



Ion Exchange Chromatography

Toyopearl Resins for IEC

650 series for most proteins

Anion Exchange

Toyopearl DEAE-650

Toyopearl SuperQ-650

Cation Exchange

Toyopearl CM-650

Toyopearl SP-650

650 series for very high protein capacity

Toyopearl GigaCap S-650 **NEW!**

Toyopearl GigaCap Q-650 **NEW!**

550 series for smaller proteins

Anion Exchange

Toyopearl QAE-550

Cation Exchange

Toyopearl SP-550

Toyopearl MegaCap II SP-550

TSK-GEL High Performance Resins for IEC

For all proteins

Anion Exchange

TSK-GEL SuperQ-5PW

TSK-GEL DEAE-5PW

Cation Exchange

TSK-GEL SP-5PW

ToyoScreen Process Development Columns for IEC

Toyopearl Ion Exchange Chromatography resins

Ion Exchange Chromatography (IEC) is the most common liquid chromatographic method used in manufacturing therapeutic proteins. Due to the high dynamic binding capacities of ion exchange resins relative to those of the other chromatographic modes (*Table 1*), it is the technique selected by many developers for the capture or concentration chromatographic step.

Tosoh Bioscience offers a broad range of products for ion exchange applications.

How does IEC work?

IEC is based on the binding of proteins to positively or negatively charged groups which are immobilized on a stationary phase and which are in equilibrium with free counter ions in the mobile phase. In the process of adsorption, the mobile phase counter ions are exchanged by the protein solute. The binding of proteins to the ion exchange matrix predominantly occurs via charged amino acid residues located at the surface of the protein molecule.

The development of optimum chromatographic system conditions requires knowledge of both the protein's pI and the pK_a of the ion exchange media. A binding buffer pH is selected between the pI of the target and the ion exchanger's pK_a (*Figure 1*). This ensures that the protein is in the opposite charge state compared to the ion exchange media. When possible, the pH is also optimized to effect the highest solubility of the target protein. Higher protein solubilities make more efficient use of the overall ion exchange capacity of the resin.

A salt is selected as the source of counter ions in the mobile phase and elution occurs as the salt strength is increased to a higher concentration than the target's binding salt conditions.

Ion exchange groups available

Toyopearl and TSK-GEL IEC resins are available with 7 different ion exchange groups as shown in *Table II*:

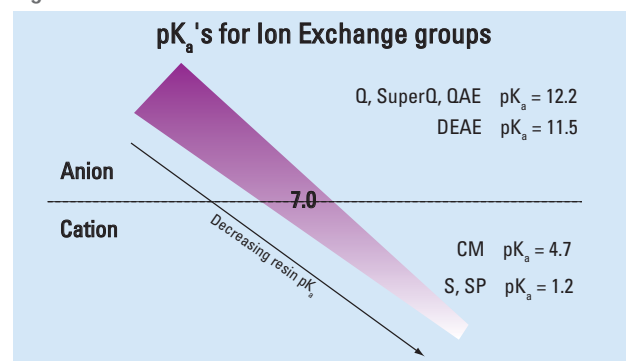
- 4 for anion exchange – SuperQ, QAE, DEAE, Q
- 3 for cation exchange – SP, CM, S

The pK_a 's for these ion exchange groups are listed in *Figure 1*.

Table I

Separation mode	Binding capacity for standard proteins (mg/mL)	Binding capacity in production processes (mg/mL)
Ion Exchange	200 - 300	50 - 100
Hydrophobic Interaction	40 - 60	10 - 30
Affinity (group specific ligands)	40 - 100	20 - 60
Reversed Phase (polymeric media)	60 - 100	30 - 50

Figure 1



Pore sizes offered

Tosoh Bioscience offers a broad range of base bead pore sizes (*Figure 2*). There are currently 2 different mean pore diameters used for the ion exchangers: 1000 Å and 500 Å.

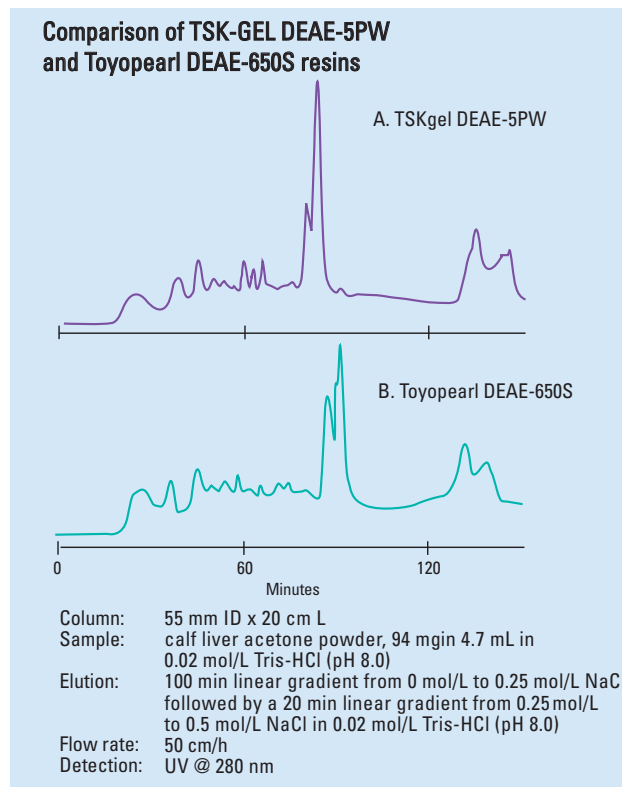
- Toyopearl GigaCap Q-650, Toyopearl GigaCap S-650, Toyopearl SuperQ-650, DEAE-650, SP-650, and CM-650; utilize the 1000 Å mean pore diameter size exclusion chromatography (SEC) resin Toyopearl HW-65 as the base bead.
- TSK-GEL SuperQ-5PW, SP-5PW, and DEAE-5PW use the 1000 Å mean pore diameter TSK-GEL G5000PW SEC resin as the support.
- Toyopearl QAE-550C, SP-550C, and Toyopearl MegaCap II SP-550EC use Toyopearl HW-55 as the base resin, with a 500 Å mean pore diameter.

