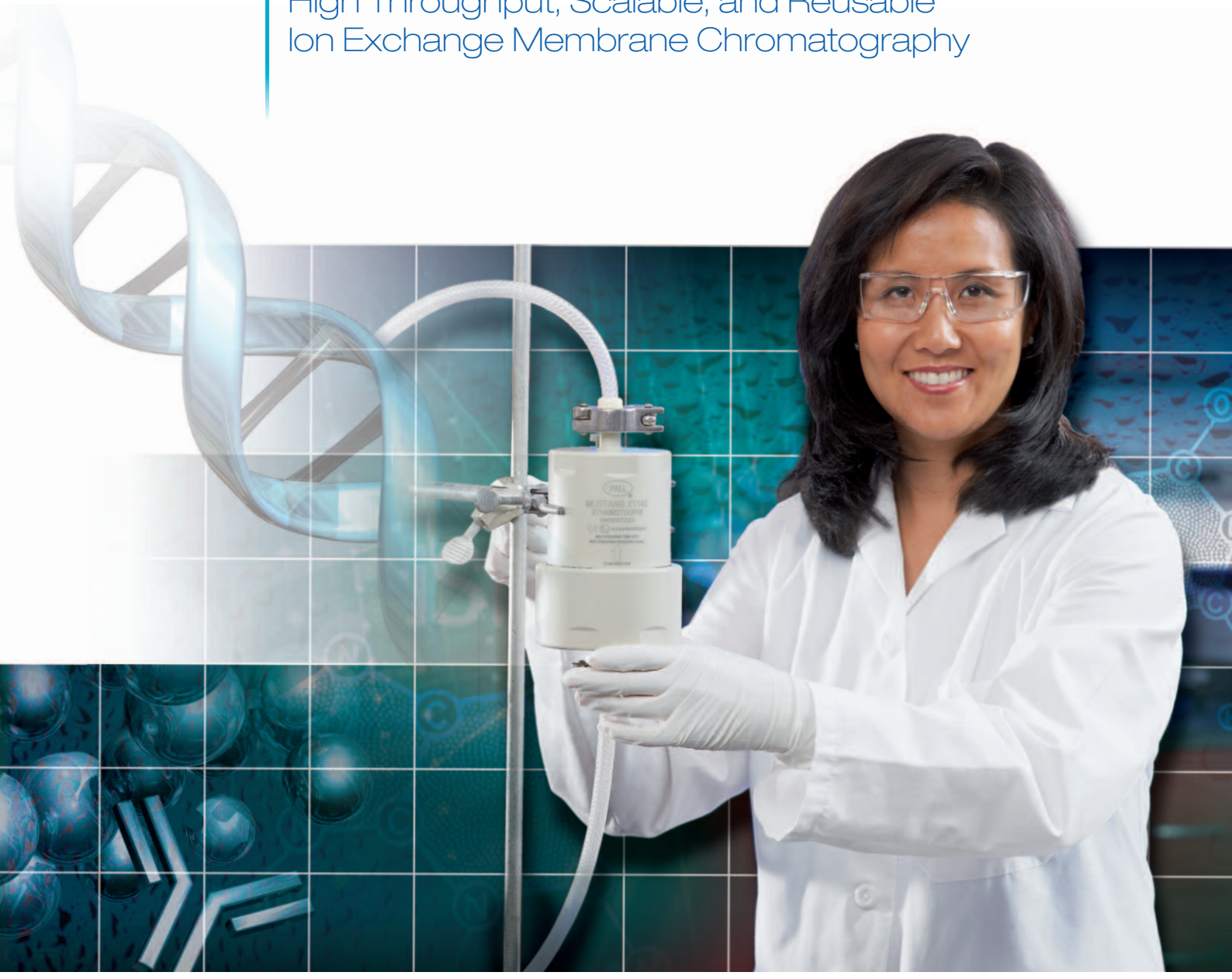
PALL Life Sciences

USD 2599

Mustang® Q XT Chromatography Capsules

High Throughput, Scalable, and Reusable Ion Exchange Membrane Chromatography



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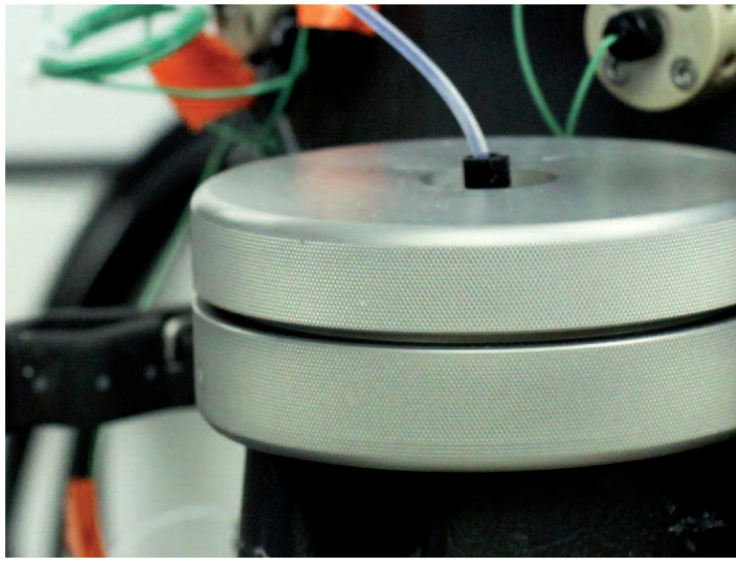
Meeting Process Demands for Scalability and Economy

The use of ion exchange chromatography for purification in downstream processing is well established. Many regulatory approved processes make use of large process columns packed with ion exchange sorbent for effective and reliable performance. As demand intensifies for improved throughput and reduced processing costs, Pall's Mustang ion exchange membrane technology keeps pace, enabling process developers to:

- Reduce process times through use of high volumetric flow rates.
- Improve process economics through increased throughput and reduced buffer consumption.
- Enhance process flexibility through use of a much smaller operating footprint.
- Increase process capacities by linking units in parallel or series.

Pall has combined its competencies in membrane device design and chromatography to develop a range of high-performance, scalable Mustang Q XT membrane chromatography capsules. These capsules are reliable, easy to use and enable users to significantly improve their process economics through reduced buffer consumption, increased throughput and reduced capital expenditure. Processes benefit from:

- **High Binding Efficiency** – Mustang Q XT capsules exhibit high capacities and high flow at low pressure drops, allowing binding of charged biomolecules in a single pass.
- **Speed** – High flow rates enable the processing of large volumes in less than a single working shift. Mustang Q XT5000 capsules typically operate at 10 MV/min flow rates (50 L/min) making membrane chromatography 30 to 50 times faster than conventional chromatography sorbents.
