SILICYCLE

E-PAK® Cartridges

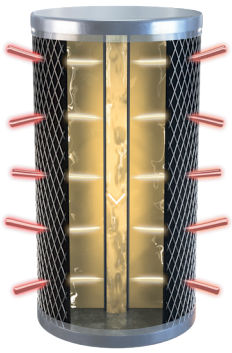
Flow-through Fixed Bed Radial Purification Cartridges

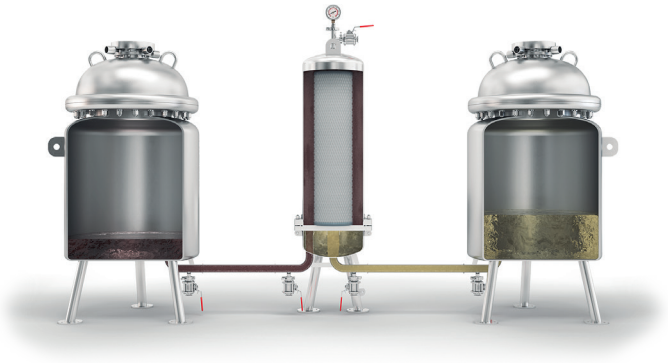
Scavengers in E-PAK Flow Cartridges

E-PAK is a family of radial flow adsorption cartridges developed specifically for pharmaceutical processings.

Created with proprietary technology, E-PAK cartridges provide rapid adsorption kinetics at flow rates and processing capacities suitable for laboratory, pilot and commercial operations.

They are designed for use with both organic and aqueous solvents, and incorporate design features useful for the production of active pharmaceutical ingredients (*API*).



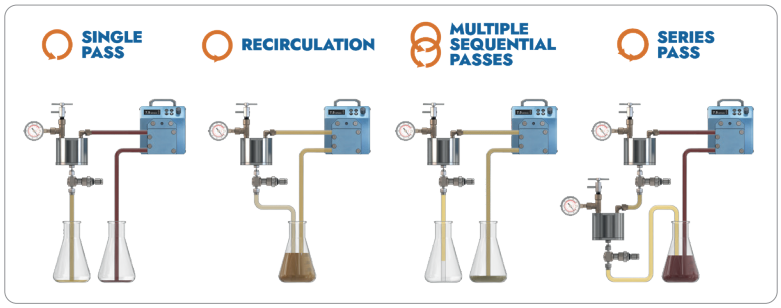


Features and Benefits

- Proven cartridge design ensures rapid, simple and reliable technology
- High adsorption capacity and flow rate
- Fixed-bed design ensuring safer handling, clean-up and disposal
- Large adsorbent capacity in small area footprint increases product recovery and reduces solvent requirements

Various Ways of Using E-PAK

Depending on the application and how you prefer to work, E-PAK cartridges can be used in different ways as shown below on all housing scales (*lab, pilot and commercial scale)*.



For a single pass usage, we suggest to run at very low flow rate compared to recirculation process, which can be run at higher flow rate.

Click on the picture below to access the video on E-PAK purification methods.

Sorbents for E-PAK Cartridges

E-PAK cartridges are available in a range of sorbents to accommodate the broad range of processing requirements. Other adsorbents are available under request.

