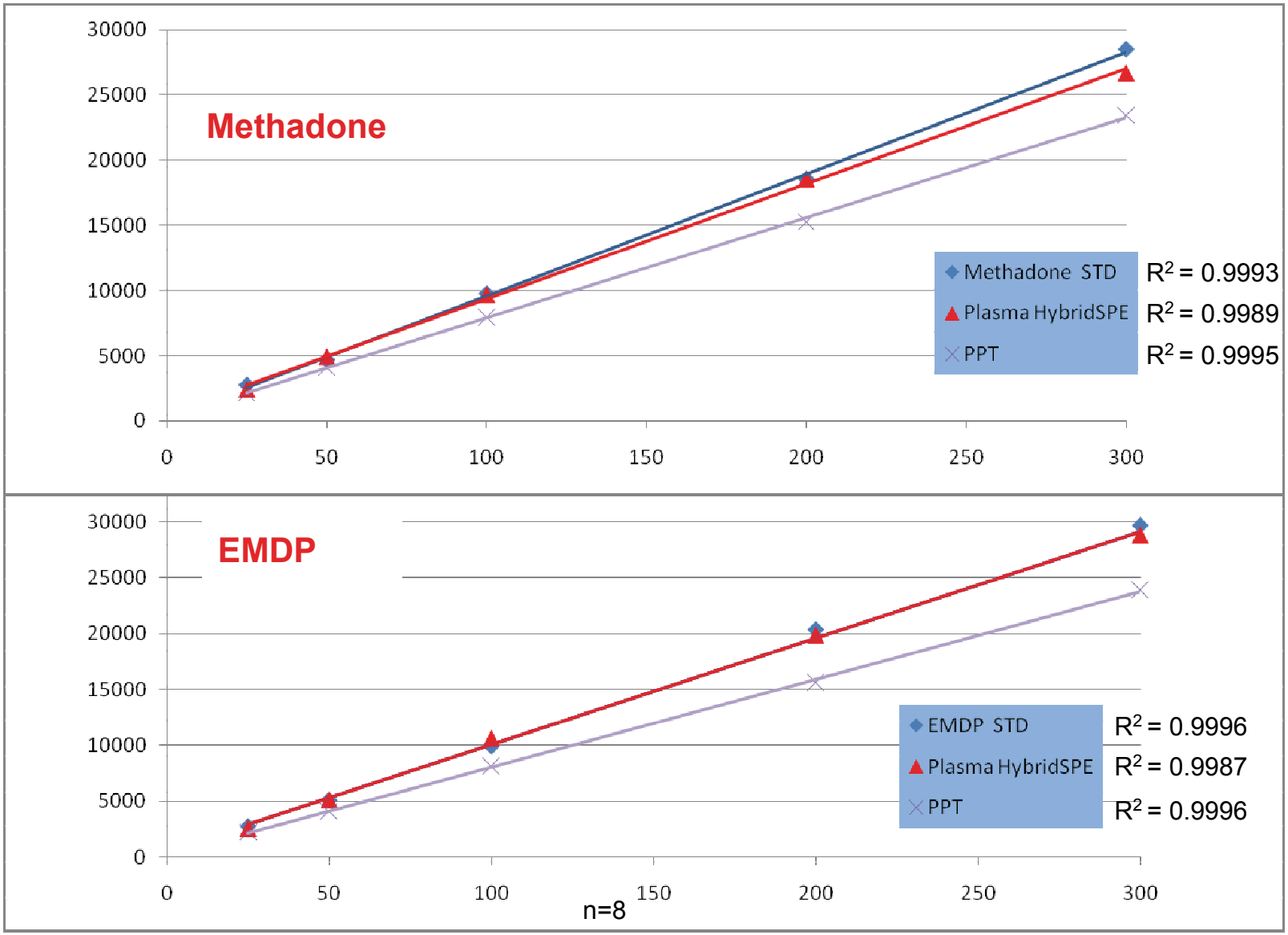


Figure 9. Calibration Table

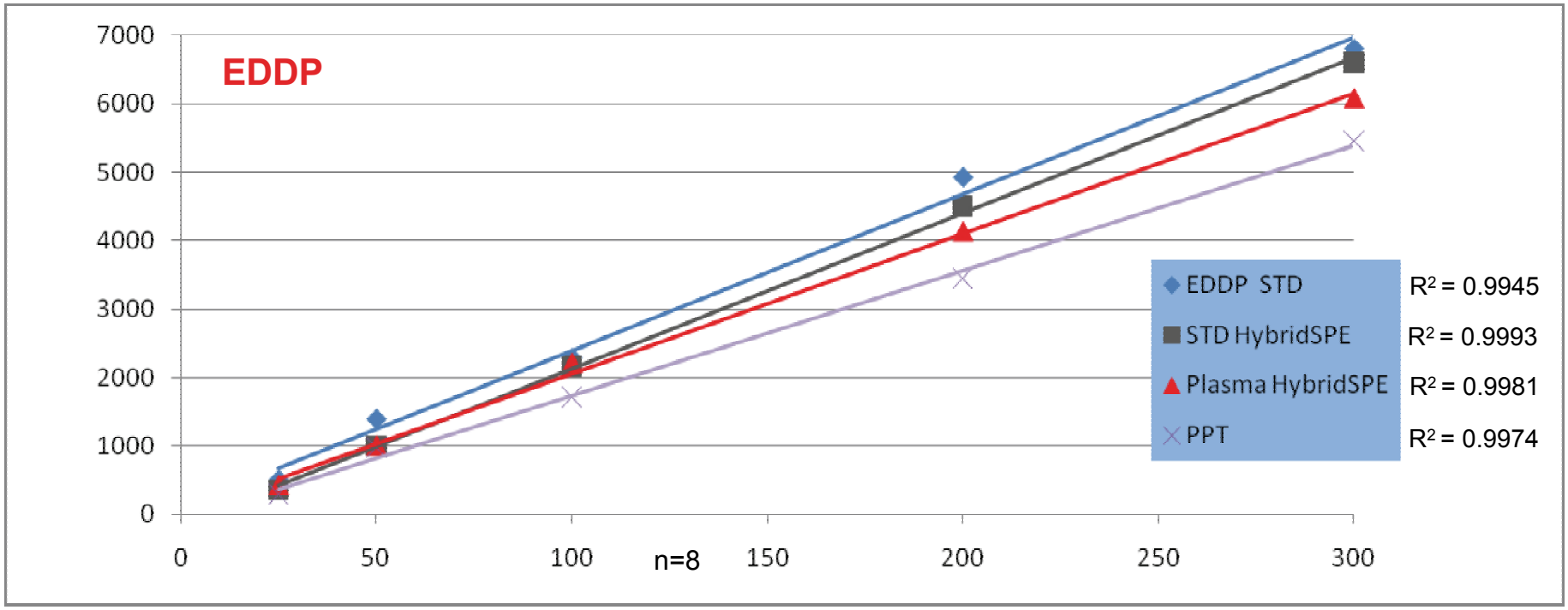


Figure 10. Phospholipid Buildup on Column from Protein Precipitation Method (isocratic)

