Syringe Filter Suitability for Sample Preparation in Drug Assays

Application Note

Small Molecule Pharmaceuticals & Generics

Authors

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Abstract

Agilent Captiva Premium syringe filters were tested thoroughly for sample preparation in drug assays. The potential impact on drug binding through filtration was evaluated based on analyte recovery. Five representative drugs were selected, covering a wide variety of chemical and physical properties and drug binding propensity. All of the tests were performed following USP (United States Pharmacopeia) methods. The results demonstrated that, with appropriate selection of filtration membrane based on target analyte and sample medium, Agilent Captiva Premium syringe filters provided excellent recovery for a wide variety of compound structures and chemistries.

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Introduction

Sample preparation for the analysis of drug products involves dissolving formulations in solutes or media, followed by sample centrifugation or filtration, and then injection into an analytical instrument, usually HPLC. The purpose of sample centrifugation or filtration is to remove nondissolved particulates prior to HPLC analysis, because particulates can interfere with the resulting chromatography, plugging the column, and subsequently causing column failure [1].

Compared to centrifugation, sample filtration saves time, cost and labor, and provides equivalent or better efficiency in particulate removal. Sample filtration prior to LC injection protects columns from the impacts of particulates, extends column lifetime and reduces HPLC instrument downtime [2]. The major concern with filtration is the potential adsorption of active pharmaceutical ingredients (APIs) during the process, which results in lower assay values or even out-of-specification results. Another concern is the introduction of extractables to the samples from the filters, which interfere with the chromatographic separation, causing difficult peak integration and even false results.

From both qualification and quantitation aspects, unwanted drug adsorption and the presence of extractables resulting from sample filtration during routine pharmaceutical drug analysis can be a serious problem. Agilent syringe filters are tested thoroughly for cleanliness and are supplied with either HPLC or LC/MS certificates demonstrating that they are entirely or largely free of detectable extractables during filtration [3].

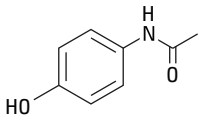
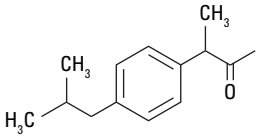
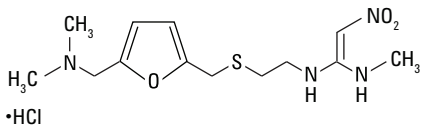
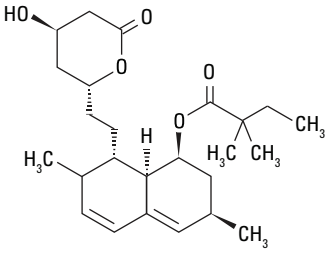
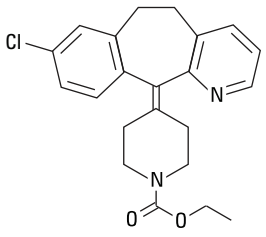
Analyte binding is usually caused by the interaction of the filter membrane and target compounds. Target compound physical properties, chemical structure, ionization state, and molecular weight, as well as product formulations, can affect these interactions. Properties of the membrane also contribute to interactions, such as the membrane polymer's chemical structure, hydrophobicity or hydrophilicity, polymer formulation and purity, and so forth. Selecting an appropriate membrane is related to the properties of the target analyte. However, it is expected that membrane selectivity for target analytes is less specific, and so certain filters can be used for a wider variety of targets. The less selective the membrane for the analyte, the broader the range of applications that the filter can be used for, with no or minimal concern related to adsorption.

Sample medium is another factor that can impact potential adsorption, as it can directly affect compound solubility and membrane wettability. The selection of appropriate filters also depends on the sample medium and the filter membrane's chemical compatibility.

- For aqueous samples, hydrophilic-type membranes are preferred, such as cellulose acetate (CA) or polyethersulfone (PES).
- For organic samples, especially with aggressive solvents, polypropylene (PP) or polytetrafluoroethylene (PTFE) filters should be used.
- For mixtures of organic and aqueous samples, PTFE, PP, nylon, regenerated cellulose (RC), and PES filters can be used, according to the percentage of aqueous/organic solvent.