Sorbents for E-PAK		
Active Adsorbents (*Typical Loading*)	**For Removal And / Or Recovery of:**	**pH Operation**
Silia*MetS* Thiol (*1.2 mmol/g*)	**Pd, Ag, Au, Hg, Os & Ru** Cu, Ir, Pb, Rh, Se, Sn & U	2 to 9
Silia*MetS* DMT (*0.5 mmol/g*)	**Pd, Ag, As, Au, Bi, Ir, Ni, Os, Pt, Rh, Ru, Se & U** Cd, Co, Cu, Fe, Sc & Zn	
Silia*MetS* Imidazole (*0.96 mmol/g*)	**Cd, Co, Cu, Fe, Ir, Li, Mg, Ni, Os, U, W & Zn** Cr, Pd & Rh	
Silia*MetS* AMPA (*0.8 mmol/g*)	**Al, Ce, Dy, Er, Eu, Gd, Ho, La, Lu, Mg, Mn, Nd, Ni, Pm, Pr, Sb, Sm, Tb, Tm, V, Yb & Zr** Co, Cu, Fe & Zn	
Silia*Bond* Amine (*1.2 mmol/g*)	**Pd, Cr, Pt, Rh, W & Zn** Cd, Co, Cu, Fe, Hg, Ni, Pb, Ru, Sc, Se & U	
Silia*MetS* Diamine (*1.28 mmol/g*)		
Silia*MetS* Triamine (*1.11 mmol/g*)		
Silia*MetS* TAAcONa (*0.41 mmol/g*)	**Bi, Ca, Cd, Cs, Cu, Fe, Ir, La, Li, Mg, Ni, Os, Rh, Ru, Sc & U** Cr, Pd, Se & Sn	
Silia*Bond* Cyano (*1.38 mmol/g*) and **Florisil®**	Various organic molecules	
Silia*Bond* Propylsulfonic Acid SCX-2 (*0.63 meq/g*)	Amines & anilines, ion exchange	
Silia*Flash* Bare Silica	Very vast range of organic impurities, metals, pigments, etc.	
Activated Carbon Silia*Carb* C-CA	Precious metal catalysts & colors	1 to 13
Activated Carbon Silia*Carb* C-HA		
Activated Carbon Silia*Carb* C-VA		
Activated Carbon Silia*Carb* C-VW		

Best scavenger for the removal of a particular metal is indicated in Navy Blue while good scavenger is indicated in Pale Blue.

Solvent Compatibility

E-PAK cartridges are manufactured using a proprietary technology and chemically stable materials in most common organic solvents. They have been tested and found satisfactory for use with the following commonly used solvents:

- 2-Butanone
- Dichloromethane
- Ethanol
- Ethyl acetate
- Heptane
- Methanol
- MTBE
- N-ethyl-2-pyrrolidone
- Tetrahydrofuran (*at room temperature*)
- Toluene (*at room temperature*)

E-PAK Cartridges Portfolio

Lab Scale

Lab scale cartridges are designed to facilitate small samples evaluation. Testing with loose media can be done with samples as small as a few milliliters and is normally done before cartridge testing to identify the formula with the highest capacity to remove contaminants with the highest recovery.

Lab Scale Cartridges				
Cartridge Size Diameter × Height	Typical Flow Rate Range	Pressure Drop with w/1 cP Fluid	Media Weight	
			SiliaFlash, SiliaMetS & SiliaBond	SiliaCarb
5 × 1 cm	1 - 20 mL/min	≤ 5 psig	8 g	5 g
5 × 10 cm	10 - 200 mL/min	≤ 5 psig	75 g	50 g
5 × 25 cm	25 - 500 mL/min	≤ 5 psig	200 g	125 g

Note: Faster flow rates can be used for the lab scale cartridges depending on the application or the scavenging difficulty (*1 cm up to 100 mL/min, 10 cm up to 500 mL/min and 25 cm up to 1 L/min*).

Pilot & Commercial Scale

E-PAK pilot scale cartridges provide rapid processing for volumes from 10 to hundreds of liters, and can establish the parameters upon moving to larger scales, since E-PAK achieve true linear scalability. E-PAK commercial scale cartridges provide rapid processing for manufacturing operations needing to process batch sizes of > 10,000 litres or can be adapted for continuous operation using a duplex design.

Pilot & Commercial Scale Cartridges				
Cartridge Size Diameter × Height	Typical Flow Rate Range	Pressure Drop with w/1 cps Fluid	Media Weight	
			SiliaFlash, SiliaMetS & SiliaBond	SiliaCarb
Pilot Scale				
16.5 × 12.5 cm	0.10 - 2.5 L/min	≤ 10 psig	0.87 kg	0.55 kg
16.5 × 25 cm	0.25 - 5 L/min	≤ 10 psig	1.75 kg	1.10 kg
Commercial Scale				
16.5 × 50 cm	0.50 - 10 L/min	≤ 10 psig	3.50 kg	2.10 kg
16.5 × 100 cm	1 - 20 L/min	≤ 10 psig	7.00 kg	4.10 kg

Both pilot and commercial cartridges are provided with a Code 8 (*closed top & open bottom end caps-bottom with double 2-222 Teflon® encapsulated Viton® o-ring*) cartridge sealing configuration. To meet commercial processing requirements, E-PAK cartridges can be operated in parallel for increased capacity.

