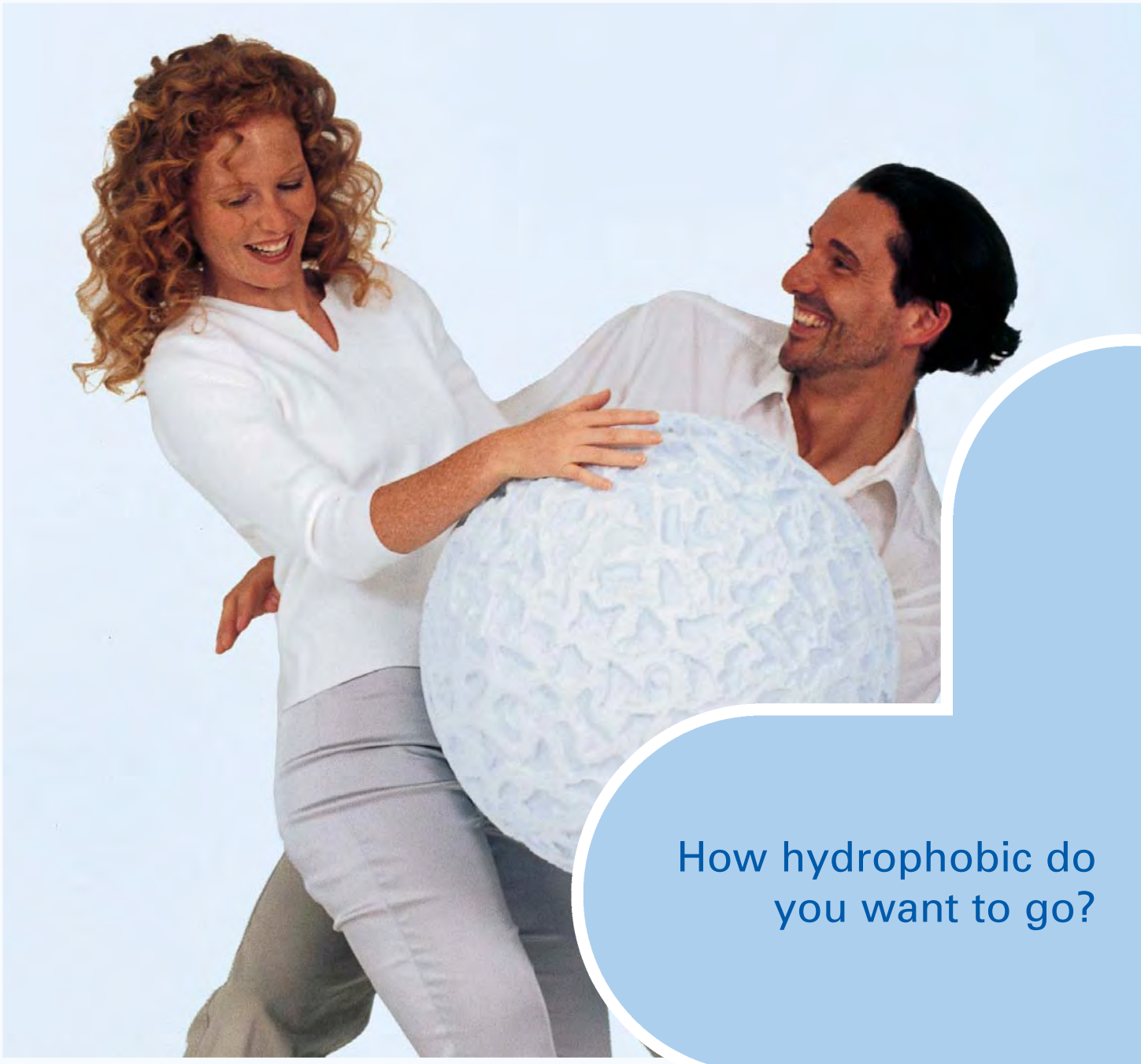
TOSOH BIOSCIENCE

Separations Business Unit

Hydrophobic Interaction Chromatography



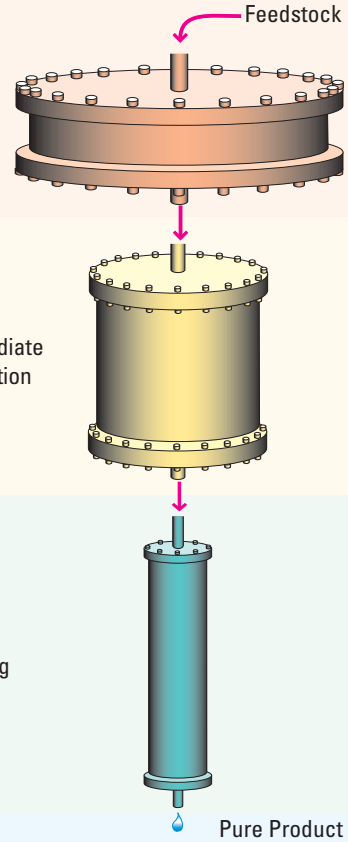
How hydrophobic do you want to go?

Why we are different

- Tosoh Bioscience is a global leader in the field of bioseparations
- Tosoh Bioscience is the leading manufacturer of methacrylic polymer resins
- Tosoh Bioscience provides comprehensive technical and regulatory support
- Tosoh Bioscience is a competent partner for customized solutions
- Tosoh Bioscience offers the broadest range of innovative HIC resins

For Hydrophobic Interaction, Tosoh Bioscience offers optimized products with various ligands and particle sizes used in a chromatography manufacturing train fom capture, intermediate purification to polishing steps.

Process Step	Bead size	Process Media
Capture	100 µm	Toyopearl SuperButyl-550C Toyopearl Hexyl-650C Toyopearl Butyl-650C Toyopearl Phenyl-650C Toyopearl Ether-650C
Intermediate Purification	65 µm	Toyopearl Butyl-600M Toyopearl PPG-600M
		Toyopearl Butyl-650M Toyopearl Phenyl-650M Toyopearl Ether-650M
	35 µm	Toyopearl Butyl-650S Toyopearl Phenyl-650S Toyopearl Ether-650S
Polishing	30 µm	TSKgel Phenyl-5PW (30) TSKgel Ether-5PW (30)
	20 µm	TSKgel Phenyl-5PW (20) TSKgel Ether-5PW (20)
QC	10 µm	TSKgel Phenyl-5PW columns TSKgel Ether-5PW columns



Same selectivity HPLC columns are available for most process media

If help is needed, contact our technical support specialists to offer you assistance at +49 (0)711 13257-0.

Why use TOYOPEARL & TSK-GEL HIC resins

Features & Benefits of Toyopearl HIC resins

- Broad range of ligands, particle and pore sizes