- **Scalability and Flexibility** – A full range of capsule sizes accommodates various volumes and capacities required in biopharmaceutical processing, from process development to full-scale manufacturing. Capsules can be used as single-use or cleaned and reused.
- **Reproducibility** – Capsules are manufactured using the Six Sigma statistical process control system to ensure reproducible process and conformance to specifications, and enable consistent process performance.
- **Convenience** – Easy-to-use capsules eliminate need for packing protocols. If used as disposables, there are no cleaning, cleaning validation, or cross-contamination issues.
- **Lower Cost** – Membrane capsules offer lower operating and capital investment costs than conventional columns that require validated packing and cleaning protocols.
- **Reduced Buffer Consumption** – Small device footprint requires significantly less buffer yet maintains efficient contaminant removal performance.



Each Mustang Q XT capsule is made with the same materials of construction and void volume-to-membrane ratio for scalable chromatographic performance. The XT5 device, shown above with the XT5 Jacket, is ideal for scale-down optimization studies.

Proven Applications

Mustang Q capsules with the same membrane technology and smaller membrane volumes are proven in a wide range of approved processes and clinical trials for applications such as:

- Contaminant removal for DNA, virus, host cell protein, and endotoxin
- Plasmid, virus, protein capture, and oligonucleotide purification
- Column guard to enhance selectivity of subsequent chromatography steps