Features		Benefits
porous, hydrophilic polymer based resin		<ul style="list-style-type: none"> • suitable for laboratory scale and process chromatography
chemical stability		<ul style="list-style-type: none"> • autoclavable at 121°C • temperature range 4°-60°C • pH range 2-13, can be regenerated with acid or base • compatible with organic solvents
column bed stability		<ul style="list-style-type: none"> • constant packing volume over a wide range of salt concentrations
mechanical stability		<ul style="list-style-type: none"> • excellent flow characterization in large industrial columns (up to 7 bar)
continuous selectivity		<ul style="list-style-type: none"> • easy scale up from TSK-GEL IEC columns • high yields of biologically active proteins

Table II

Structure of Toyopearl ion exchange resins		
Toyopearl resin	Pore size	Functional group
DEAE-650S DEAE-650M DEAE-650C	1000 Å	-O-CH ₂ -CH ₂ -HN ⁺ -(C ₂ H ₅) ₂ anion exchanger
GigaCap Q-650M SuperQ-650S SuperQ-650M SuperQ-650C	1000 Å	-O-R'-N ⁺ -(CH ₃) ₃ strong anion exchanger
QAE-550C	500 Å	-O-CH ₂ -CH ₂ -N ⁺ -(CH ₃) ₃ strong anion exchanger
CM-650S CM-650M CM-650C	1000 Å	-O-CH ₂ -COO ⁻ weak cation exchanger
GigaCap S-650M	1000 Å	-O-R'-SO ₃ ⁻ strong anion exchanger
SP-650S SP-650M SP-650C	1000 Å	-O-R'-O-CH ₂ -CH ₂ -CH ₂ -SO ₃ ⁻ strong cation exchanger
SP-550C MegaCap II SP-550EC	500 Å	-O-R'-O-CH ₂ -CH ₂ -CH ₂ -SO ₃ ⁻ strong cation exchanger

Figure 4



Higher surface area = more capacity

A bead with a small pore size has more surface area than the same size bead with a larger pore. If a protein will fit into the smaller pore, (see Figure 3), it will typically have a higher dynamic binding capacity than the larger pore version. For a comparison of the dynamic binding capacities of most Toyopearl anion exchangers, see Figure 5. For a comparison of the dynamic binding capacity of Toyopearl strong cation exchange resins, please see Table V.

Figure 2

Tosoh methacrylic base beads available for IEC							
Pore size (Å)	50	125	400-500	750	1000	>1000	>1700
Product name							
Toyopearl HW:	40	50	55	60	65	75	80
TSK-GEL PW:	G1000	G2000	G4000	G5000		G6000	

← Increasing pore surface area →

Figure 3

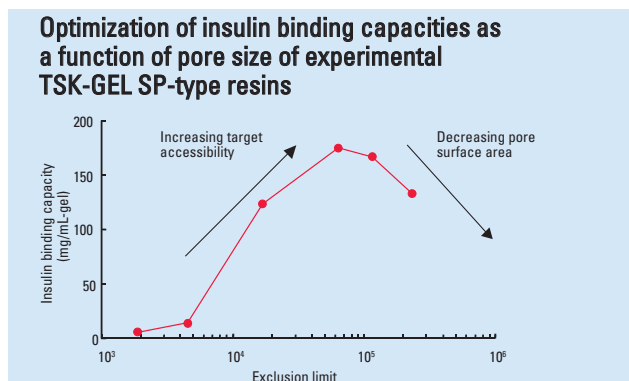


Figure 5

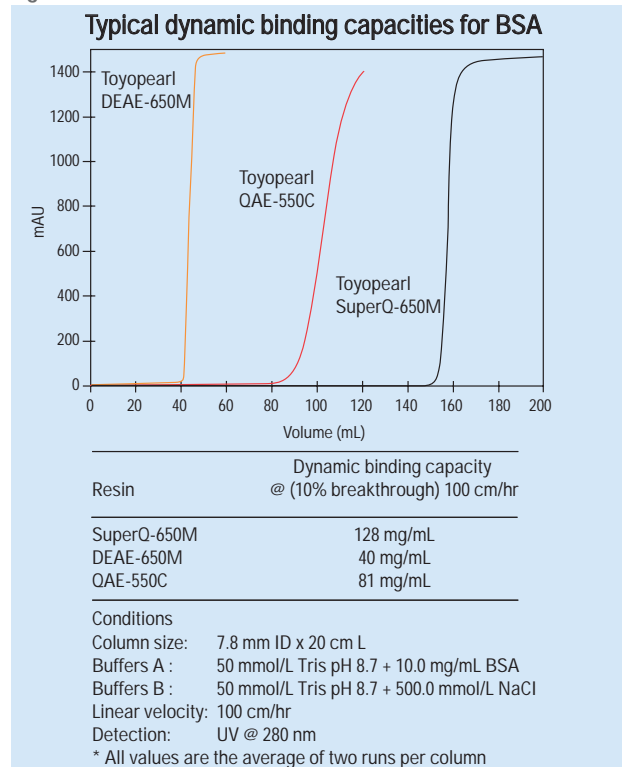
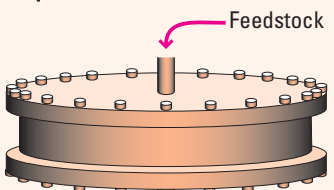
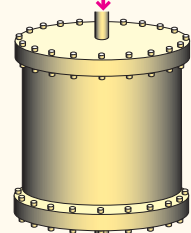
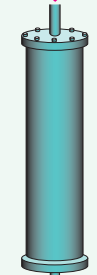








Figure 6

Process step	Bead size	Process media	
		Anion	Cation
 Capture	200 μm		Toyopearl MegaCap II SP-550EC
	100 μm	Toyopearl SuperQ-650C Toyopearl DEAE-650C Toyopearl QAE-550C	Toyopearl SP-650C Toyopearl SP-550C Toyopearl CM-650C
 Intermediate Purification	75 μm	Toyopearl GigaCap Q-650M	Toyopearl GigaCap S-650M
	65 μm	Toyopearl SuperQ-650M Toyopearl DEAE-650M	Toyopearl SP-650M Toyopearl CM-650M
	35 μm	Toyopearl SuperQ-650S Toyopearl DEAE-650S	Toyopearl SP-650S Toyopearl CM-650S
 Polishing	30 μm	TSKgel SuperQ-5PW (30) TSKgel DEAE-5PW (30)	TSKgel SP-5PW (30)
	20 μm	TSKgel SuperQ-5PW (20) TSKgel DEAE-5PW (20)	TSKgel SP-5PW (20)
 QC Pure Product	10 μm	TSKgel SuperQ-5PW 7.5mmID x 7.5cmL TSKgel DEAE-5PW 7.5mmID x 7.5cmL	TSKgel SP-5PW 7.5mmID x 7.5cmL TSKgel CM-5PW 7.5mmID x 7.5cmL

Same selectivity HPLC columns are available for most process media

IEC Resins are available in 4 particle diameter ranges:

	S	20 - 40 μm	(Superfine)
	M	40 - 90 μm	(Medium)
	M	50 - 100 μm	(Medium)*
	C	50 - 150 μm	(Coarse)
	EC	100 - 300 μm	(Extra Coarse)

*For both capture and intermediate purification

Multiple particle sizes simplify scaling up or down

Because Toyopearl HW-65 and TSK-GEL 5000PW products have the same resin backbone chemistry and selectivity, scale-up or scale-down for a selected ion exchanger is simple. Practically speaking, the chromatographic conditions that work for one particle size will work for a different particle size. The elution order of the feedstock components will remain the same with increasing resolution as the particle size gets smaller (Figure 4).

Figure 6 lists the complete range of ion exchange products, their particle sizes, and suggests how they are typically placed into a manufacturing scheme. Please note that the specific particles shown are in mean diameter sizes of: 200 (EC), 100 (C), 75, 65 (M), 35 (S), 30, and 20 μm .

Also, a number of products are available as prepacked TSK-GEL analytical columns which utilize 5 and 10 μm versions of the beads. Please refer to our Laboratory Catalog or our website www.tskgel.com for more information on these items.