- Seamless scalability from method development to full scale manufacturing
- Hydrophilic polymer matrix with high mechanical stability
- Excellent flow characteristics in all column dimensions
- Constant bed volume over a wide range of salt concentrations
- High protein recovery
- Low non-specific protein binding
- Chemical robustness between pH 1.0 and 13.0
- Autoclavable at 121°C
- Compatible with organic solvents

Hydrophobic Interaction Chromatography

Hydrophobic Interaction Chromatography (HIC) is a widely-used technique for separation and purification of proteins and peptides. HIC sorts biomolecules by degree of their surface hydrophobicity. Samples are adsorbed to the resin at relatively high salt concentrations and eluted by applying a decreasing salt gradient. The mild conditions used in HIC separation of peptides and proteins typically maintain protein structure and biologic activity. This makes HIC a powerful tool for the process purification of biomolecules.

TSK-GEL® and Toyopearl® HIC resins

Proteins show varying degrees of hydrophobicity depending on their amino acid composition, structure and size. Separation can therefore be optimized either by varying the mobile phase or by using different HIC packings. Matching the hydrophobicity of the target compound to the resin hydrophobicity is critical for the best overall purification performance. This is the reason why Tosoh Bioscience offers seven product lines of Toyopearl HIC resins using five different ligands. The different degrees of hydrophobicity and selectivity support the user in selecting the best solution for a given target. The hydrophobicity increases through the ligand series: Ether, Polypropylenglycol (PPG), Phenyl, Butyl, Hexyl.