Scalable Design

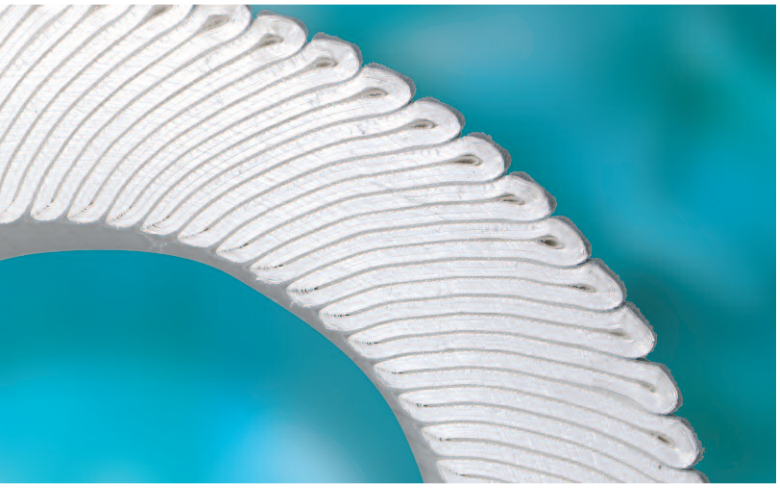
Scalable Mustang Q XT products meet processing requirements in a range of volumes:

- Mustang Q XT5: 5 mL capsule, for laboratory scale process development work
- Mustang Q XT140: 140 mL capsule, for pilot scale work and small scale clinical manufacturing runs
- Mustang Q XT5000: 5 L process scale capsule, for process scale clinical manufacturing

Featuring Innovative Membrane Chromatography Capsule Design

Robust, Reusable, Scalable Capsule Design

Mustang Q XT capsules are available in 5 mL, 140 mL and 5 liter volumes, and are constructed with 16 layers of Pall's advanced Mustang membrane for consistent performance and scale up. Process capacities can be increased by linking units in parallel or series. Set-up is simple, and each device is 100% integrity tested before shipment for added assurance of quality performance.



Pall's patented Ultipleat technology minimizes hold-up volume and significantly reduces buffer consumption.

Mustang Q XT140 and XT5000 capsules incorporate patented Ultipleat® membrane pleating technology to maximize membrane volume and maintain a small device footprint. This unique pleating technology also minimizes hold-up volume to enhance chromatographic performance and significantly reduce buffer consumption.

The durable polypropylene housings have been designed to minimize upstream and downstream hold-up volume, enhancing chromatographic performance. The housings provide the chemical stability needed for cleaning, reuse and long-term storage, allowing sanitization and storage in 0.1 M NaOH/1 M NaCl for up to 12 months.

Advanced Mustang Membrane Technology

Mustang membrane chromatography continues to make advances in chromatographic separations. Mustang membrane is a polyethersulfone (PES)-based membrane with a 0.8 µm nominal pore size and a surface coating of an irreversibly cross-linked polymer containing pendant Q groups. Mustang chromatography allows access to all of the membrane binding sites for small biomolecules (mononucleotides), large biomolecules (pDNA), and virus particles by direct fluid convection.

The open pore structure of Mustang membrane eliminates the diffusion limitations of sorbents, allowing biomolecules to access all binding sites by direct fluid convection. This means that high dynamic binding capacities and sharp breakthrough curves are achieved over a very wide range of flow rates and a large range of molecular sizes. This property results in significant advantages over sorbents packed in columns, especially where high flow rates may be used and where large molecules are to be captured or removed.

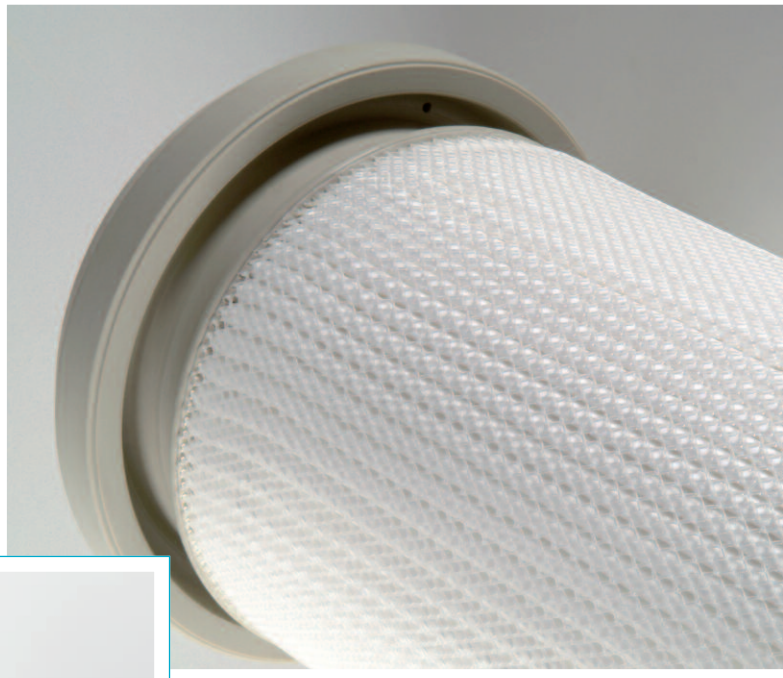
Mustang Q XT Capsules Offer Consistent Scale Up Performance