Mechanical stability

If recommended packing procedures are followed, Toyopearl and TSK-GEL IEC resins maintain stable bed volumes during the pH and ionic strength changes that occur during normal ion exchange chromatography (Consult our Toyopearl and TSK-GEL 5PW Packing Guide for the recommended packing conditions for each ion exchanger). Multi-cycle gradient operation and re-equilibration are accomplished without volume changes in the Toyopearl column bed. Notice in Figure 7 that the bed volume of competitive anion exchangers may change several percent during the course of a salt or pH gradient.

The mechanical stability of Toyopearl resins allows the use of longer column beds with more efficiency or higher operational flow rates. Typical linear velocities for Toyopearl SP-550C (100 μm particle) packed in a 140 cm ID process column are shown in Figure 8. The pressure-flow relationship remains linear up to 600 cm/h. The recommended operational backpressure for Toyopearl resins is a maximum of 7 bar (105 psi).

TSK-GEL IEC resins have a smaller particle size and a corresponding higher intrinsic backpressure than the Toyopearl products. Since the TSK-GEL type resins have the same backbone methacrylic polymer chemistry as their larger particle Toyopearl complementary products, their degree of crosslinking is slightly higher allowing them to withstand operational backpressures up to 20 bar (300 psi).

Figure 7

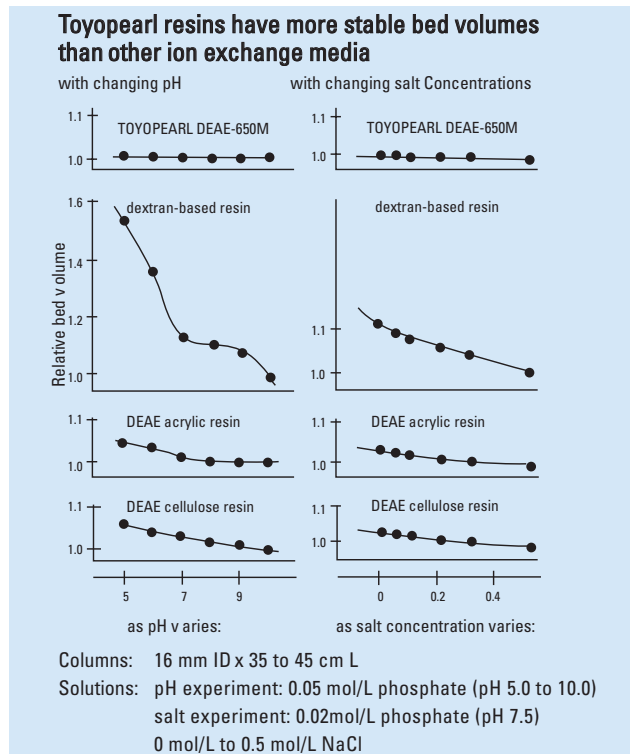
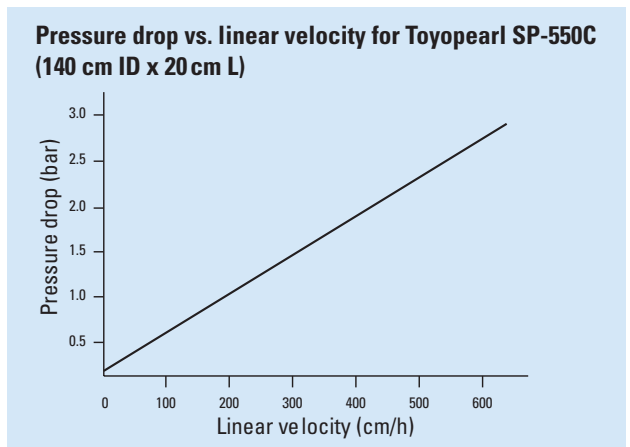


Figure 8



Scale up from a 14 mm ID to a 600 mm ID column

A 5000-fold scale-up of the β -galactosidase enzyme purification was accomplished using Toyopearl DEAE-650M. The chromatograms in Figure 9 demonstrate the excellent scale up characteristics of Toyopearl ion exchange media. Gradient slope and particle diameter remained unchanged in the scale up. Linear velocity was reduced by 15% in the largest scale separation, and resolution actually improved relative to the smallest scale separation. This may be partly attributed to increased bed height and the slower linear velocity. Although the column volume was increased in part by increasing the bed height, the principal change in column volume was a result of the greater column diameter (14 mm to 600 mm). This example illustrates how Toyopearl media can be conveniently scaled up from laboratory to production scale applications using the same particle size if desired.