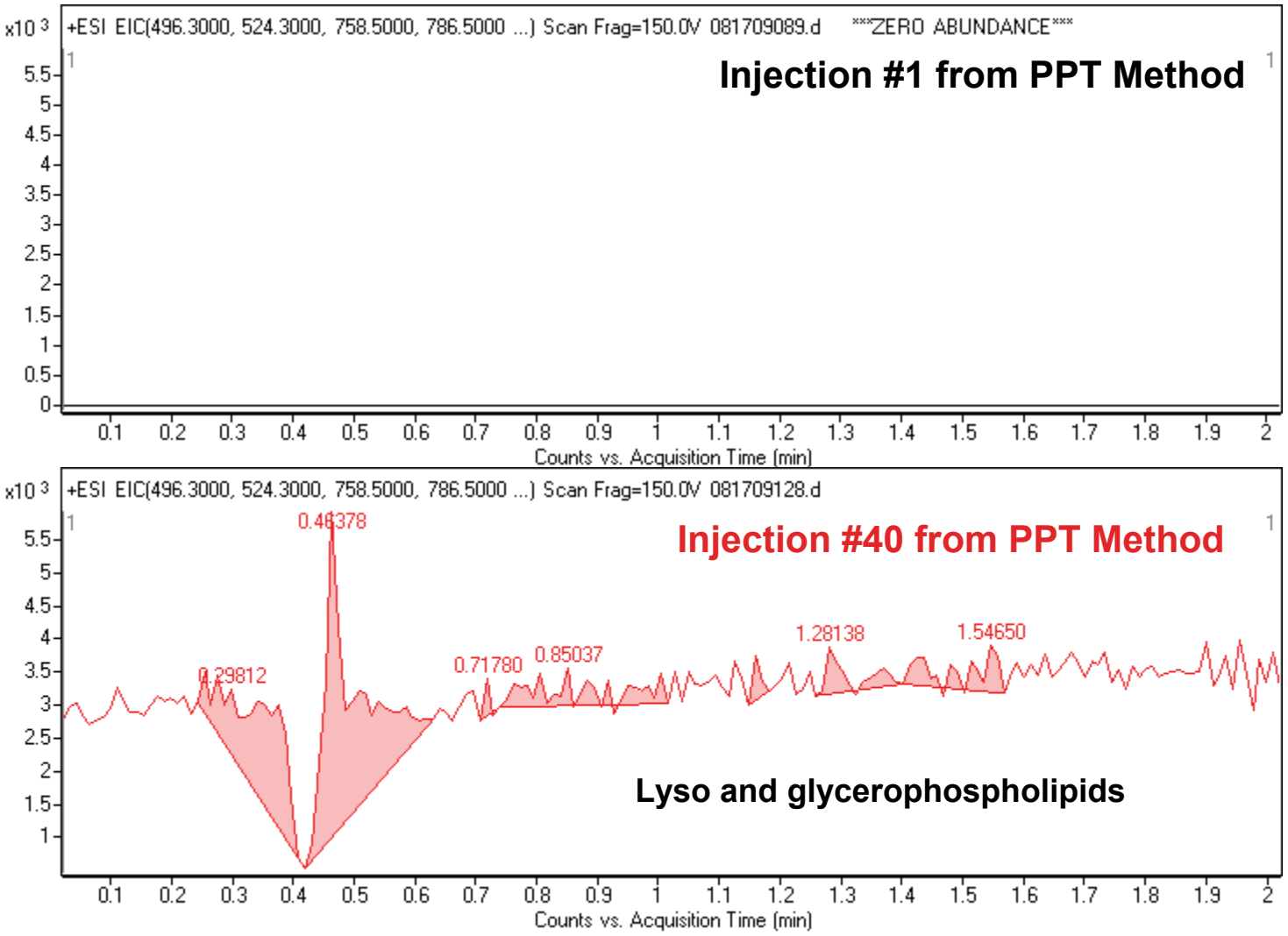
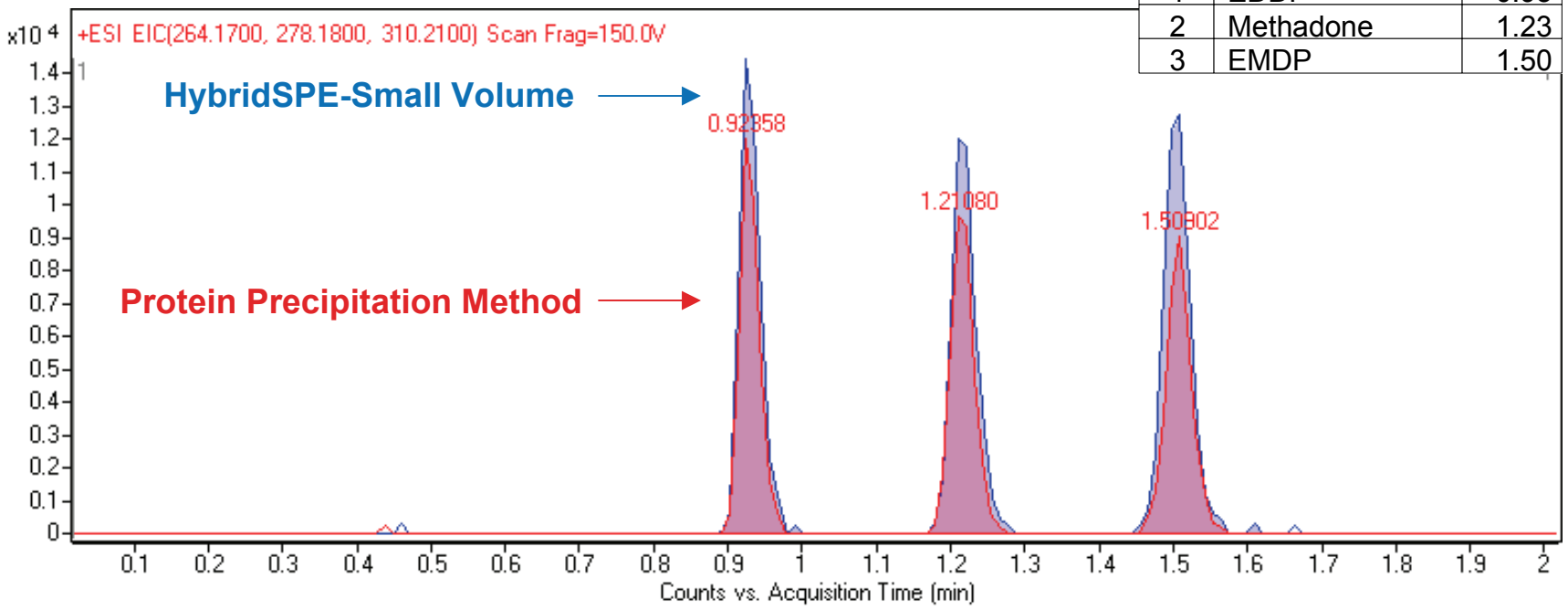