Device	HSA in Elution (g)	HSA Binding Capacity (g/L)	ΔP at 10 MV/min (psig)
Coin (0.35 mL)	0.013	36	7.1
Mustang XT5 (5 mL)	0.172	34	10
Mustang XT140 (140 mL)	4.2	30	7.5
Mustang XT5000 (5 L)	212	42	7.9

HSA dynamic binding capacity from the capture of clarified human plasma on differently-sized Mustang Q XT capsules at a flow rate of 10 MV/min demonstrating scalability with respect to protein dynamic binding capacity.

High Quality Standards

- Manufactured to high quality assurance standards in accordance with ISO 9000
- Membrane lots tested for dynamic protein and DNA binding capacity
- Identified by lot number and a unique serial number for complete traceability of manufacturing history, satisfying stringent QC/QA requirements
- Supplied with Certificate of Analysis to confirm Pall quality standards
- Meets USP biological reactivity tests *in vivo* in accordance with requirements for USP Class VI-50 °C Plastics and all materials listed in Drug Master File submitted to the FDA



Mustang Q XT capsules pack big Mustang membrane performance into a small device footprint, delivering processing performance typically reserved for much larger systems. The XT5000 capsule, shown above and left, is ideal for process-scale manufacturing applications.

Ensuring Highly Efficient Contaminant Removal

Mustang Q XT capsules use the same Mustang Q membrane technology already accepted in a wide range of regulatory approved processes and clinical trials for applications such as:

- Efficient contaminant removal in polishing applications (host cell protein, DNA and virus)
- Capture of relatively large target molecules (recombinant proteins, plasmids, viral vectors and blood plasma fractions)

In applications where efficient contaminant removal is the goal, the benefits of using Mustang membrane chromatography are considerable. The open pore structure of the Mustang membrane enables very high flow rates while giving sufficient binding capacity to remove trace levels of contaminants such as host cell protein (HCP), DNA, virus and endotoxin.

Adding Mustang Q XT Capsules to the Chromatography Process Can Improve Viral Clearance and Enhance Selectivity of Subsequent Chromatography Steps

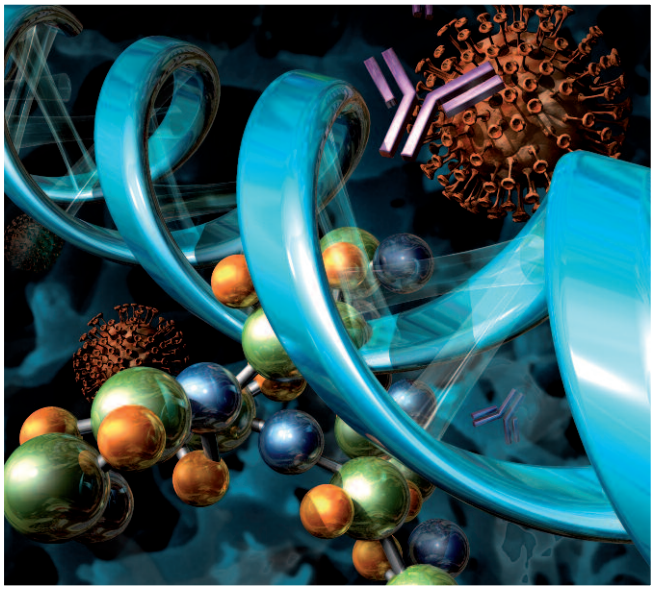
	Virus Spike	Mustang Q XT5 Capsule LRV	LRV of Subsequent Chromatography Steps	LRV of Subsequent Viral Clearance Step	Total LRV
Initial Process	MLV		Run A > 7.55	Run A > 4.10	11.65
			Run B > 7.61	Run B > 4.11	11.72
	Reo3		Run A > 8.37	Run A > 4.38	12.75
			Run B > 10.04	Run B > 4.26	14.30
	MVM		Run A > 2.90	Run A > 4.74	7.64
			Run B > 3.51	Run B > 4.56	8.07
New Process with Mustang Q Membrane Pre-capture	MLV	Run A > 4.52	Run A > 9.87	Run A > 4.06	18.45
		Run B > 4.57	Run B > 10.31	Run B > 4.05	18.93
	Reo3	Run A > 4.78	Run A > 11.39	Run A > 4.16	20.33
		Run B > 5.13	Run B > 11.39	Run B > 4.22	20.74
	MVM	Run A > 4.81	Run A > 10.75	Run A > 5.15	20.71
		Run B > 5.17	Run B > 11.69	Run B > 5.50	22.36