This application note focuses on the evaluation of Agilent Captiva Premium syringe filters for adsorption of APIs. A variety of compounds was selected with different drug-binding properties. A wide range of sample media was used to evaluate the elution profile for different membrane types. Six types of popular syringe filters were tested, including nylon, glass fiber prefilter/nylon (GF/Nylon), RC, PES, PTFE, and GF/PTFE filters. Based on the sample medium of each drug, four different kinds of filters were evaluated for each drug.

Table 1. Molecular and structural information of tested drugs [4-8].

Drug product (brand name)	Molecule type	Molecular structure	Structural features	MW and pKa
Acetaminophen tablets (Tylenol, 500 mg/tablet)	Acetamide		Single aromatic ring, a more planar structure	MW 151.17 pKa 9.38 Log P 0.46
Ibuprofen tablets (Advil, 200 mg/tablet)	A propionic acid derivative		Single aromatic ring, flexible flat structure	MW 206.28 pKa 4.91 Log 3.97
Ranitidine HCl tablets (Zantac, 84 mg/tablet)	Hydrochloride salt of a base		Single aromatic ring, flexible flat structure	MW 350.87 (salt) MW 314.40 (base) pKa 8.08 Log P 0.27
Simvastatin tablets (Zocor, 10 mg/tablet)	Highly nonpolar compound with a lactone and ester		Nonaromatic polycyclic rings, rigid and distinct 3-D structure	MW 418.57 pKa 4.7 Log P 4.68
Loratadine tablets (Claritin, 10 mg/tablet)	Piperidine carbamate		Multiple aromatic rings, rigid and distinct 3-D structure	MW 382.88 pKa 4.8 Log P 5.20

Experimental

Chemicals and reagents

Five drugs and their properties are listed in Table 1. These drugs were purchased from local pharmacy stores.

Simvastatin USP reference standard was purchased from Rockwell Compounding Associates, Inc. (Rockville, MD, USA). Ibuprofen, acetaminophen, ranitidine HCl, and loratadine USP-level standards and other chemicals were purchased from Sigma-Aldrich Co. (St Louis, MO, USA). HPLC-grade acetonitrile (ACN) and methanol (MeOH) were from Honeywell (Muskegon, MI, USA).

Solutions and standards

Buffers, mobile phases and dissolving/diluting solutions were prepared as follows.

Acetaminophen: The mobile phase was made by combining 500 mL MeOH with 1,500 mL Milli-Q water. The mobile phase solution was also used for the dissolving/diluting solution.

Ibuprofen: The buffer (pH 4.0) was made by dissolving 10.0 g chloroacetic acid in 900 mL water, adjusting with ammonium hydroxide to pH 4.0, and then diluting to 1 L with water. The mobile phase was made by combining 1,200 mL ACN with 800 mL buffer 4.0. The dissolving/diluting solution was made by dissolving 105 mg valerophenone into 300 mL of the mobile phase solution.

Ranitidine HCl: The ammonium acetate solution (0.1 M) was made by dissolving 3.85 g ammonium acetate into 500 mL Milli-Q water. The mobile phase was made by combining 1,700 mL MeOH with 300 mL 0.1 M ammonium acetate buffer. This solution was also used as the dissolving/diluting solution.

Simvastatin: The buffer (pH 4.5) was made by dissolving 3.9 g monobasic sodium phosphate in 900 mL water, adjusting to pH 4.5 with 5 N NaOH or concentrated phosphoric acid, and then diluting to 1 L with water. The mobile phase was made by combining 1,300 mL acetonitrile and 700 mL pH 4.5 buffer. The buffer (pH 4.0) was made by adding 3.0 mL glacial acetic acid to 900 mL water, adjusting with 5 N NaOH solution to pH 4.0, and then diluting with water to 1 L. The dissolving/diluting solution was made by combining 800 mL acetonitrile and 200 mL pH 4.0 buffer.