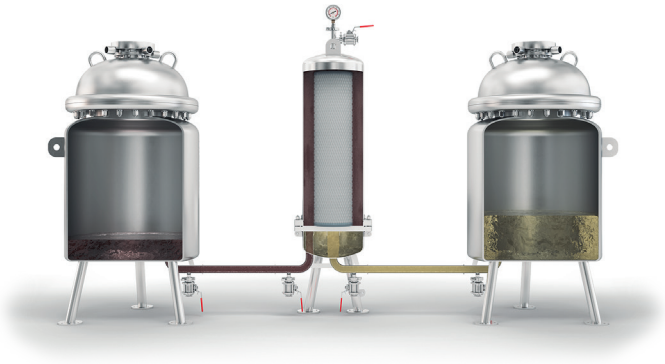
E-PAK Cartridges Housing

Lab Scale

- Various housing lengths available (*for 1 cm, 10 cm, and 25 cm cartridges*)
- Made in stainless steel 316L or Hastelloy C276
- Pressure rating for housing 150 psi (*10 bar*)
- Easy housing conversion for all lengths by changing the bowl
- Operated with standard pump, low pressure and peristatic

Pilot & Commercial Scale

- Various housings available for simultaneous operation of 1 to 12 cartridges (*for 12.5 cm, 25 cm, 50 cm, and 100 cm cartridges*)
- Made in stainless steel 316L or Hastelloy C276
- Pressure rating for housing 150 psi (*10 bar*)
- Can be operated in parallel to process batch sizes of ≥ 1,000 L
- ASME and PED 2014/68/EU, CE compliant



Scale-Up Calculation

Although there are always exceptions, scale-up projections based on a linear extrapolation of adsorbent mass have proven to be quite accurate when test conditions including contact time, temperature, solvent type, and contaminant and compound levels are held constant.

The following table shows the scale-up / relative change in mass between lab, pilot and commercial size E-PAK cartridges available with activated carbons and scavengers.

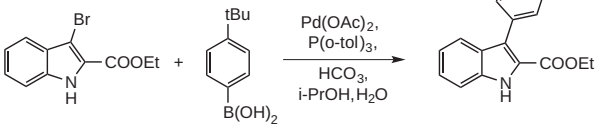
Scale-Up Calculation for Various Adsorbents							
Cartridge Sizes (*cm*)	**5 × 1**	**5 × 10**	**5 × 25**	**16.5 × 12.5**	**16.5 × 25**	**16.5 × 50**	**16.5 × 100**
Typical Scale-up Factor	-	10	25	110	220	440	875
Mass of Activated Carbon (*g*)	5	50	125	550	1,100	2,100	4,100
Mass of Silica (*g*)	8	75	200	875	1,750	3,500	7,000
# mmol Silia*MetS* AMPA (*0.8 mmol/g*)	6.4	60	160	700	1,400	2,800	3,600
# mmol Silia*MetS* Diamine (*1.28 mmol/g*)	10.2	96	256	1,120	2,240	4,480	8,960
# mmol Silia*MetS* DMT (*0.50 mmol/g*)	4.0	38	100	438	875	1,750	3,500
# mmol Silia*MetS* Imidazole (*0.96 mmol/g*)	7.7	72	192	840	1,680	3,360	6,720
# mmol Silia*MetS* TAAcONa (*0.41 mmol/g*)	3.3	31	82	359	717	1,435	2,870
# mmol Silia*MetS* Triamine (*1.11 mmol/g*)	8.9	83	222	971	1,942	3,885	7,770
# mmol Silia*MetS* Thiol (*1.20 mmol/g*)	9.6	90	240	1,050	2,100	4,200	8,400
# mmol Silia*Bond* Amine (*1.20 mmol/g*)	9.6	90	240	1,050	2,100	4,200	8,400
# mmol Silia*Bond* Cyano (*1.38 mmol/g*)	11.0	103	276	1,207	2,415	4,830	9,660
# mmol Silia*Bond* SCX-2 (*0.63 meq/g*)	5.0	47	126	551	1,102	2,205	4,410
Bed Volume (*cm³*)	18.8	188	470	2,375	4,750	9,500	19,000
Recommended Flow Rate (*mL/min*)	7.5	75	190	950	1,900	3,800	7,600
Typical Flow Rate Range (*mL/min*)	1 - 20	10 - 200	25 - 500	100 - 2,500	250 - 5,000	500 - 10,000	1,000 - 20,000
Approximated Tank Volume (*mL*)	50	200	450	2,500	5,000	11,600	23,300
Minimum System Flushing (*mL*)	150	600	1,350	7,500	15,000	35,000	70,000