Figure 9

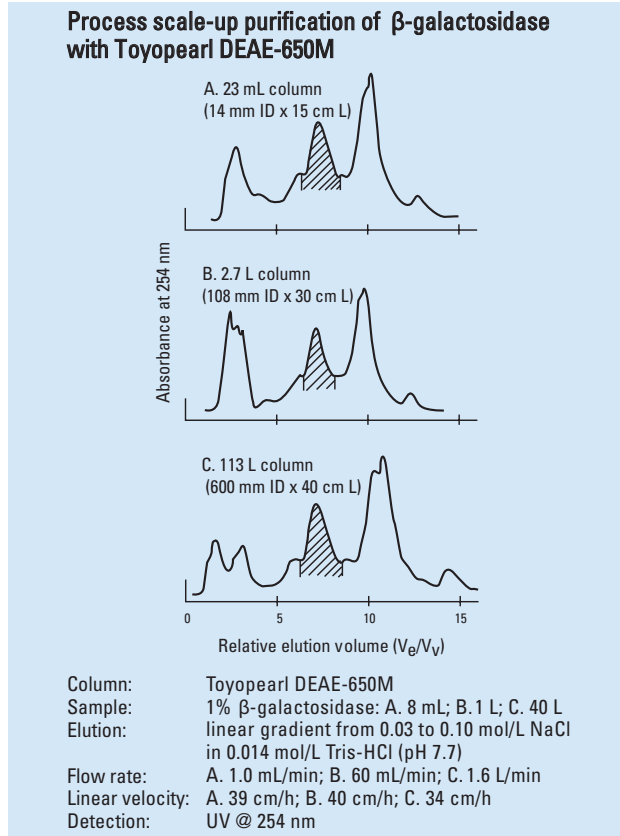


Figure 10

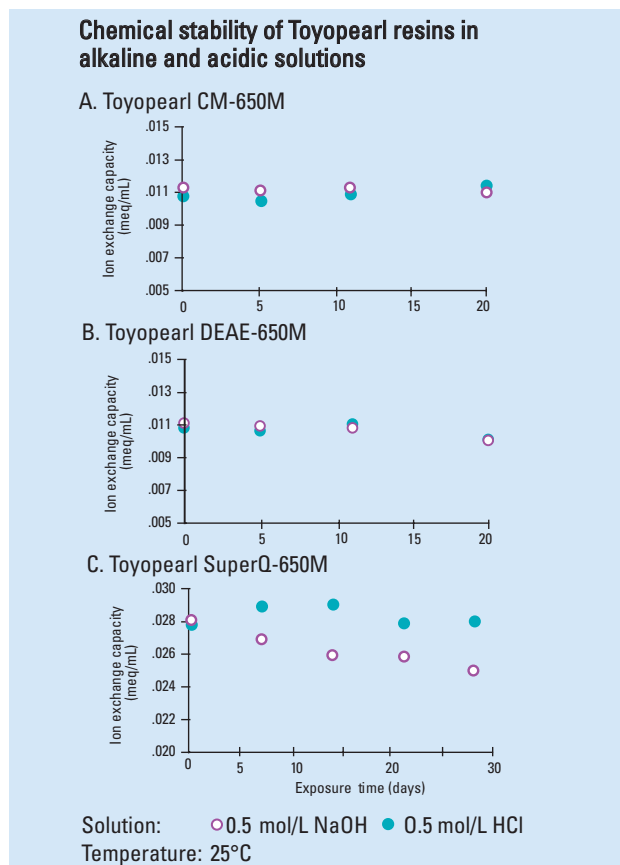


Figure 11

Toyopearl DEAE-650M can be autoclaved at 121°C

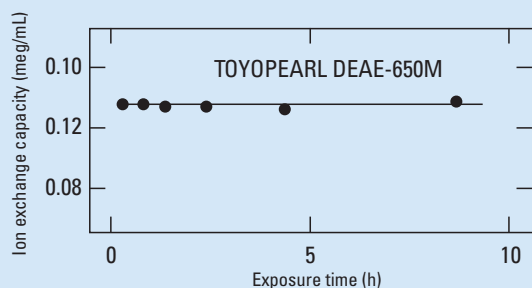


Table III

Recovery of enzymatic activity on Toyopearl CM-650M

Protein	MW (Da)	% Activity recovery
Phospholipase D	~56,000	87
Lipid transfer protein	69,000	91
Purine nucleotide phosphorylase	68,000	99

Table IV

Recovery of enzymatic activity on Toyopearl DEAE-650M

Protein	MW (Da)	% Activity recovery
Phospholipase D	~56,000	92
Prolyl endopeptidase	79,000	96
Alanine dehydrogenase	240,000	79
Phenylalanine dehydrogenase	310,000	95
Serine acetyltransferase	650,000	95

Chemical stability and routine cleaning

The polymeric base resins of all Toyopearl and TSK-GEL ion exchangers are chemically and thermally stable. Caustic or acidic solutions may be used for cleaning, sanitization and depyrogenation (Figure 10). Although ten days of exposure to strong base (pH = 12) decreases the small ion capacity of Toyopearl SuperQ-650M, the bovine serum albumin adsorption capacity remains constant after 28 days of exposure. Overnight cleaning or sterilization procedures with strong acid or base are therefore possible with Toyopearl and TSK-GEL ion exchange resins. These resins can also be autoclaved at 121°C (Figure 11).

Protein recovery

Toyopearl and TSK-GEL ion exchange resins deliver exceptional protein mass recovery, as shown in Table III and IV. The mass recovery percentage of each protein was determined spectrophotometrically from the recovered fractions. Retention of activity indicates that protein-resin interactions do not disrupt the native conformation of the product. Nonspecific protein/resin interactions, which can lead to protein inactivation or irreversible binding, are minimized with Toyopearl resins.

The capture step

Ion exchange chromatography is well known for its high binding capacities of charged biomolecules. These high capacities allow the adsorption of significant quantities of target from a dilute feedstock and then the subsequent elution of the same molecule into a more concentrated fraction.

This is one of the principal reasons ion exchange is most often chosen as the initial capture step in a process. It is also the reason that ion exchange may be used after a diluting unit operation such as size exclusion chromatography.

Feedstock clarity and particle size selection

There are many considerations in the choice of the right particle size for an ion exchange capture step. If the feedstock has a high level of particulate, is viscous, etc. then a traditional adsorbent step using a very large particle, such as a 600 µm bead, is utilized. However, large particle diameters compromise adsorption because of their poor binding kinetics. This can lead to increased load times, longer elution times and low dynamic binding capacities.

On the other hand, if the feedstock has been clarified, such as through a 0.2 µm filter, then smaller particle sizes can be used and the bead size selection is more influenced by the pressure and flow specifications of the pumps and column hardware.

Because the smaller bead has faster adsorption kinetics, its effective dynamic binding capacity is significantly higher than that of the very large particles. The improved kinetics provided by the smaller particle sizes also allows the loading of feedstocks at higher linear velocities.

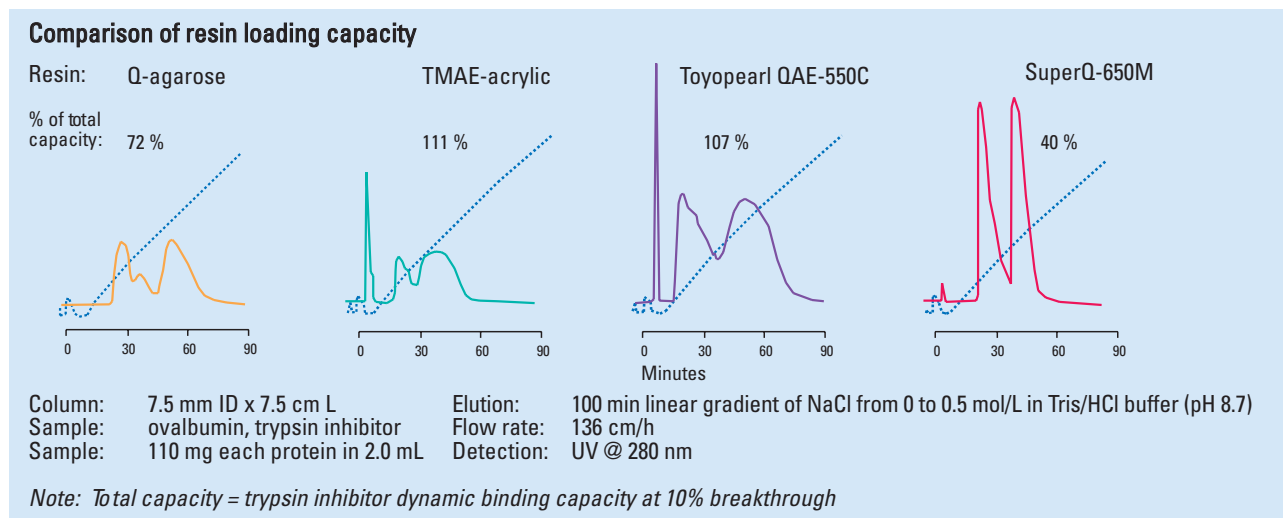
A column packed with a smaller particle will also have more theoretical plates than one of the same dimensions packed with larger particles, thus increasing separation efficiency. Higher efficiency translates to higher resolution which can enhance the purity of the eluted product.

Tosoh Bioscience offers a wide range of particle sizes to address the needs of most process steps as seen in Figure 6 (page 16).