Loratadine: The dibasic potassium phosphate buffer (0.01 M) was made by dissolving 1.74 g anhydrous K_2HPO_4 into 900 mL Milli-Q water, adjusting to pH 7.2 with concentrated phosphoric acid. The mobile phase was made by combining 600 mL MeOH, 600 mL ACN and 800 mL 0.01 M K_2HPO_4 buffer (pH 7.2). The HCl solution (0.05 N) was made by adding 41.5 mL HCl to a 500 mL volumetric flask containing approximately 400 mL water, and then diluting to volume with water. The K_2HPO_4 buffer (0.6 M) was made by dissolving 10.5 g of K_2HPO_4 to 100 mL water. The dissolving/diluting solution was made by adding 400 mL 0.05 M HCL solution and 80 mL 0.6 M K_2HPO_4 buffer to a 1 L volumetric flask, and diluting to volume with a mixture of 1:1 MeOH:ACN.

Drug standard solutions were prepared by dissolving accurately weighed amounts of standard powder into known volumes of dissolving/diluting solution. The standard solutions were then ready for HPLC injection. Table 2 shows detailed information of drug standards and sample preparation.

Sample preparation

The active ingredient concentrations in drug samples should be equivalent to concentrations in the corresponding standard solutions. Based on the active ingredient content in drug tablets, the drug assay sample solutions were prepared following the procedures in Table 2. The final drug samples were either centrifuged or filtered prior to HPLC injection.

Table 2. Drug standards and sample preparation [9-13].

Drug compound	Acetaminophen	Ibuprofen	Ranitidine HCl	Simvastatin	Loratadine
Dissolving/diluting solution (DDS)	1:3 MeOH:water	60:40 ACN:pH 4.0 buffer with 0.35 mg/mL valerophenone (IS)	85:15 MeOH:0.1 M ammonium acetate	80:20 ACN:pH 4.0 buffer	26:26:48 MeOH:ACN:buffer
Active ingredient testing concentration (mg/mL)	0.01	12	0.112	0.1	0.4
Standard solution preparation	1. Accurately weigh approximately 1 mg of standard powder 2. Dissolve in calculated volume of DDS (approximately 10 mL) 3. Dilute 1 mL of the above solution 10 times with DDS	1. Accurately weigh approximately 120 mg of standard powder 2. Dissolve in calculated volume of DDS (approximately 10 mL)	1. Accurately weigh approximately 1.12 mg of standard powder 2. Dissolve in calculated volume of DDS (approximately 10 mL)	1. Accurately weigh approximately 1 mg of standard powder 2. Dissolve in calculated volume of DDS (approximately 10 mL)	1. Accurately weigh approximately 1 mg of standard powder 2. Dissolve in calculated volume of DDS (approximately 2.5 mL)
Drug tablets	Tylenol, 500 mg/tablet	Advil, 200 mg/tablet	Zantac, 84 mg/tablet	Zocor, 10 mg/tablet	Claritin, 10 mg/tablet
Drug tablet assay sample preparation	1. Dissolve 10 tablets with DDS to 500 mL 2. Dilute 1 mL of the above solution with DDS to 1,000 mL	Dissolve 15 tablets with DDS to 250 mL	1. Dissolve 10 tablets with DDS to 250 mL 2. Dilute 16.67 mL with DDS to 500 mL	1. Dissolve 10 tablets with DDS to 250 mL 2. Dilute 25 mL with DDS to 100 mL	Dissolve 10 tablets with DDS to 250 mL

Instrumentation

USP methods were adapted to use Agilent Poroshell 120 columns. In each case, allowed modifications were implemented. The HPLC system was an Agilent 1200 Infinity Series with a DAD SL detector.

Table 3 lists HPLC conditions for each drug. Since 2.7 µm Poroshell 120 columns were used in these drug tests, and given that 0.45 µm syringe filters have been demonstrated to efficiently protect these type of columns [2], all the syringe filters used in this study had 0.45 µm membranes, and were 25 mm in diameter.

Agilent supplies

Vials:	Amber, write-on spot, 100/pk (p/n 5182-0716)
Vial caps:	Blue, screw cap, 100/pk (p/n 5182-0717)
Syringe:	10 mL, 100/pk (p/n 9301-6474)
Captiva Premium syringe filters:	Nylon (p/n 5190-5093) PTFE (p/n 5190-5087) regenerated cellulose (p/n 5190-5111) polyethersulfone (p/n 5190-5099)
Captiva Premium layered syringe filters:	Glass fiber prefilter/nylon (p/n 5190-5135) glass fiber prefilter/PTFE

Table 3. HPLC instrument conditions [9-13].