Toyopearl HIC ligand candidates

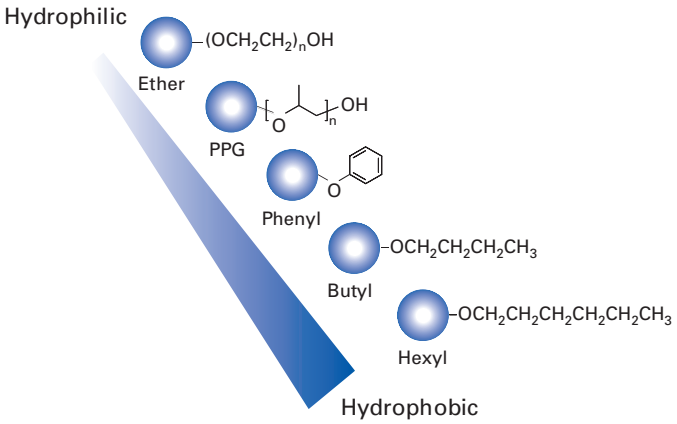


Figure 1

Toyopearl HIC resins are available in three different average particle sizes (35 µm (S), 65 µm (M) & 100 µm (C)) for intermediate purification or capture chromatography. For high resolution HIC Tosoh Bioscience offers TSK-GEL resins with particle sizes of 20 and 30 µm.

Toyopearl and TSK-GEL HIC resins are specifically designed for use in biopharmaceutical production. Their rigid methacrylic polymer structure shows excellent pressure/flow properties resulting in faster process throughput. Large pore diameter and narrow particle size distribution allow rapid adsorption kinetics and exceptional resolution. To support seamless scale-up Tosoh Bioscience offers a complete HIC toolbox, ranging from analytical TSK-GEL HPLC columns over ToyoScreen® columns for early development resin screening, up to bulk media used for pilot and production scale.

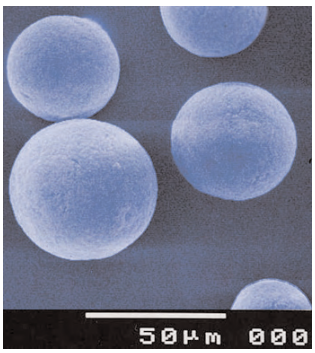


Figure 2

Regulatory support

Pharmaceutical industry all over the world successfully uses Toyopearl HIC resins in the downstream processing of a variety of biologically active proteins, including several FDA-approved therapeutic drugs. For Toyopearl and TSK-GEL HIC resins 'Regulatory Support Files' describing the specifications, the manufacturing and the QA/QC of the product are registered at the FDA. In addition, Tosoh Bioscience's application specialists are available for discussion of your specific separation challenge or process validation issues.

Resin Screening

Resin screening

An optimum HIC process step will balance high dynamic binding capacity, adequate selectivity, good mass recovery and retention of biological activity. The key parameter is selecting the best resin for the given separation problem.

Selectivity

The hydrophobicity of a target with known structure can be roughly estimated as it often increases with the size of the protein surface. Nevertheless, practical screening experiments under standard buffer conditions are essential to select the optimum resin. The hydrophobicity of the resin determines the salt concentration necessary to adsorb the target. With low-hydrophobic ligands the difference between adsorption and precipitation might be so small that certain proteins may partially precipitate under binding conditions. On the other hand a high-hydrophobic stationary phase might cause irreversible binding of hydrophobic proteins.

HIC ligands

The wide range of Toyopearl and TSK-GEL HIC selectivities enables a developer to optimize protein separations at the extremes of the hydrophobic spectrum. The hydrophobicity of the resins increases through the series:

Ether < PPG < Phenyl < Butyl < Hexyl.

Highly retentive Hexyl and Butyl resins are used to separate hydrophilic proteins and should be considered for separations requiring a low ionic strength. Toyopearl Ether resin is used for the purification of very hydrophobic targets such as certain monoclonal antibodies and membrane proteins. PPG and Phenyl phases complement the other HIC ligands and offer alternatives for mid-range hydrophobicity proteins.

Today high-resolution HIC applications are gaining more and more interest. TSK-GEL 5PW media with small particle sizes are ideally suited if high resolution is an issue. TSK-GEL 5PW bulk material is available with the ligands Ether and Phenyl. TSK-GEL columns in various dimensions are available with Ether, Phenyl and Butyl resins.