The importance of target recovery

Product recovery is of critical importance whether dealing with expensive feedstocks such as mammalian cells or scarce resources such as the isolation of proteins from blood. A 3-step purification train with a 90% product recovery at each step will yield 73% of the original target feedstock load. If an 80% recovery is achieved for each step the process will have only a 51% yield. This means that twice as much feedstock is required to produce a given quantity of target. Also of importance is the retention of the molecule's bioactivity throughout the process.

Figure 12



The high dynamic binding capacity of a given resin must be coupled with its bioactivity yield to compare with other resins. In many cases lower dynamic binding capacity resins with 100% mass and bioactivity recovery are a better choice than a higher capacity resin with compromised mass yield and bioactivity.

Toyopearl and TSK-GEL polymeric ion exchangers are excellent choices when bioactivity recovery is paramount.

Downstream steps

IEC steps also may have greater resolving power. This can be influenced by a number of variables such as: particle size, functional group, salt concentration, salt type, pH, and specific immobilization chemistry.

For this reason ion exchange chromatography is also a very useful technique for intermediate and polishing applications where separation factor plays as important a role as binding capacity.

Resolution as a function of load

The relationship of resolution to the amount of material loaded onto the resin is also an important consideration in developing a chromatographic capture step. In *Figure 12*, four competitive resins are each loaded with 33 mg of protein per mL of resin bed. Although the mass loading and bed volume are identical for all four resins, Toyopearl SuperQ-650M provides the best separation because it is loaded at a lower percentage of its potential capacity.

Sequential processing

Charge interactions between resin and target molecules are fundamental to the selective power of IEC. These interactions may be complemented with other non-charge mediated chromatographic techniques in the design of an efficient downstream purification process. IEC is often used in conjunction with hydrophobic interaction (HIC), size exclusion (SEC), or reversed phase (RPC) chromatography in a logical and effective sequence. In some cases it is used downstream from an affinity purification step. By carefully selecting the sequence, salt concentrations between unit operations can be matched, avoiding unnecessary addition or removal of salt which is time consuming and potentially costly.

Applications

Proteins, antibodies, plasma proteins, peptides, tryptic digests, nucleotides, oligonucleotides, viruses, antibiotics, glycoproteins.

Please check the application database on our website for numerous examples www.tosohbioscience.de.



Toyopearl GigaCap resins

History

In 2007, Tosoh Bioscience introduced two new high capacity ion exchange resins for packed bed use in response to upstream productivity improvements. These resins are:

1. A new high capacity cation exchange resin, Toyopearl GigaCap S-650M, for use in the purification of monoclonal antibodies and other basic proteins.
2. An improved, high capacity anion exchange resin, Toyopearl GigaCap Q-650M, for use in the purification of proteins that tend to be on the acidic side of neutrality.

These resins were developed utilizing a proprietary procedure that repositions the ionic groups into the pores of HW-65 base resin such that the proteins have better access to more of the ionic groups. The number of titratable ionic groups remains approximately the same. This relocation of the ionic groups in the Toyopearl GigaCap family results in an increase of 3-10 fold greater dynamic binding capacity compared to other Toyopearl products.

Realizing the versatility that high capacity resins would have to offer in both capture and intermediate purifications unit operations, the Toyopearl GigaCap resins were prepared on a 50 – 100 µm base bead. This particle size range is ideal for superior pressure-flow characteristics while maintaining excellent resolution for particularly difficult chromatographic separations.

The proprietary ligand attachment chemistry of the Toyopearl GigaCap series also was shown to have superior uptake and desorption profiles. This kinetic advantage promotes quicker adsorption and a more concentrated and minimally tailing desorption when compared to competitive materials.

Toyopearl GigaCap S-650M

Developed for the purification of monoclonal antibodies.

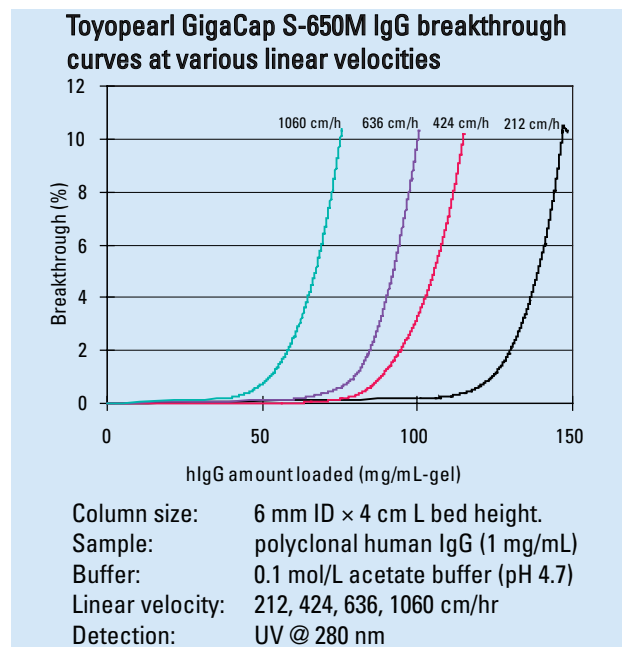
A comparison of the physical properties of Toyopearl GigaCap S-650M with Toyopearl SP-650M, and Toyopearl SP-550C is shown in Table V. Please note that even though the ion exchange capacities are similar, the proprietary chemistry of Toyopearl GigaCap S-650M has the highest dynamic capacity for both IgG and lysozyme.

The adsorption profiles of human polyclonal IgGs on Toyopearl GigaCap S-650M are demonstrated in the breakthrough curves shown in Figure 13. Even at linear velocities as high as 1060 cm/hr the breakthrough curves are sharp.

Table V

Typical properties of Toyopearl GigaCap S-650M			
	Toyopearl SP-650M	Toyopearl SP-550C	Toyopearl GigaCap S-650M
Particle size (µm)	40 - 90	50 - 150	50 - 100
Ion exchange capacity (meq/mL resin)	0.13 - 0.17	0.14 - 0.18	0.1 - 0.2
Binding capacity (mg/mL-gel)			
lysozyme @ 212 cm/hr	48	81	167 (280 cm/hr)
IgG @ 212 cm/hr	43	14	145

Figure 13



For process scale columns it is important that a resin exhibits robust pressure-flow properties at the fastest linear velocity operating conditions will allow. In Figure 14, linear velocities up to 700 cm/hr were applied to a 36 cm ID x approx. 25 cm L bed height Eastern Rivers BioStream column packed with Toyopearl GigaCap-S-650M. The data generated shows the excellent pressure-flow characteristics of the resin when the column is packed in both water and 1.0 mol/L NaCl.

The alkaline storage and CIP (clean-in-place) stabilities of Toyopearl GigaCap S-650M are shown in Figures 15 and Table VI, respectively.

The combination of high capacity and excellent adsorption kinetics are particularly important under high loading conditions. In Figure 16, a series of increasing loads of 2 proteins up to 96 mg/mL-gel is shown. Resolution is maintained between the peaks even at these high protein loads.