	Acetaminophen	Ibuprofen	Ranitidine HCl	Simvastatin	Loratadine
HPLC column	Agilent Poroshell 120 EC-C18, 4.6 × 75 mm, 2.7 µm (p/n 697975-902)	Agilent Poroshell 120 EC-C18, 4.6 × 75 mm, 2.7 µm (p/n 697975-902)	Agilent Poroshell 120 EC-C18, 4.6 × 75 mm, 2.7 µm (p/n 697975-902)	Agilent Poroshell 120 EC-C18, 4.6 × 75 mm, 2.7 µm (p/n 697975-902)	Agilent Poroshell 120 EC-C8, 4.6 × 50 mm, 2.7 µm (p/n 699975-906)
Mobile phase	1:3 MeOH:water	60:40 ACN:pH 4.0 buffer	85:15 MeOH:0.1 M ammonium acetate	65:35 ACN:pH 4.5 buffer	30:30:40 MeOH:ACN:0.01 M K_2HPO_4 buffer pH 7.2
Flow rate, column temperature, gradient	1.5 mL/min, room temperature, isocratic	2.0 mL/min, room temperature, isocratic	1.5 mL/min, room temperature, isocratic	1.5 mL/min, 45 °C, isocratic	1.2 mL/min, 35 °C, isocratic
UV detection (nm)	243	254	322	238	254
Injection volume (µL)	10	1	4	4	1

Sample collection

Four types of Captiva Premium syringe filters were selected for testing, all 0.45 µm pore size and 25 mm diameter. Three replicates were performed for each type of filter. A total volume of 20 mL of sample was filtered, and the 1st, 2nd, 3rd, 5th, 10th, 15th, and 20th 1 mL aliquots were collected. Samples (5 mL) were centrifuged at 4,000 rpm for 5 minutes.

Results and Discussion

For each drug compound, the results of standard solution and drug product samples (by centrifugation or filtration) were collected for comparison. As the standard solutions and corresponding drug samples were prepared with theoretically identical concentrations, the comparison of responses, either the peak area or area ratio, represent the recovery of active ingredients in the drug products. Absolute recovery and relative recovery were then calculated based on the comparison.

Absolute recovery is the comparison of centrifuged or filtered drug samples to the corresponding compound standard, using either peak area or area ratio.

Relative recovery is the comparison of filtered drug sample to the centrifuged drug sample, using either peak area or area ratio.

According to USP criteria, absolute recovery should be 100 ± 10% [9-13]. This criterion includes the drug products label-claimed percentage deviation and any additional deviations caused by the processing of the drug samples. The purpose of this application note was to evaluate whether filtering drug products would cause loss of analytes, that is, the sample process deviations. So we were more interested in relative recovery. As centrifugation is a traditional method, which usually would not cause concern of sample loss during processes, it was assumed to provide 100% process recovery. Therefore, we set the relative recovery acceptance criteria as 100 ± 1% to demonstrate the lack of risk in using filtration, as compared to centrifugation.

Acetaminophen

Acetaminophen, also known as paracetamol, is commonly used for its analgesic and antipyretic effects. The drug sample medium is 25:75 MeOH/water. The recovery using centrifugation as the sample process gave an average of 101.4% absolute recovery (n = 10). Table 4 shows the recovery results by filtration.

The results showed that when using nylon and glass/fiber nylon filters, the first 1 mL of filtrate can experience a small loss when the membrane is dry. So we recommend discarding the first 1 mL of filtrate when using nylon filters. It is not necessary to discard any filtrate when using RC and PES filters.

Table 4. Filtration recoveries of acetaminophen (n = 3).