Figure 11. Overlay of HybridSPE-Small Volume and Protein Precipitation Samples

No.	Name	tR
1	EDDP	0.93
2	Methadone	1.23
3	EMDP	1.50



- Signal suppression observed even at highest spike level
- Dramatic impact over short number of samples
- Determine impact in larger number study

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Long Term Injection Series

- Setup as standard bioanalytical method.
- Spiked Control Samples run every 40 sample injection.
- Control spiked at 100 ng/mL level.
- Experiment conducted over a 250 injection series.
- Control response was plotted.
- Comparison between sample prep techniques.

Figure 12. Phospholipid Buildup on Column from Protein Precipitation Method (isocratic)

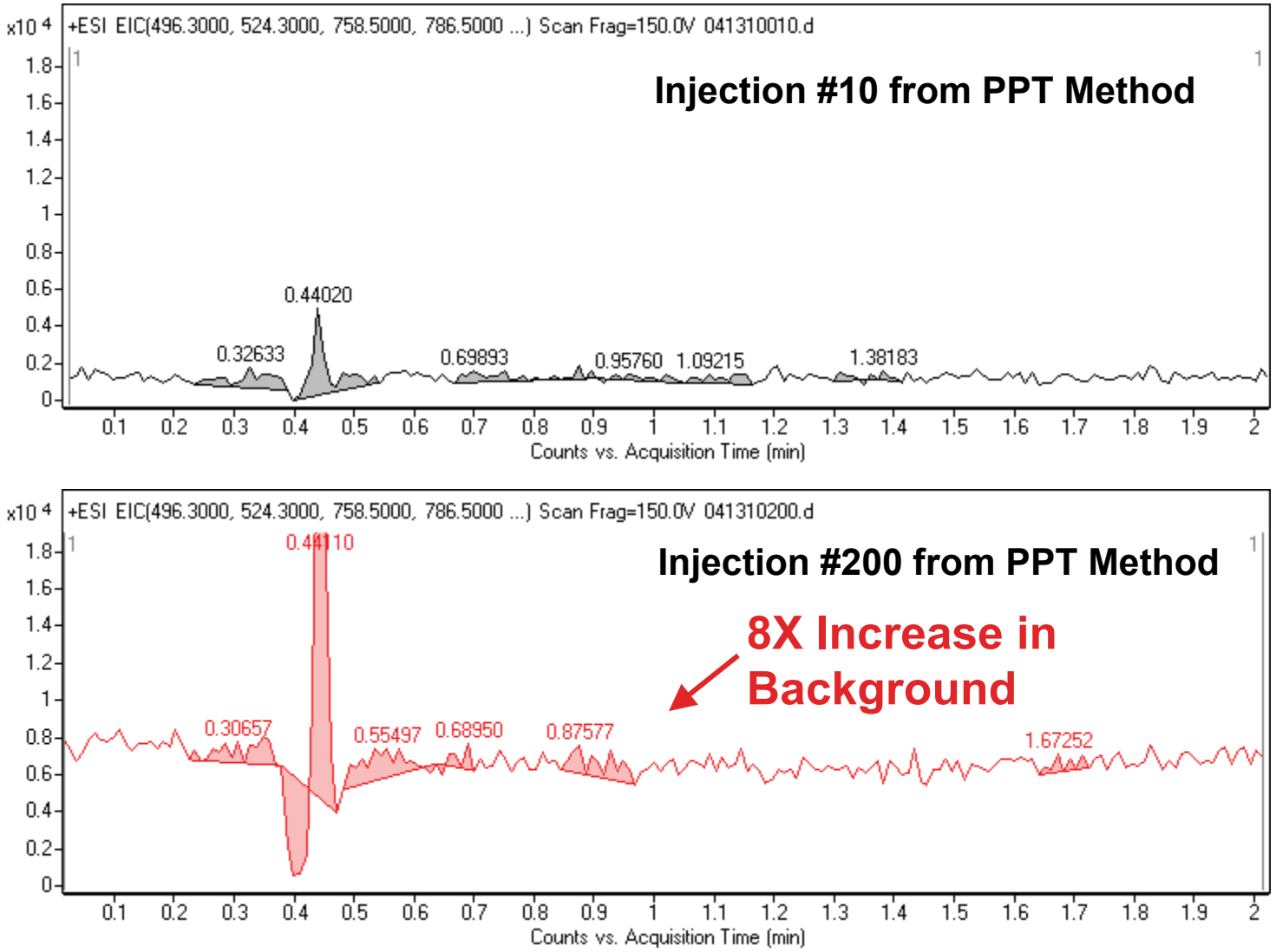
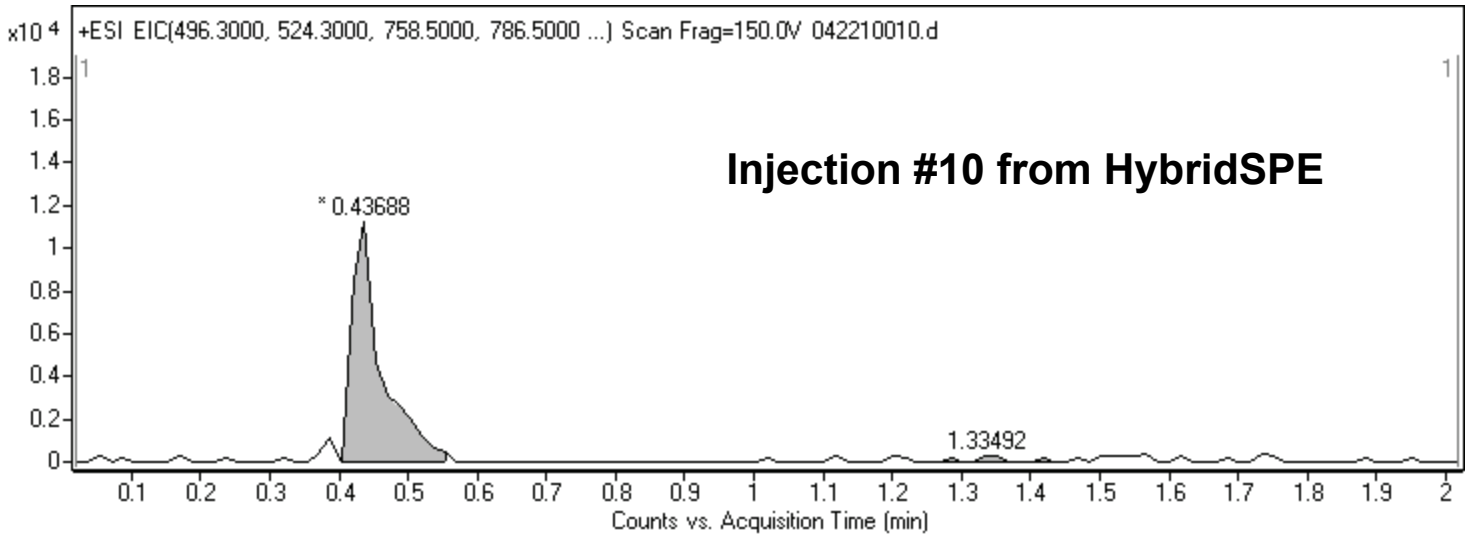