Data shows spiked model virus removal (Log Removal Value, LRV) in an optimized downstream process using a Mustang Q XT5 capsule (sample loaded at pH 7.5, conductivity 5.5 mS/cm). The addition of a Mustang Q XT capsule to the process provides orthogonal viral clearance and leads to improved clearance in the subsequent chromatography steps. (Data courtesy of Dr. Iann Rancé, Cytheris.)

Optimization of Mustang Q Coin for Host Cell Protein (HCP) Removal

Sample Description	IgG Concentration (mg/mL)	ng HCP/mg mAb
Load	3.1	208
Mustang Q Loading pH 6.5, conductivity 11 mS/cm	2.8	32
Mustang Q Loading pH 6.5, conductivity 4 mS/cm	0.9	19
Mustang Q Loading pH 8.0, conductivity 11 mS/cm	2.8	16
Mustang Q Loading pH 8.0, conductivity 4 mS/cm	0.9	4

The HCP protein removal data was obtained from a protein A purified mAb (pI ~8.7) that was pH adjusted with 3M Tris base and conductivity lowered by dilution with 18 MΩ water. The flow rate was 3.5 mL/min (10 MV/min) on a Mustang Q coin (0.35 mL = 1 MV) with a mAb load volume of 257 MV (~90 mL) at 0.9 mg/mL mAb concentration in pH 8.0 and 4 mS/cm conductivity.



The open-pore structure of Mustang membrane makes Mustang Q XT capsules especially useful in high flow rate contaminant removal applications and in the capture or removal of large molecules.

Use of Mustang Q Membrane for Removal of CHO DNA and Host Cell Protein (HCP) from a Monoclonal Antibody Feedstream

		DNA			HCP		
	IgG Recovery	Content (pg/mg of IgG) by RT PCR		Removal Factor	Content (ng/mg of IgG) by ELISA		Removal Factor
Run	%	Before Mustang Q Membrane	After Mustang Q Membrane	Log	Before Mustang Q Membrane	After Mustang Q Membrane	Log
1	95	663	1.2	2.7	6.0	1.9	0.5
2	99	426	1.2	2.6	6.0	2.9	0.3
3	99	29	0.8	1.5	9.0	4.0	0.3
4	95	513	1.3	2.6	8.0	4.1	0.3
5	97	61	2.1	1.5	2.0	2.9	0.0
6	98	148	0.7	2.3	2.0	1.2	0.2
7	101	46	1.1	1.6	9.0	2.6	0.5
8	98	807	1.1	2.8	6.0	1.6	0.5
9	94	377	2.2	2.6	9.0	3.6	0.4
10	85	2619	2.7	3.0	7.0	4.9	0.3
	96 ± 4	**DNA**		**2.3 ± 0.6**	**HCP**		**0.3 ± 0.2**

Data shows use of Mustang Q membrane for removal of CHO DNA and HCP from a monoclonal antibody feedstream (pH 8.0, 75 mM NaCl, 700 mg/mL load). Mustang Q membrane provides efficient contaminant removal and high IgG recovery over a series of runs. Data courtesy of LFB Biotechnologies, Les Ulis, France, presented at the Sixth Plasma Product Biotechnology meeting, Menorca, Spain, May 11th-15th 2009.)