Figure 14

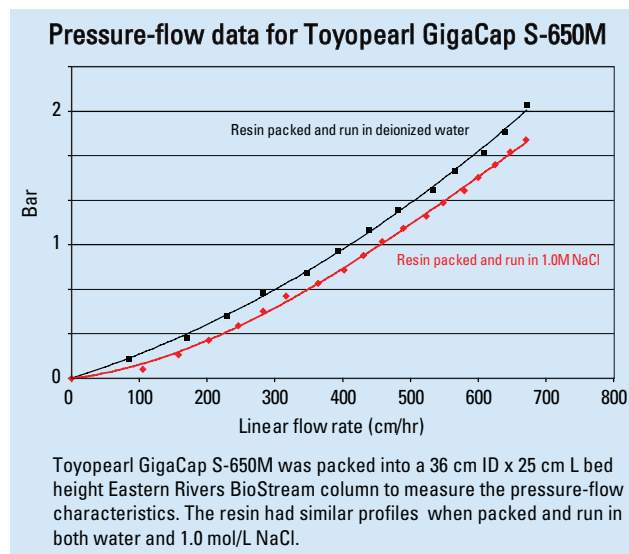


Figure 15

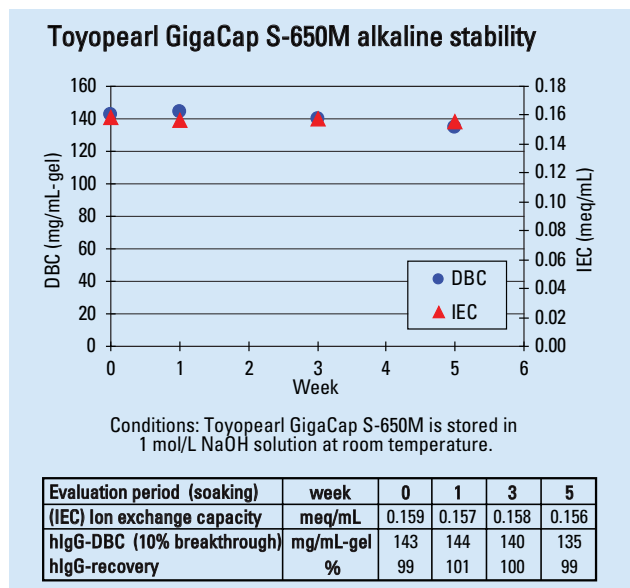


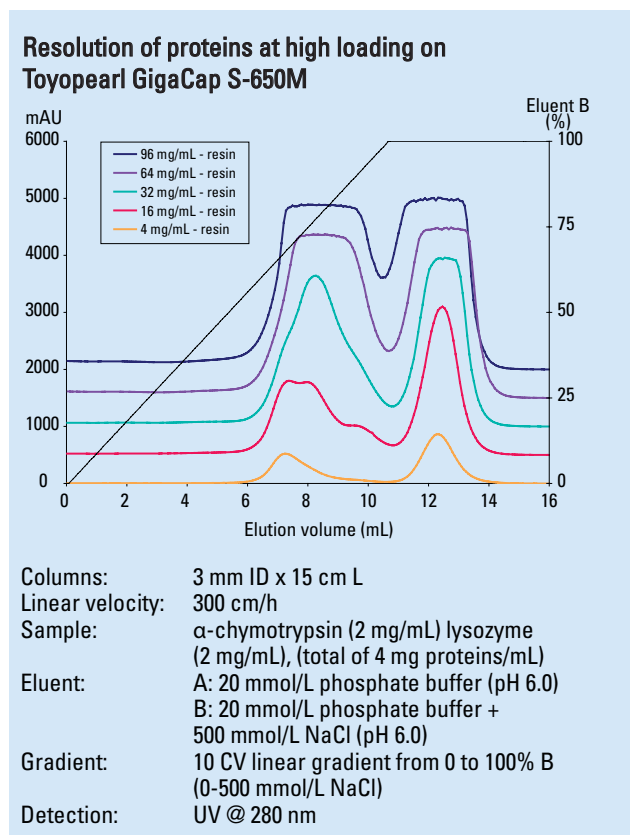
Table VI

Toyopearl GigaCap S-650M CIP-alkaline stability

	Prior to NaOH	After 50 cycles
Toyopearl GigaCap S-650M	167 mg/mL-resin	163 mg/mL-resin

1 mol/L NaOH for 50 cycles (1 hr/cycle)

Figure 16



Toyopearl GigaCap Q-650M

Developed for both small and large protein purifications.

Toyopearl GigaCap Q-650M is the second member in the Toyopearl GigaCap series. It is an anion exchange resin which shows high dynamic binding capacities for both small and large proteins. In Figure 17, the dynamic binding capacities (DBC) of Toyopearl GigaCap Q-650M are compared with a Competitor Q for bovine serum albumin (BSA) polyclonal IgG, and thyroglobulin at 212 cm/hr. In all cases, the DBCs of Toyopearl GigaCap Q-650M were greater than the competitive product. For larger molecules, such as thyroglobulin, the proprietary ligand chemistry of the Toyopearl GigaCap series effects superior adsorption kinetics and significantly greater dynamic binding capacities. The BSA dynamic binding capacity on Toyopearl GigaCap Q-650M at various flow rates is shown in Figure 18. As with Toyopearl GigaCap S-650M, the resin has very high capacity even at increased linear flow velocities.