	Nylon filter			Nylon/GF filter			RC filter			PES Filter		
	Absolute recovery	Relative recovery	RSD	Absolute recovery	Relative recovery	RSD	Absolute recovery	Relative recovery	RSD	Absolute recovery	Relative recovery	RSD
1st mL	98.3	97.0	0.47	94.4	93.1	1.34	101.0	99.6	0.00	100.8	99.4	0.17
2nd mL	101.0	99.6	0.52	100.5	99.1	0.17	101.1	99.7	0.35	101.1	99.7	0.17
3rd mL	101.1	99.7	0.17	101.3	99.9	0.30	101.2	99.8	0.17	101.0	99.6	0.30
5th mL	100.9	99.5	0.17	101.4	100.0	0.17	101.5	100.1	0.35	101.1	99.7	0.17
10th mL	101.0	99.6	0.00	101.3	99.9	0.00	101.4	100.0	0.17	101.3	99.9	0.30
15th mL	101.3	99.9	0.00	101.3	99.9	0.00	101.4	100.0	0.35	101.5	100.1	0.46
20th mL	101.0	99.6	0.30	101.3	99.9	0.00	101.3	99.9	0.00	101.3	99.9	0.30

Ibuprofen

Ibuprofen, a propionic acid derivative, is a prototypical nonsteroidal anti-inflammatory agent (NSAIA) with analgesic and antipyretic properties. The drug sample medium is 60:40 ACN:aqueous buffer. The recovery using centrifugation provided an average of 100.1% absolute recovery (n = 10). The recovery results by filtration in Table 5 show that excellent results were achieved for all types of Captiva Premium syringe filters, and that filtrate can be collected for analysis right away.

Ranitidine HCl

Ranitidine HCl is a nonimidazole blocker of the histamine receptors that mediate gastric secretion (H_2 receptors). The drug sample medium is 85:15 MeOH:aqueous buffer. The recovery results by using centrifugation gave out an average of 95.6% absolute recovery (n = 10). This result was reinforced by the filtration absolute recoveries, which indicated that the drug product contains approximately 4% less active ingredient. However, the excellent and consistent relative recoveries demonstrate that filtration is fully comparable to centrifugation without concern of analyte loss during filtration (Table 6).

Table 5. Filtration recoveries of ibuprofen (n = 3).

	PTFE filter			PTFE/GF filter			Nylon filter			RC Filter		
	Absolute recovery	Relative recovery	RSD	Absolute recovery	Relative recovery	RSD	Absolute recovery	Relative recovery	RSD	Absolute recovery	Relative recovery	RSD
1st mL	99.9	99.8	0.17	99.9	99.7	0.26	100.1	99.9	0.32	100.1	100.0	0.04
2nd mL	100.0	99.9	0.19	100.2	100.1	0.08	100.2	100.0	0.17	100.4	100.3	0.11
3rd mL	100.0	99.8	0.22	100.0	99.8	0.38	100.3	100.2	0.23	100.1	100.0	0.14
5th mL	100.0	99.9	0.12	99.9	99.8	0.26	99.9	99.8	0.36	99.9	99.8	0.28
10th mL	100.1	99.9	0.16	100.0	99.8	0.13	100.2	100.1	0.18	100.3	100.2	0.18
15th mL	100.1	100.0	0.18	99.9	99.8	0.04	100.2	100.0	0.32	100.2	100.0	0.18
20th mL	99.9	99.8	0.19	100.0	99.8	0.16	100.1	100.0	0.35	100.0	99.9	0.07

Table 6. Filtration recoveries of ranitidine HCl (n = 3).

	PTFE filter			PTFE/GF filter			Nylon filter			RC Filter		
	Absolute recovery	Relative recovery	RSD	Absolute recovery	Relative recovery	RSD	Absolute recovery	Relative recovery	RSD	Absolute recovery	Relative recovery	RSD
1st mL	95.6	100.0	0.24	95.7	100.1	0.08	96.0	100.4	0.00	96.0	100.4	0.24
2nd mL	95.9	100.2	0.21	96.0	100.4	0.14	96.2	100.6	0.00	96.0	100.4	0.29
3rd mL	95.9	100.2	0.08	95.9	100.3	0.16	95.9	100.3	0.16	96.1	100.5	0.21
5th mL	95.8	100.2	0.16	96.0	100.4	0.08	99.8	100.2	0.08	96.1	100.5	0.16
10th mL	95.9	100.3	0.24	95.9	100.2	0.08	95.9	100.3	0.28	96.0	100.4	0.14
15th mL	95.7	100.1	0.29	95.9	100.3	0.21	96.0	100.4	0.21	95.9	100.3	0.14
20th mL	95.7	100.1	0.08	96.0	100.4	0.14	96.0	100.4	0.21	96.0	100.4	0.08