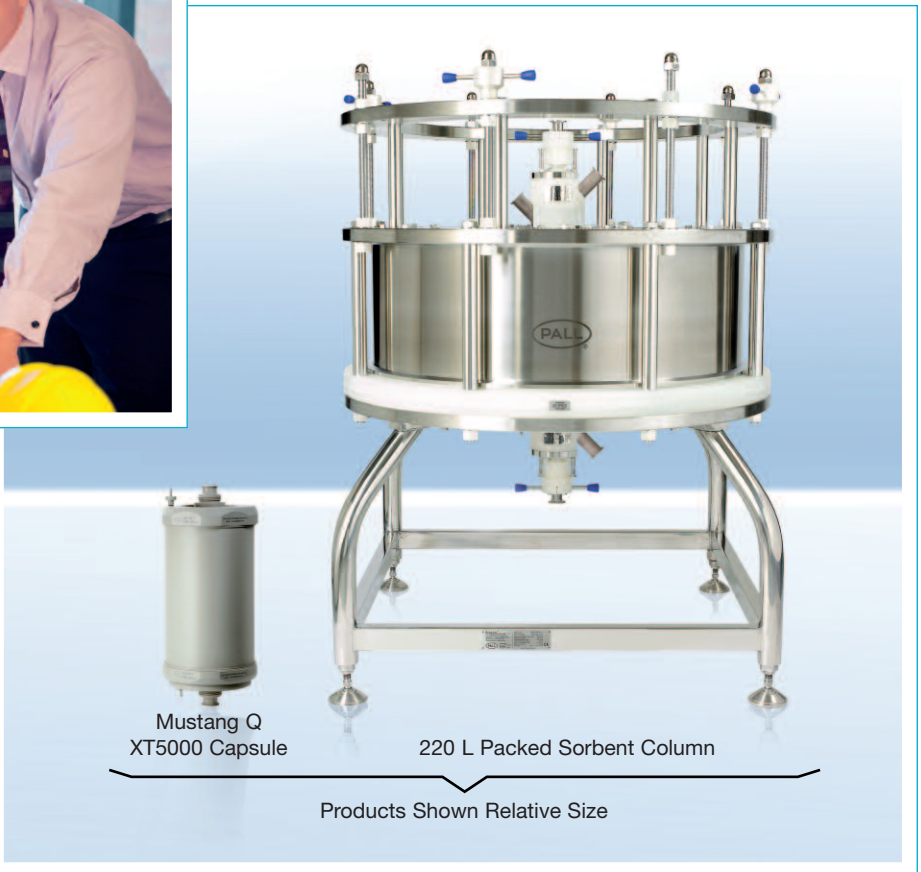
Enhancing Process Economics and Flexibility

In many applications, the dynamic binding capacity of Mustang Q membrane is equivalent to or greater than the equivalent sorbent chemistries. And unlike sorbents, the dynamic binding capacity is independent of flow rate. In polishing applications where low levels of contaminants must be removed, this results in high flow rates (more than 10 MV/min) and low pressure drops that can be fully exploited with minimum membrane volume.

Considering that a 5 L Mustang Q XT5000 capsule has equivalent contaminant removal performance to a 220 L packed sorbent, the process economic benefits of using Mustang membrane chromatography in polishing applications are easy to see:

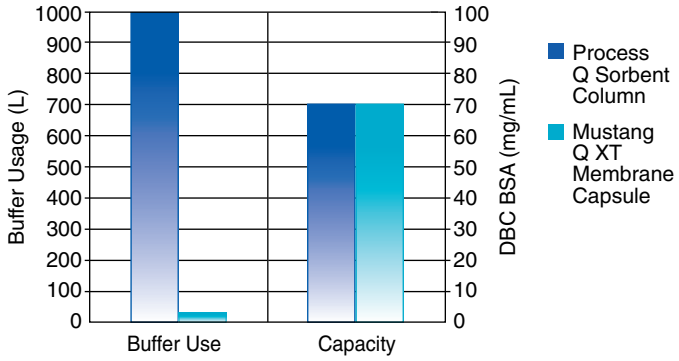
- Smaller footprint
- Reduced buffer consumption
- Reduced processing times
- Labor savings
- No cleaning or cleaning validation costs (if used as a disposable)

Pall's experienced specialists work with our customers to design and implement strategies that streamline processes and reduce overall costs.