Figure 17

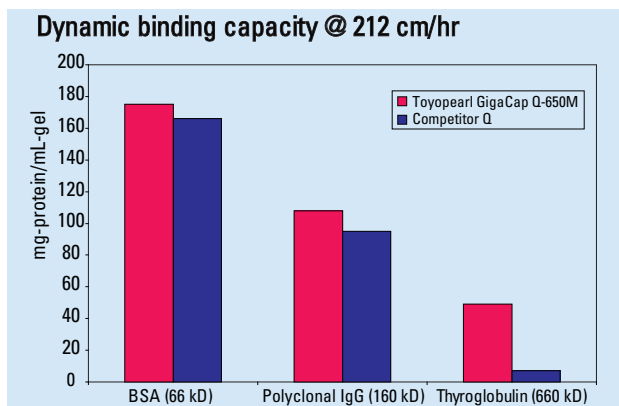


Figure 18

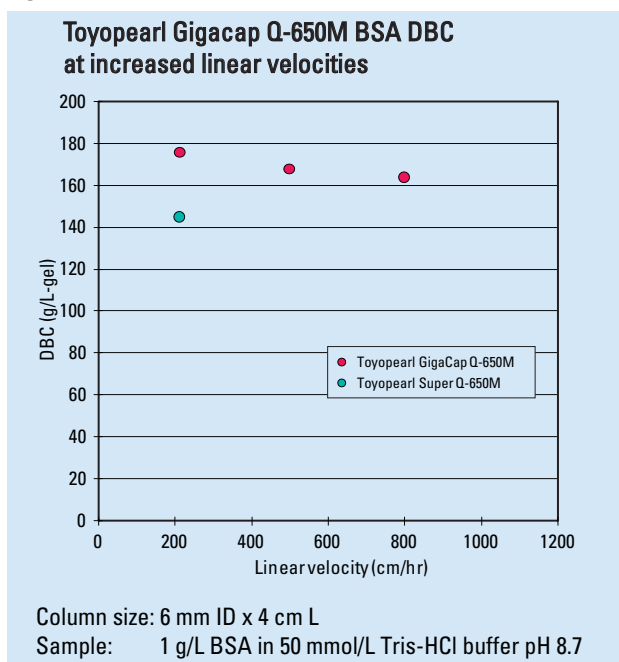
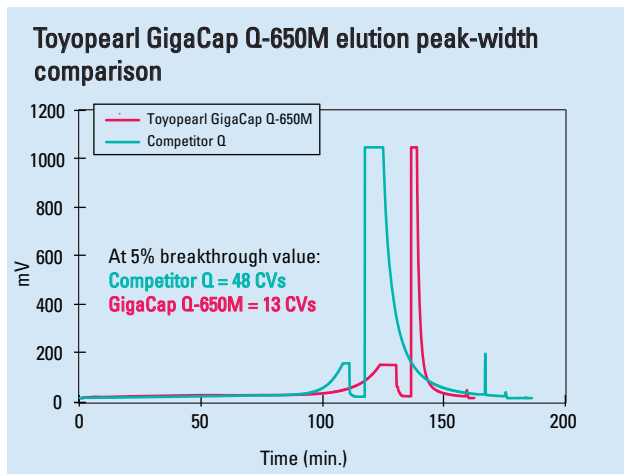


Figure 19



The improved adsorption kinetics are also complemented by excellent desorption kinetics. In *Figure 19*, the elution profile of Toyopearl GigaCap Q-650M is compared with another Q product. The data shows that Toyopearl GigaCap Q-650M has not only a higher loading capacity than the competitive Q resin but elutes the protein in a much smaller volume. The combination of higher loading and smaller elution volume (with less tailing!) contribute to a more concentrated protein elution fraction. This may have a favorable impact on subsequent process steps as well as shortening the cycle time.

Figure 20

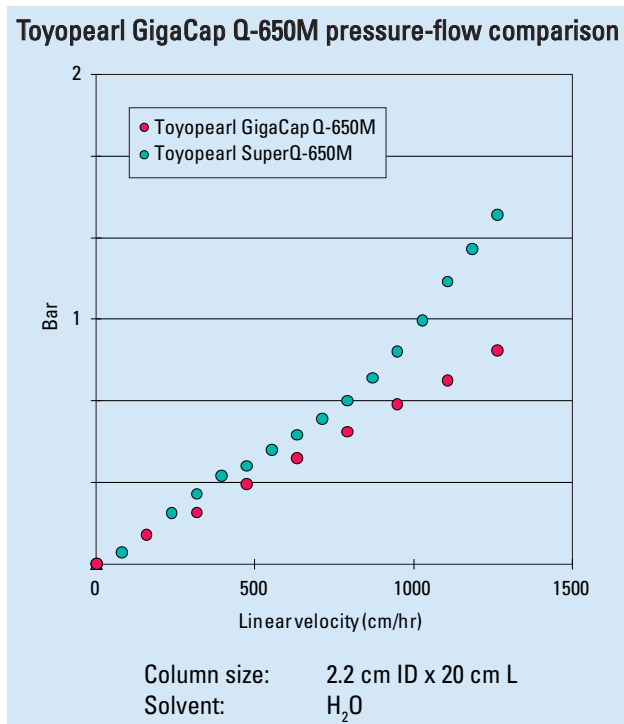


Figure 21

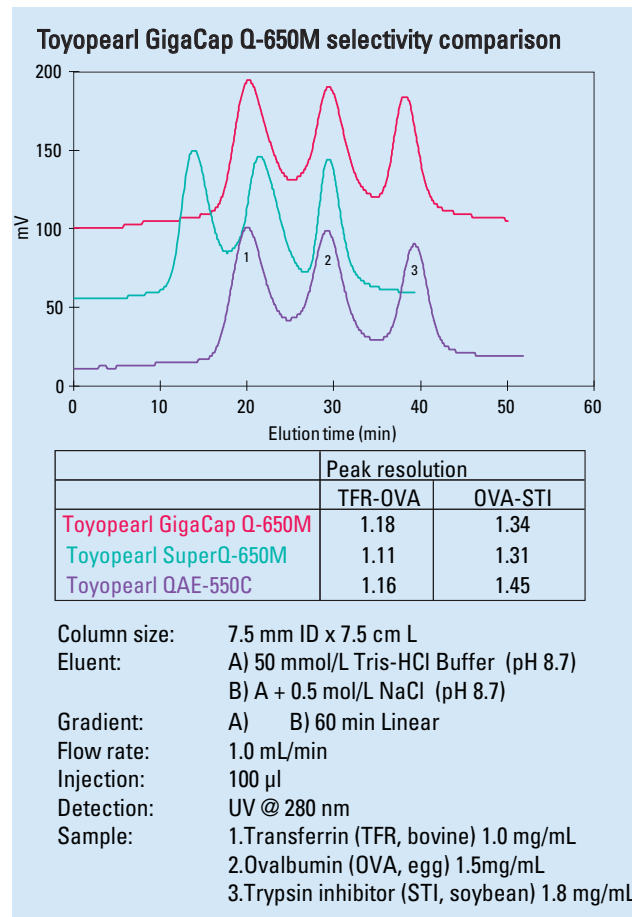
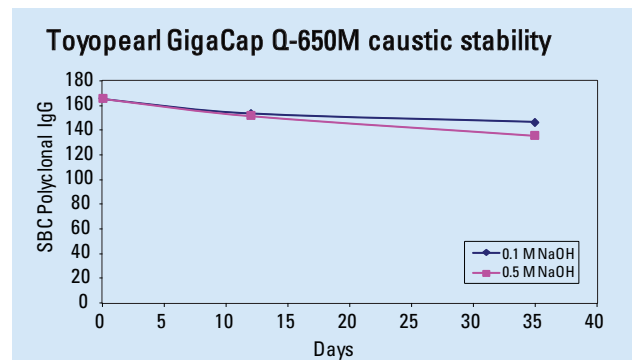


Figure 22



The improved pressure-flow properties of Toyopearl GigaCap Q-650M are shown in *Figure 20*. The primary reason for the lower pressure-flow response of the Toyopearl GigaCap Q-650M is due to the larger particle size.

A comparison of Toyopearl GigaCap Q-650M's selectivity with Toyopearl SuperQ-650M and Toyopearl QAE-550C is shown in *Figure 21*. The alkaline stability in 0.1 mol/L and 0.5 mol/L is shown in *Figure 22*.

ToyoScreen prepacked columns for process development

ToyoScreen columns packed with the full range of our Toyopearl IEC products are available in 1 mL and 5 mL resin volumes. They provide a convenient way to perform early resin screening for both target retention and recovery. Multiple columns can be connected in series for additional capacity or resolution. Please see the ordering information at the end of this section or contact us for more information on these products.

LabPak

For scientists wishing to develop a better physical understanding of the packing properties of Toyopearl and TSK-GEL ion exchange resins, we offer Toyopearl LabPaks of small quantities of the bulk resins. Please see the ordering information at the end of this section or contact us for more information on these products.