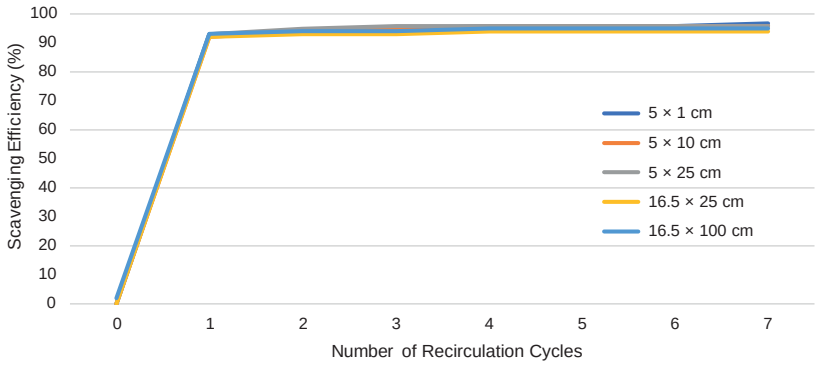
Measurement Methodology:

- **Scale-up Factor**: mass of silica / 8 g *(smallest size)*.
- **Mass of Activated Carbon** (*g*) / **Mass of Silica** (*g*): amount of Silia*Carb* / Silia*MetS* / Silia*Bond* in the cartridge.
- **# mmol Silia*MetS* / Silia*Bond* XXX** (*X.X mmol/g*): silica mass × typical loading of Silia*MetS* / Silia*Bond*
- **Bed Volume** (*cm³*): total volume of the cartridge without the volume of the hole.
- **Recommended Flow Rate** (*mL/min*): for residence times of 2.5 minutes.
- **Flow Rate Range** (*mL/min*): for residence times from 1 to 20 minutes. Faster flow rate can be used for some applications.
- **Minimum System Flushing** (*mL*): corresponds to 3 tank volumes measured experimentally with the cartridges inside the housing. The volume of solvents needed for conditioning can vary depending on experimental conditions. It is recommended to do a minimum of 3 system flushing before use.

Scale-Up Linearity Demonstration

Using the Suzuki-Miyaura reaction shown below, with ≈ 12 molar equiv., scale-up reactions were performed from lab to commercial scale. As you can see, each format behaved similarly in terms of efficiency and kinetics.