Dynamic binding capacity

In downstream processing steps, the dynamic binding capacity (DBC) of the resin for a given target is even more important than selectivity. Selecting media with a different pore size might be an option, if DBCs are not satisfying. Tosoh Bioscience provides resins designed for maximum dynamic binding capacity for dedicated proteins. The standard Toyopearl resins have an average pore size of 1000 Å, suitable for most targets.

The accessible surface area of a porous bead increases by decreasing the mean pore diameter and so does the dynamic binding capacity. This lead to the development of two specialty lines of HIC materials with smaller pores.

Pore size

For monoclonal antibodies a pore size of 750 Å is sometimes favorable. Toyopearl resins exhibiting this pore size are available with two ligands: PPG-600 and Butyl-600. For smaller molecules such as peptides Toyopearl particles with even narrower pore diameter (500 Å) are used to create the SuperButyl-550C resin.

Figure 3 and 4 show the dynamic binding capacities of Toyopearl resins for Lysozyme and a monoclonal antibody. For a small protein such as Lysozyme the SuperButyl-550C is the best choice (Figure 3).

Typical dynamic binding capacities for lysozyme

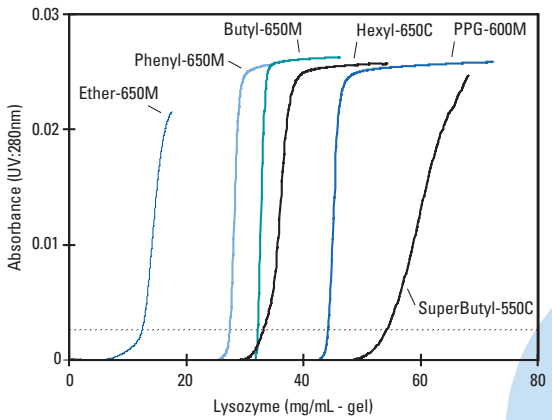


Figure 3

	Binding capacity (mg/mL - gel) (10% breakthrough)
Ether-650M	12.5
Phenyl-650M	27.5
Butyl-650M	32.2
Hexyl-650C	33.2
PPG-600M	44.2
SuperButyl-550C	54.3

Column size: 7.8 mm ID x 20 cm L
Feed : 1 mg lysozyme in 0.1 M phosphate buffer + 1.8 M sodium sulfate (pH 7.0)
Linear velocity: 100 cm/h
Detection: UV (280 nm)

Resin Screening

Figure 4 demonstrates the superior DBC of the PPG-600M and Butyl-600M resins for large proteins.

Typical dynamic binding capacities for mAb

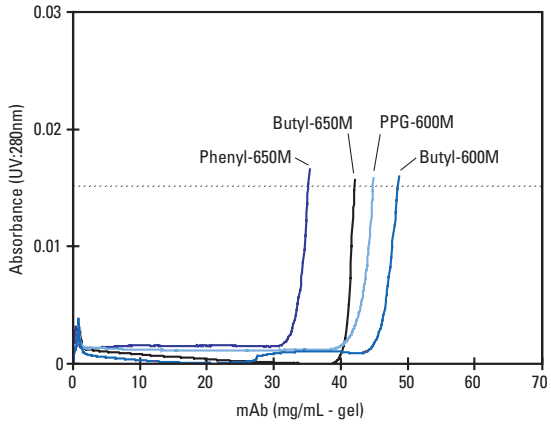


Figure 4

	Binding capacity (mg/mL - gel) (10% breakthrough)
Phenyl-650M	35.2
Butyl-650M	42.1
PPG-600M	44.8
Butyl-600M	48.5

Column size: 7.8 mm ID x 20 cm L
Feed : 1 mg lysozyme in 0.1 M phosphate buffer + 1.8 M sodium sulfate (pH 7.0)
Linear velocity: 100 cm/h
Detection: UV (280 nm)

Figure 5 shows all available Toyopearl resins sorted according to their pore size and relative hydrophobicity. This variety of HIC phases increases the probability of matching a resin best to the given target, at the same time making the screening procedure more complex.