The XT5000 capsule provides equivalent or better flow rate and contaminant removal performance to a 220 L packed sorbent column in a much smaller device footprint, making Mustang Q XT capsules ideal for flow through polishing applications.

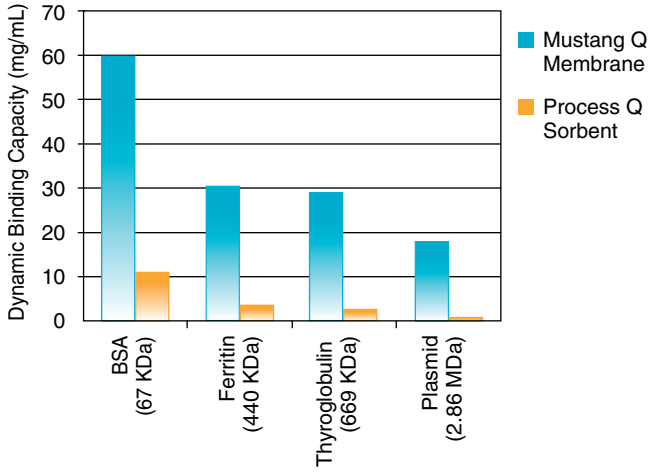
Using Mustang Q XT Capsules Significantly Reduces Buffer Consumption



Comparison of buffer usage between Mustang Q XT5000 membrane capsule and a 220 L process chromatography column, single use at 50 L/min volumetric flow.

In capture applications where the target molecule is relatively large, Mustang membrane exhibits improved capacities and recoveries, and higher flow rates compared to packed bed sorbents. Each Mustang Q XT capsule is engineered with a uniform flow path and very low total volume-to-membrane-volume ratio, enabling good resolution with high yields and minimal elution volumes.

Mustang Q Membrane Exhibits High Dynamic Binding Capacities



Testing performed at 3 CV or 3 MV/min flow rates.

Mustang Q XT140 Capsule Provides Efficient Capture and Recovery of Plasmid DNA (7kb) from *E. Coli* Lysate

Fraction (7 kb) Mustang XT140	Total Volume (L)	pDNA (g/L)	Endotoxin (EU/mg)	Total pDNA (g)	Yield (%)
Filtered Lysate	36.8	0.10	*	3.68	–
Mustang Q pDNA Pool	3.33	0.89	204	2.96	80

Clarified lysate loading conductivity of 89.6 mS/cm was obtained by dilution with 18 MΩ water following classical alkaline lysis and neutralization with 7M ammonium acetate plus 1M potassium acetate. The plasmid DNA lysate was loaded in two cycles at 10 MV/min flow rate. (Data courtesy of A. Carnes, Natures Technology, Wilbio Conference, November 2008.)
**Not measured, but typical endotoxin levels from E. Coli lysate 2.1x10^6 (S. Zhang, A. Krivosheyeva and S. Nochumson. Biotechnol. Appl. Biochem. [2003] 37, 245-249.)*

Add Flexibility to Your Process

The Pall family of Mustang Q XT membrane chromatography capsules offers a flexible solution to bioprocessing challenges, providing process developers the option of a disposable single-use device that requires no cleaning validation, or a reuse option for better process economics. Additionally, the low pressure drop, low dead volume, and small footprint of the Mustang Q XT capsules mean that systems may be configured with multiple units for even higher throughput per cycle in large-volume applications with scalable performance.

Specifications

Materials of Construction

	5 L Process Capsule	140 mL Pilot Scale Capsule	5 mL Scale Down Capsule
Part Number	**XT5000MSTGQP1**	**XT140MSTGQP05**	**XT5MSTGQPM6**
Membrane	Modified hydrophilic polyethersulfone (PES) membrane	Modified hydrophilic polyethersulfone (PES) membrane	Modified hydrophilic polyethersulfone (PES) membrane
Membrane Support and Drainage	Polypropylene	Polypropylene	Polypropylene
Core/Cage/Endcaps	Polypropylene	Not applicable	Not applicable
Housing	Polypropylene	Polypropylene	Polypropylene
O-rings	Silicone	Silicone	Silicone
Valve	Polypropylene	Polypropylene	Not applicable

Mustang XT stand is 316/316L stainless steel.