Simvastatin

Simvastatin is a derivative of lovastatin and a potent competitive inhibitor of 3-hydroxy-3-methylglutaryl coenzyme A reductase. The drug sample medium is 65:35 ACN:aqueous buffer. The average absolute recovery was 97.1% (n = 10) by centrifugation, showing approximately 3% less of active ingredient in the drug product. The relative recoveries, however, showed excellent and consistent recoveries through filtration (Table 7).

Loratadine

Loratadine is a derivative of azatadine and a second-generation histamine H1 receptor antagonist used in the treatment of allergic rhinitis and urticaria. The drug sample medium is 30:30:40 ACN:MeOH:aqueous buffer. The average absolute recovery was 94.8% (n = 10) by centrifugation, showing approximately 5% less of active ingredient in the drug product. The relative recoveries, however, showed excellent and consistent recoveries through filtration (Table 8).

Table 7. Filtration recoveries of simvastatin (n = 3).

	PTFE filter			PTFE/GF filter			Nylon filter			RC Filter		
	Absolute recovery	Relative recovery	RSD	Absolute recovery	Relative recovery	RSD	Absolute recovery	Relative recovery	RSD	Absolute recovery	Relative recovery	RSD
1st mL	97.1	100.0	0.49	96.8	99.6	1.01	98.0	100.9	0.33	96.3	99.1	0.62
2nd mL	96.5	99.4	0.90	97.6	100.5	0.46	97.7	100.6	0.42	96.4	99.3	0.45
3rd mL	97.8	100.7	0.15	96.4	99.3	1.10	97.9	100.8	0.46	96.4	99.3	0.39
5th mL	97.6	100.5	0.95	96.6	99.5	1.01	97.9	100.7	0.65	96.8	99.6	0.55
10th mL	97.6	100.5	0.60	97.1	100.0	0.58	97.8	100.7	0.78	96.4	99.6	0.42
15th mL	97.6	100.5	0.08	97.4	100.3	1.35	97.8	100.7	0.71	96.9	99.8	0.29
20th mL	97.3	100.2	0.44	96.8	99.6	0.53	97.4	100.3	0.45	96.6	99.4	0.51

Table 8. Filtration recoveries of loratadine (n = 3).

	PTFE filter			PTFE/GF filter			Nylon filter			RC Filter		
	Absolute recovery	Relative recovery	RSD	Absolute recovery	Relative recovery	RSD	Absolute recovery	Relative recovery	RSD	Absolute recovery	Relative recovery	RSD
1st mL	95.0	100.2	0.84	95.3	100.6	0.48	95.1	100.3	0.23	95.2	100.4	0.48
2nd mL	95.3	100.6	0.77	94.6	99.8	1.37	95.0	100.3	0.53	95.4	100.7	0.26
3rd mL	94.7	100.0	0.71	95.2	100.5	0.31	95.3	100.5	0.40	95.0	100.3	0.38
5th mL	95.1	100.4	0.54	95.0	100.2	0.15	94.8	100.0	0.31	95.4	100.7	0.30
10th mL	94.6	99.8	0.66	95.2	100.4	0.61	94.9	100.1	0.57	95.8	100.1	0.82
15th mL	94.9	100.2	0.46	95.0	100.2	0.52	95.5	100.8	0.83	94.9	100.1	1.09
20th mL	94.7	100.0	0.09	94.6	99.8	0.15	95.3	100.5	0.30	95.2	100.4	0.38

All Captiva Premium filters were suitable for the assay of the drug products. Only nylon and glass fiber/nylon filters gave slightly lower recovery for the very first 1 mL of filtrate when filtering acetaminophen, indicating minor adsorption of this drug when the nylon membrane was dry. However, excellent recoveries were obtained for the subsequent filtrate after the first 1 mL, which demonstrated that a wetted membrane would not cause adsorption. Although excellent recoveries were obtained for all the other filters for the other drug tests, it was worthwhile discarding the first 1 mL of filtrate to ensure accuracy. Given this recommendation, all filtrate samples were retested, with the first 1 mL of filtrate discarded. The 2nd 1 mL to 20th 1 mL of filtrate were combined (approximately 6 mL in total). The mixed filtrate sample was then retested on HPLC. Triplicate tests were performed for each drug and each filter, and Table 9 shows the results. Only relative recovery data are shown as they reflect more appropriately filtration impact.