Pore sizes and relative hydrophobicities of Toyopearl

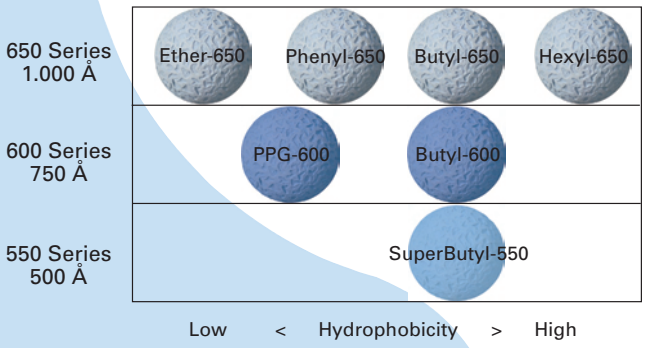


Figure 5

Figure 6

ToyoScreen® for easy resin scouting

In order to simplify the screening process, Tosoh Bioscience offers sets of prepacked columns with different resins. They provide a convenient way to screen different resins effectively for both, target retention and recovery. ToyoScreen is available with 1 and 5 ml bed volumes for all Toyopearl resins and can be connected to all common laboratory liquid chromatography instrumentation. If the LC system is equipped with automated solvent and column switching valves, screening of resins at various buffer conditions can be easily performed in overnight runs.

Screening of Toyopearl HIC resins - standard proteins

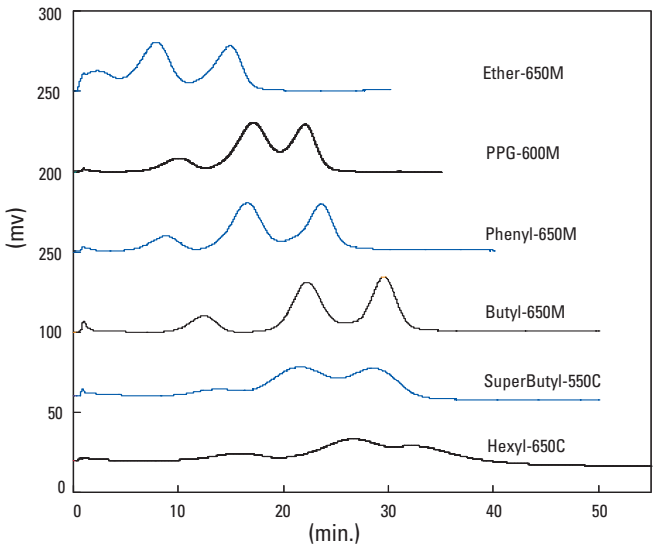


Figure 7

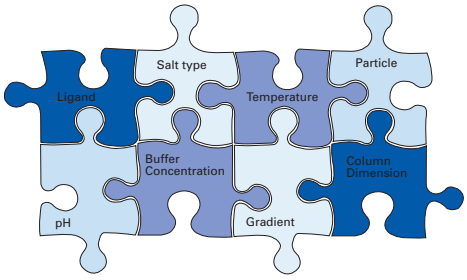
Column: ToyoScreen (1 mL)
Eluent A: 0.1 M phosphate buffer +1.8 M sodium sulfate (pH 7.0)
Eluent B: 0.1 M phosphate buffer (pH 7.0)
Flow rate: 1 mL/min gradient: 30 min linear
Inj. vol.: 50 µL
Samples: Ribonuclease A, Lysozyme, α-Chymotrypsinogen, 1 mg/mL

Method Development

The effect of the different hydrophobicities of Toyopearl resins on retention and resolution of standard proteins are illustrated in Figure 7. A standard mixture of proteins was separated using ToyoScreen columns. Fast screening of a larger number of resins under various conditions can be realized by applying robotic fluid handling systems and high throughput screening tools in 96 well plate formats.

Effect of the base resin

Non-specific binding effects from the base material of the resin can alter resolution and selectivity. The matrix of Toyopearl and TSK-GEL HIC resins is a uniform, hydrophilic polymer. HIC resins from other manufacturers, based on different base resins, might exhibit different properties regarding hydrophobicity, selectivity and resolution even if they are functionalized with the same ligand. This is important to consider when screening resins of various manufacturers.