*ToyoScreen Process
Development Columns*



Ordering Information

ToyoScreen process development columns for IEC:

<i>Part #</i>	<i>Product description</i>	<i>Package</i>
21360	ToyoScreen DEAE-650M	1 mL x 6 each
21361	ToyoScreen DEAE-650M	5 mL x 6 each
21859	ToyoScreen GigaCap Q-650M	1 mL x 6 each
21860	ToyoScreen GigaCap Q-650M	5 mL x 6 each
21362	ToyoScreen SuperQ-650M	1 mL x 6 each
21363	ToyoScreen SuperQ-650M	5 mL x 6 each
21364	ToyoScreen QAE-550C	1 mL x 6 each
21365	ToyoScreen QAE-550C	5 mL x 6 each
21366	ToyoScreen CM-650M	1 mL x 6 each
21367	ToyoScreen CM-650M	5 mL x 6 each
21868	ToyoScreen GigaCap S-650M	1 mL x 6 each
21869	ToyoScreen GigaCap S-650M	5 mL x 6 each
21870	ToyoScreen MegaCap II SP-550EC	1 mL x 6 each
21871	ToyoScreen MegaCap II SP-550EC	5 mL x 6 each
21368	ToyoScreen SP-650M	1 mL x 6 each
21369	ToyoScreen SP-650M	5 mL x 6 each
21370	ToyoScreen SP-550C	1 mL x 6 each
21371	ToyoScreen SP-550C	5 mL x 6 each
21392	ToyoScreen IEC Anion Mix Pack	1 mL x 3 Grades x 2 each
21393	ToyoScreen IEC Anion Mix Pack	5 mL x 3 Grades x 2 each
21394	ToyoScreen IEC Cation Mix Pack	1 mL x 3 Grades x 2 each
21395	ToyoScreen IEC Cation Mix Pack	5 mL x 3 Grades x 2 each
21396	ToyoScreen IEC Mix Pack	1 mL x 6 Grades x 1 each
21397	ToyoScreen IEC Mix Pack	5 mL x 6 Grades x 1 each

ToyoScreen column accessories

<i>Part #</i>	<i>Product description</i>	<i>Comment</i>
21400	ToyoScreen Column Holder	

TSK-GEL LabPak

<i>Part #</i>	<i>Product description</i>	<i>Container size (mL)</i>	<i>Particle size (µm)</i>
43380	IEXPAK PW (20) (SP-5PW, DEAE-5PW, SuperQ-5PW)	3 x 25 mL	15-25
43280	IEXPAK PW (30) (SP-5PW, DEAE-5PW, SuperQ-5PW)	3 x 25 mL	20-40

Toyopearl LabPak

<i>Part #</i>	<i>Product description</i>	<i>Container size (mL)</i>	<i>Particle size (µm)</i>
19817	IEXPAK HP (CM-650S, SP-650S, DEAE-650S, SuperQ-650S)	4 x 25 mL	20-50
43210	AIEXPAK (DEAE-650M, SuperQ-650M, QAE-550C)	3 x 100 mL	40-90 and 50-150
43220	CIEXPAK (CM-650M, SP-650M, SP-550C)	3 x 100 mL	40-90 and 50-150

Ordering Information

Anion exchange resins:

Toyopearl bulk media

Part #	Product description	Container size (mL)	Particle size (µm)	Ion exchange capacity (meq/mL resin)	Typical capacity (mg BSA/mL resin)
43271	Toyopearl QAE-550C	100	50-150	0.28-0.38	60-80
14026		250			
14704		1,000			
14027		5,000			
18365		50,000			
21854	Toyopearl GigaCap Q-650M	100	50-100	0.20-0.30	105-155
21855		250			
21856		1,000			
21857		5,000			
21858		50,000			
19823	Toyopearl SuperQ-650S	25	20-50	0.20-0.30	105-155
17223		250			
17224		1,000			
17225		5,000			
19679		50,000			
43205	Toyopearl SuperQ-650M	100	40-90	0.20-0.30	105-155
17227		250			
17228		1,000			
17229		5,000			
21311		50,000			
43275	Toyopearl SuperQ-650C	100	50-150	0.20-0.30	105-155
17231		250			
17232		1,000			
17233		5,000			
19804	Toyopearl DEAE-650S	25	20-50	0.08-0.12	25-35
07472		250			
14692		1,000			
07973		5,000			
21483		50,000			
43201	Toyopearl DEAE-650M	100	40-90	0.08-0.12	25-35
07473		250			
14693		1,000			
07974		5,000			
18367		50,000			
07988	Toyopearl DEAE-650C	250	50-150	0.05-0.11	25-35
14694		1,000			
07989		5,000			

TSK-GEL bulk resin

43383	TSK-GEL SuperQ-5PW (20)	25	15-25	0.12-0.18	52-88
18535		250			
18546		1,000			
18547		5,000			
43283	TSK-GEL SuperQ-5PW (30)	25	20-40	0.12-0.18	52-88
18536		250			
18548		1,000			
18549		5,000			
43381	TSK-GEL DEAE-5PW (20)	25	15-25	0.05-0.11	25-45
14710		250			
14711		1,000			
18436		5,000			
43281	TSK-GEL DEAE-5PW (30)	25	20-40	0.05-0.11	20-40
14712		250			
14713		1,000			
18370		5,000			

Ordering Information

Cation exchange resins:

Toyopearl bulk media

Part #	Product description	Container size (mL)	Particle size (µm)	Ion exchange capacity (meq/mL resin)	Typical capacity (mg lysozyme/mL resin)
21833	Toyopearl GigaCap S-650M	100	50-100	0.14-0.18	80-120
21834		250			
21835		1,000			
21836		5,000			
21837		50,000			
43272	Toyopearl SP-550C	100	50-150	0.14-0.18	80-120
14028		250			
14705		1,000			
14029		5,000			
18366		50,000			
19822	Toyopearl SP-650S	25	20-50	0.13-0.17	40-60
08437		250			
14698		1,000			
08438		5,000			
21477		50,000			
43202	Toyopearl SP-650M	100	40-90	0.13-0.17	40-60
07997		250			
14699		1,000			
07998		5,000			
18369		50,000			
07994	Toyopearl SP-650C	250	50-150	0.12-0.18	35-55
14700		1,000			
07995		5,000			
19803	Toyopearl CM-650S	25	20-50	0.08-0.12	30-50
07474		250			
14695		1,000			
07971		5,000			
43203	Toyopearl CM-650M	100	40-90	0.08-0.12	30-50
07475		250			
14696		1,000			
07972		5,000			
19839		50,000			
07991	Toyopearl CM-650C	250	50-150	0.05-0.11	25-45
14697		1,000			
07992		5,000			
19329		50,000			
21804	Toyopearl MegaCap II SP-550EC	100	100-300	0.14-0.18	60-90*
21805		250			
21806		1,000			
21807		5,000			
21808		50,000			

TSK-GEL bulk media

43382	TSK-GEL SP-5PW (20)	25	15-25	0.06-0.12	20-40
14714		250			
14715		1,000			
18435		5,000			
43282	TSK-GEL SP-5PW (30)	25	20-40	0.06-0.12	20-40
14716		250			
14717		1,000			
18384		5,000			

* Adsorption capacity for insulin: 90-120 mg/mL resin

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