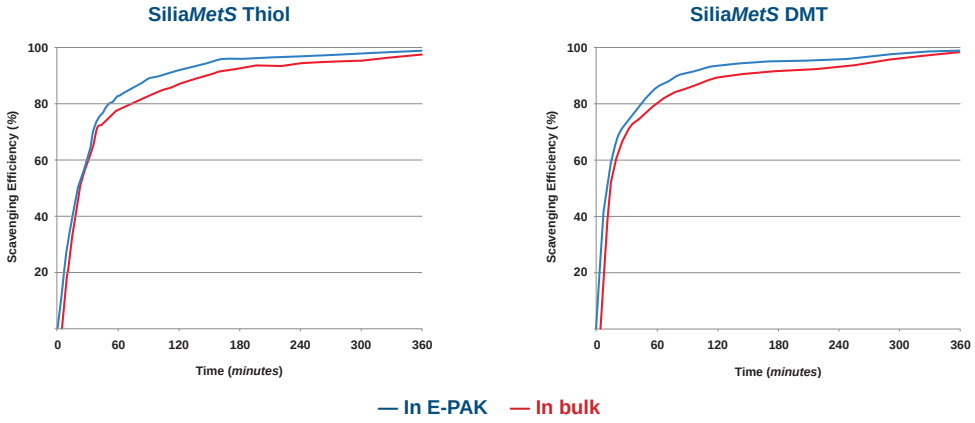




Pd Scavenging: Bulk vs E-PAK

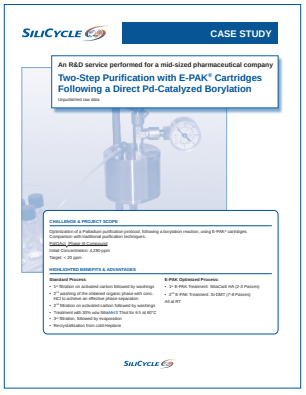
A typical Suzuki-Miyaura reaction was performed (*see above*). Silia*MetS* in a 5 × 1 cm E-PAK and bulk (≈ *8 molar equiv.*), solution recirculated at 50 mL/min for E-PAK, contact time of 6 h for both.

No backpressure was observed for E-PAK with a slightly faster scavenging efficiency versus bulk.



■ Consult our Application Note Appn_SM004 “Silia*MetS* VS E-PAK”

Case Study: Two-Step Purification with E-PAK Cartridges Following a Direct Pd-Catalyzed Borylation



Optimization of a Palladium purification protocol, following a borylation reaction, using E-PAK cartridges. Comparison with traditional purification techniques.

- $Pd(OAc)_2$ Phase III Compound
- Initial Concentration: 4,280 ppm
- Target: < 20 ppm

■ Read the case study on our website: CS_EP001 “Two-Step Purification with E-PAK Cartridges Following a Direct Pd-Catalyzed Borylation”

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We Redefine Purity

High Value Silica-based and Specialty Products for Organic Chemistry, Chromatography and Purification

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METAL AND ORGANIC SCAVENGING

Silia*MetS*® – Metal Scavengers
Silia*Bond*® – Organic Scavengers
E-PAK® – Fixed Bed Flow-Through Purification Cartridges



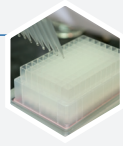

CHROMATOGRAPHY AND PURIFICATION

Silia*Flash*® – Irregular Silica Gels | **Silia*Sphere*™ PC** – Spherical Silica Gels
Silia*Bond*® – Chromatographic Phases
Silia*Sep*™ – Flash Cartridges | **Silia*Plate*™** – TLC Plates



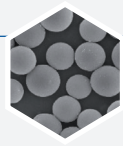

SAMPLE PREPARATION

Silia*Prep*™ – Silica-based SPE Cartridges and Well Plates
Silia*PrepX*™ – Polymeric SPE Cartridges and Well Plates

ANALYTICAL AND PREPARATIVE CHROMATOGRAPHY

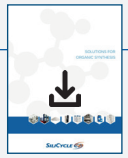
Silia*Sphere*™ – Spherical Silica Gels
Silia*Chrom*® – HPLC Columns

ORGANIC SYNTHESIS

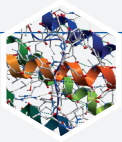
Silia*Bond*® – Reagents and Oxidants
Silia*Cat*® – Heterogeneous Catalysts



PEPTIDE SYNTHESIS

Peptide Synthesis and Purification Solutions
Amine Free Basing and TFA Removal




R&D SERVICES

Metal and Organic Scavenging Screenings | Organic Synthesis
Chromatography and Purification | Material Science
Method Development, Optimization, and Transfer




Technical Support

At SiliCycle, we are committed to providing the best technical support possible.

Our worldwide Technical Support Group of highly qualified M. Sc., Ph. D. Chemists and Engineers will answer your questions and provide solutions to your most advanced chemistry and purification needs. Contact us at **support@silicycle.com** or **call us**.

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