HIC method development

The goal in purification method development is optimizing conditions for maximum capacity and recovery of the target molecules. There are several parameters which affect HIC separations in addition to the hydrophobicity of the ligand:

- salt type
- buffer concentration
- pH
- temperature
- gradient type and slope
- particle and pore size
- column dimensions

Optimizing salt type and concentration

Besides the hydrophobicity of the resin, the eluent salts make a major impact on a HIC separation. Ammonium sulfate and sodium chloride are the most commonly used salts in HIC applications, sometimes Citrate-buffers are used as well. Recently, it was shown that dual salt systems might further improve resolution. While the type of salt affects retention and selectivity the initial salt concentration is the key to maximize binding capacity for the target.

The salt concentration required for binding is broadly related to the size of the surface area of a protein. Small, hydrophilic proteins will need up to 3 M ammonium sulfate for efficient binding, whereas the concentration decreases to below 1 M for very large proteins.

Figure 8 shows the influence of salt concentration on binding capacity of TSKgel Phenyl-5PW for various proteins.

Dynamic binding capacities of TSKgel Phenyl-5PW

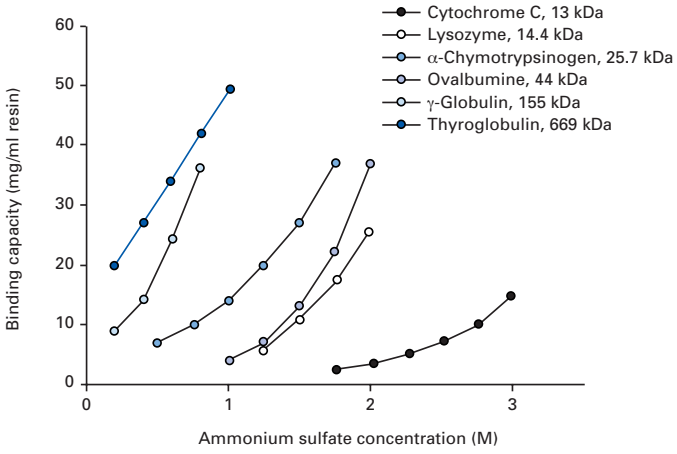


Figure 8

Other parameters

pH could be another tool for fine tuning. A good initial pH is 7.0, irrespective of the component's isoelectric point. The pH can influence not only the retention but also the DBC (see Figure 9).

Influence of pH

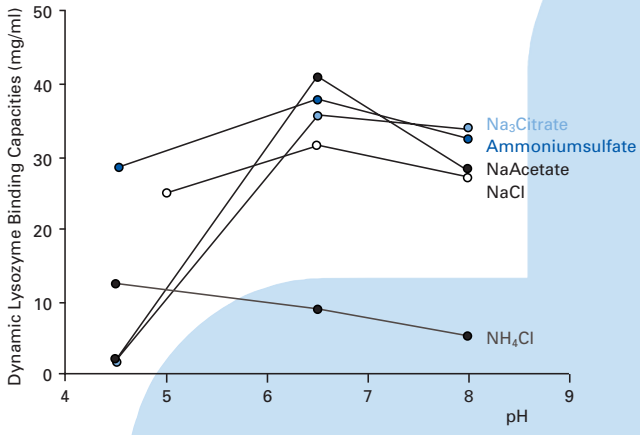


Figure 9

Method Development

Most HIC applications are performed at room **temperature** due to economical reasons or at 4°C to reduce degradation of proteins. If the target is not heat sensitive, a higher temperature might be used to influence binding strength and selectivity.

Gradient elution is the most frequently used elution mode for HIC. The sample is applied at a salt concentration high enough for adsorption of the target molecules. As the salt concentration is lowered, the proteins become increasingly desorbed and move down the column. The retention depends on the flow rate and on the slope of the gradient. Resolution can be increased by decreasing gradient slope. In manufacturing scale processes step elution is often applied due to cost and reliability reasons.

Organic modifiers can speed up a HIC separation or alter the selectivity. For purification of small molecules up to 20% ethanol might be used.

The **particle size** depends on the type of sample used and the required resolution. Capturing steps from a crude feedstock are usually performed with coarse particles (Toyopearl C; 100 µm particle size). In intermediate purification steps medium size particles (Toyopearl S or M, 35-65 µm) are used, whereas for polishing the even smaller TSK-GEL materials with 20 µm or 30 µm particles are ideal. TSK-GEL columns with 10 µm beads are best suited for analytical purposes or for small scale purifications.