Conclusions

Membrane, sample matrix, and drug chemistry can affect the potential adsorption of drug products during filtration, and so selection of the appropriate filters (membrane type, membrane pore size, and filter size) is critical to achieve accurate and precise results. This application note showed that it may be necessary to discard the initial filtrate to ensure accuracy. Agilent Captiva Premium syringe filters with PTFE, nylon, regenerated cellulose, and PES membranes, with and without glass fiber prefilters, demonstrate excellent recoveries, and compatibility with centrifugation, for a variety of drug assay sample preparations.

Table 9. Filtration recoveries of drug and Agilent Captiva Premium syringe filters (n=3).

		Acetaminophen		Ibuprofen		Ranitidine		Simvastatin		Loratadine	
Syringe filter	Discarded volume (mL)	Mean relative recovery (%)	% RSD	Mean relative recovery (%)	% RSD	Mean relative recovery (%)	% RSD	Mean relative recovery (%)	% RSD	Mean relative recovery (%)	% RSD
PTFE	1	N/A		99.9	0.2	100.2	0.2	100.3	0.5	100.2	0.5
GF/PTFE	1	N/A		99.9	0.2	100.3	0.1	99.9	0.8	N/A	
Nylon	1	99.6	0.2	100.0	0.3	100.3	0.2	100.6	0.6	100.2	0.5
GF/Nylon	1	99.8	0.1	N/A		N/A		N/A		100.4	0.5
RC	1	99.9	0.2	100.0	0.2	100.4	0.2	99.5	0.4	100.6	0.5
PES	1	99.8	0.3	N/A		N/A		N/A		N/A	

N/A = not tested

References

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http://www.chromatographyonline.com/lcgc/article/articleDetail.jsp?id=755108.

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3. Anon. Agilent Captiva Syringe Filters. Raise Your Sample Filtration Standards. Brochure, Agilent Technologies, Inc., Publication number 5991-1230EN (2013).

4. http://www.drugbank.ca/drugs/DB00316

5. http://www.drugbank.ca/drugs/DB01050

6. http://www.drugbank.ca/drugs/DB00863

7. http://www.drugbank.ca/drugs/DB00641

8. http://www.drugbank.ca/drugs/DB00455

9. USP Monographs: Acetaminophen Tablets
http://www.pharmacopeia.cn/v29240/usp29nf24s0_m200.html
USP Monographs: Acetaminophen Capsules
http://www.pharmacopeia.cn/v29240/usp29nf24s0_m160.html#usp29nf24s0_m160

10. USP Monographs: Ibuprofen
http://www.pharmacopeia.cn/v29240/usp29nf24s0_m39860.html
USP monographs: Ibuprofen Tablets
http://www.pharmacopeia.cn/v29240/usp29nf24s0_m39890.html

11. USP Monographs: Ranitidine Tablets
http://www.pharmacopeia.cn/v29240/usp29nf24s0_m73048.html
USP Monographs: Ranitidine Hydrochloride
http://www.pharmacopeia.cn/v29240/usp29nf24s0_m73040.html

12. USP Monographs: Simvastatin Tablets
http://www.pharmacopeia.cn/v29240/usp29nf24s0_m75460.html
USP Monographs: Simvastatin.
http://www.pharmacopeia.cn/v29240/usp29nf24s0_m75450.html

13. USP Monographs: Loratadine Tablets
http://www.pharmacopeia.cn/v29240/usp29nf24s0_m45896.html
USP Monographs: Loratadine.
http://www.pharmacopeia.cn/v29240/usp29nf24s0_m45894.html

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Printed in the USA
May 14, 2013
5991-2409EN

Agilent Technologies