Figure 13. Phospholipid Buildup from HybridSPE (isocratic)



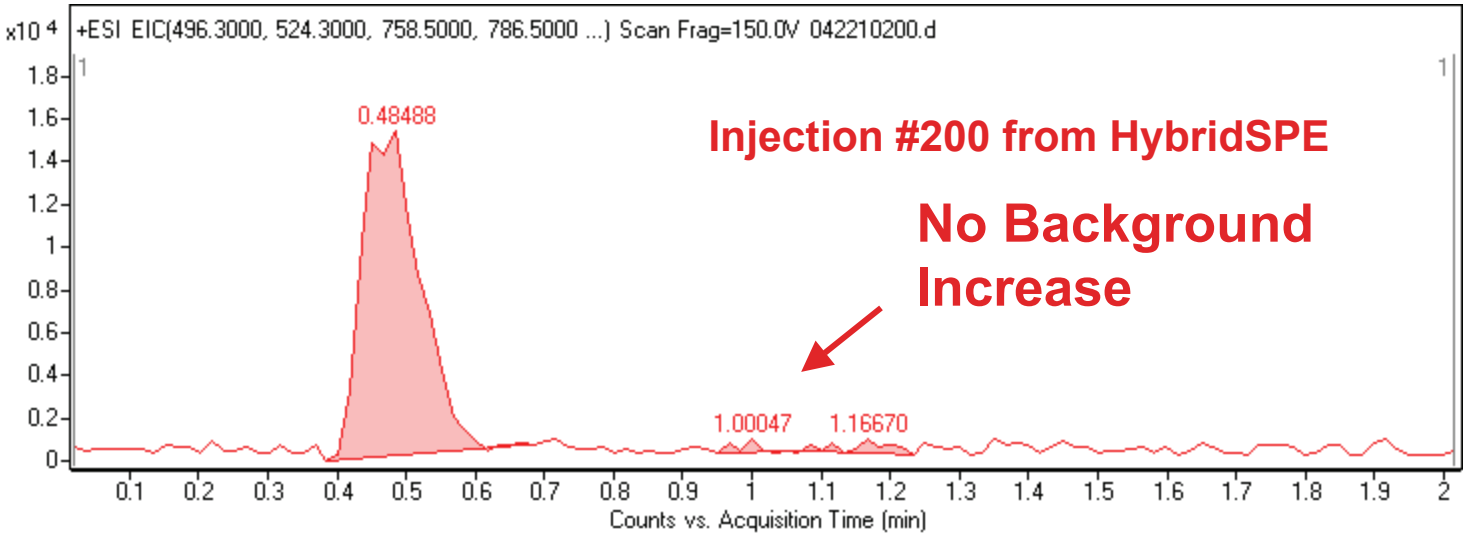
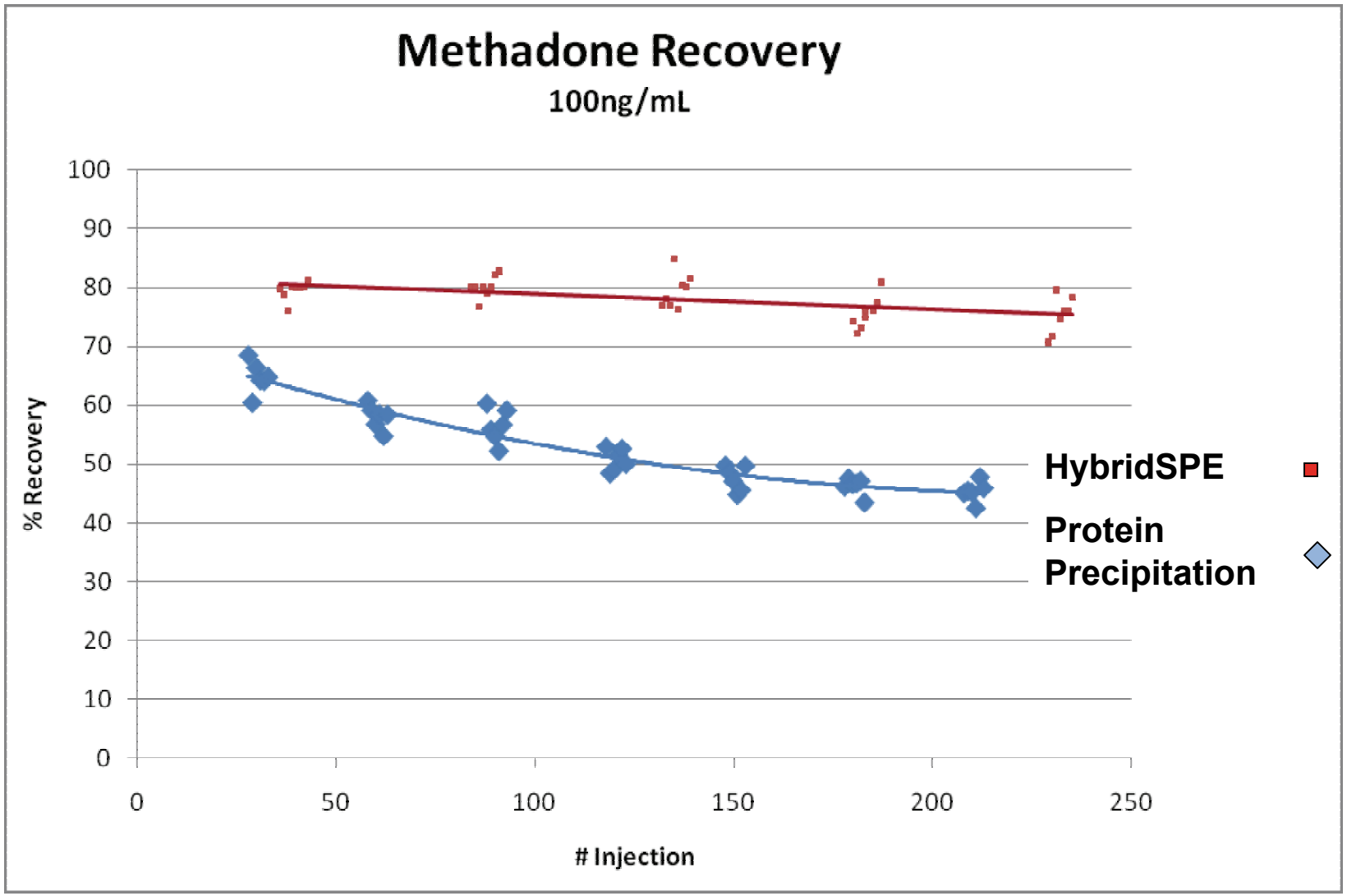


Figure 14. Ionization Effect of Phospholipid Buildup (Isocratic)



Results and Discussion

- Signal suppression along with irreproducible control response observed for standard protein precipitation.
- Samples prepared using the HybridSPE Small Volume plate demonstrated consistent response across the study range considering no internal standard was used.
- Demonstrated technique for small volume plasma.
- Samples were not affected by the matrix buildup due to depletion of phospholipids.
- Enable isocratic elution for increase speed while eliminating timely gradient washing.

Conclusions

- Phospholipid buildup and resulting matrix ionization effect was demonstrated when performing standard protein precipitation techniques.
- HybridSPE-Small Volume plate demonstrated high recovery of methadone and associated metabolites across the concentration range along with depletion of proteins and phospholipids from the plasma samples.
- Unique approach to processing small volume samples enable a high degree of matrix removal when dealing with minimal plasma volumes.
- Utilizing the zirconia-Si particles as a sample preparation media, phospholipid matrix interference was selectively bound to the particle via Lewis acid/base interaction resulting in high degree of phospholipid removal.
- Consideration towards sample matrix… fast chromatographic separation do not always translate to fast bioanalytical methods,e.g due to matrix components theat need to be washed off.

References

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