Operating Characteristics*

	5 L Process Capsule	140 mL Pilot Scale Capsule	5 mL Scale Down Capsule
Part Number	**XT5000MSTGQP1**	**XT140MSTGQP05**	**XT5MSTGQPM6**
Maximum Operating Temperature	38 °C	38 °C	38 °C
Maximum Operating Pressure	3 barg (43.5 psig) at 38 °C	3 barg (43.5 psig) at 38 °C	5 barg (75.0 psig) at 38 °C**
Maximum Differential Pressure	3 barg (43.5 psig) at 38 °C	3 barg (43.5 psig) at 38 °C	5 barg (75.0 psig) at 38 °C**
Storage Conditions	0.1 M NaOH plus 1 M NaCl	0.1 M NaOH plus 1 M NaCl	0.1 M NaOH plus 1 M NaCl

** With fully compatible fluids that do not soften, swell or adversely affect the capsule or its materials of construction.*
*** Maximum operating pressure for the Mustang XT5 capsule is 13 barg (196 psig) at 38 °C when used with the XT5 Jacket.*

Nominal Dimensions

Part Number	5 L Process Capsule	140 mL Pilot Scale Capsule	5 mL Scale Down Capsule
Length without Protective Inlet/Outlet Caps	605 mm (23.8 in.)	190 mm (7.48 in.)	39 mm (1.5 in.)
Diameter of Capsule Body (Central Section)	246 mm (9.7 in.)	91 mm (3.6 in.)	97 mm (3.8 in.)
Diameter at Inlet/Outlet Ends	270 mm (10.6 in.)	Inlet: 107 mm (4.21 in.) Outlet: 90 mm (3.54 in.)	Not applicable
Diameter Across Flats at Inlet/Outlet Ends	Not applicable	Inlet: 104 mm (4.09 in.) Outlet: 86 mm (3.39 in.)	Not applicable
Weight Dry	10.3 kg (22.7 lb.)	768 grams (1.5 lb.)	187.2 grams (6.6 oz.)
Weight Drained (Wet Membrane)	14.2 kg (31.3 lb.)	917 grams (1.8 lb.)	191.2 grams (6.74 oz.)
Weight in Use (Filled)	19.6 kg (43.2 lb.)	1009 grams (2.0 lb.)	195.0 grams (6.88 oz.)
Connectors	38 mm (1.5 in.) sanitary flange	12.7 mm (0.5 in.) sanitary flange	Female M6 threads

Ordering Information

Mustang Q XT Membrane Chromatography Capsules

Part Number	Description	Packaging
XT5000MSTGQP1	Mustang Q XT5000, Q chemistry with 5 L membrane volume for clinical manufacturing	1/pkg
XT140MSTGQP05	Mustang Q XT140, Q chemistry with 140 mL membrane volume for pilot scale process development	1/pkg
XT5MSTGQPM6	Mustang Q XT5, Q chemistry with 5 mL membrane volume for scale-down process development; the capsule inlet and outlet have female M6 threads and include connectors and tubing	1/pkg
XT5MSTGJKT	Mustang XT5 Jacket, to be used when operating a chromatography workstation that gives inlet pressures in excess of 5 barg (75 psi) when operated at flow rates of 50 mL/min	1/pkg

Mustang XT5000 Stand

Part Number	Description	Packaging
XT5000B100	Stand base	1/pkg
XT5000T100	Top portion of stand	1/pkg
XT5000H100	Handle	1/pkg

Optimize Your Scale Up with Pall

When it is time to scale up your process, Pall offers a comprehensive range of pilot- and process-scale PK chromatography control systems. PK systems:

- Ensure your purification is consistent and optimal at pilot and manufacturing scales
- Provide flexibility and execution of all biochromatography applications
- Exhibit robust operation from hardware and software
- Cover a range of applications from 10 to 4000 L/h

Pall offers the most comprehensive range of chromatography products for biopharmaceutical manufacturing including scalable sorbents, columns, and systems. Our industry-leading technical support can help to ensure the most efficient development, start-up and lifetime operation of your processes, thereby lowering operating costs.

Visit www.pall.com/biopharm to learn more.

PALL Life Sciences

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The information provided in this literature was reviewed for accuracy at the time of publication. Product data may be subject to change without notice. For current information consult your local Pall distributor or contact Pall directly.

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9/09, 2K, GN09.2908 USD 2599