The chemistry of the resins is very similar from the pre-packed TSK-GEL PW columns to the TSK-GEL-5PW and Toyopearl bulk resins. This offers the opportunity to find the ideal particle size for the intended use regardless of whether it is laboratory scale purification, a process polishing, intermediate or capture step. Figure 10 shows the separation of four standard proteins on the various Phenyl media. Increasing the bead size from 10 µm (TSKgel Phenyl-5PW) over 35 µm and 65 µm up to 100 µm only reduces resolution but does not impair selectivity.

Resolution in HIC can be improved by increasing the column lengths, since the full length of the column bed interacts continuously with sample components. For standard method development purposes the Tosoh MD-G columns filled with Toyopearl S-Grade or TSK-GEL 5PW media have suitable column dimensions.

Improvement of performance by reducing particle size

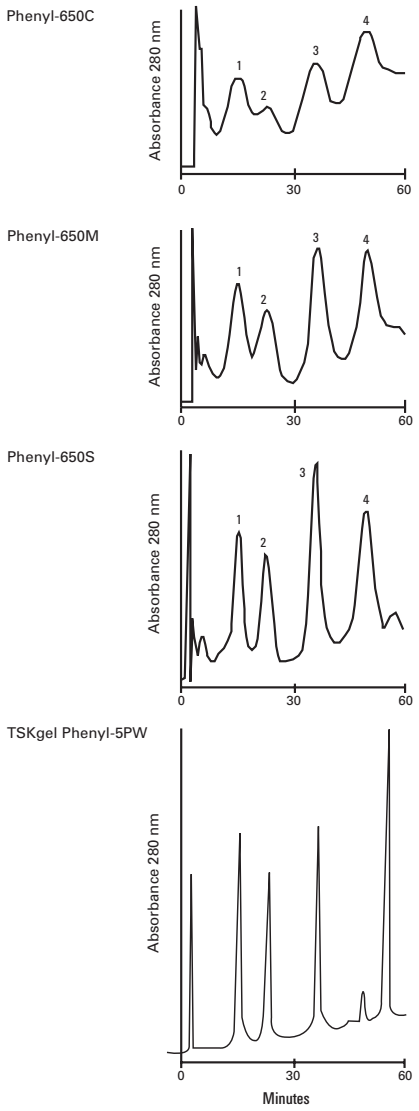


Figure 10

Column:	7.5 mm ID x 7.5 cm L
Sample:	1. Myoglobin, 2. Ribonuclease A, 3. Lysozyme, 4. α -Chymotrypsinogen
Injection:	200 µl
Elution:	60 min. linear gradient from 2.0 M to 0 M of $(NH_4)_2SO_4$ in 0.1 M phosphate buffer, pH 7.0
Flow rate:	1.0 ml/min.
Detection:	UV @ 280 nm

Regeneration of the column

The type and frequency of regeneration of a column naturally depends on the samples applied. Standard cleaning procedures often involve washing with high pH (e.g. 0.5 N NaOH). Toyopearl and TSK-GEL HIC resins are recommended for use from pH 2.0 to 12.0, although short exposures to higher pH for cleaning in place are possible.

Seamless Scale Up

Seamless scale up

In terms of cost efficiency a production step should deliver maximum yield of the active product in short time. It will always be a compromise between throughput, resolution and recovery. The capacity of the column must fit to the yield of the upstream process or of the previous purification steps respectively. The target capacity determines the column dimensions, while the nature of the sample and the approached resolution determine the particle size.

TSK-GEL-5PW and Toyopearl media based on the same methacrylic polymer matrix are available in particle size ranges for laboratory, pilot and production scale chromatography. They can easily be packed into columns up to the largest industrial size.

Superior pressure/flow characteristics

High flow rates reduce process cycle time and increase productivity. The rigid polymeric backbone of Toyopearl and TSK-GEL HIC resins assures superior pressure/flow characteristics over a wide range of flow rates. Figure 11 shows the excellent pressure flow/curves for all grades of Toyopearl Butyl-650, determined on a production size column with 40 cm ID and 20 cm length.

Pressure/flow curve

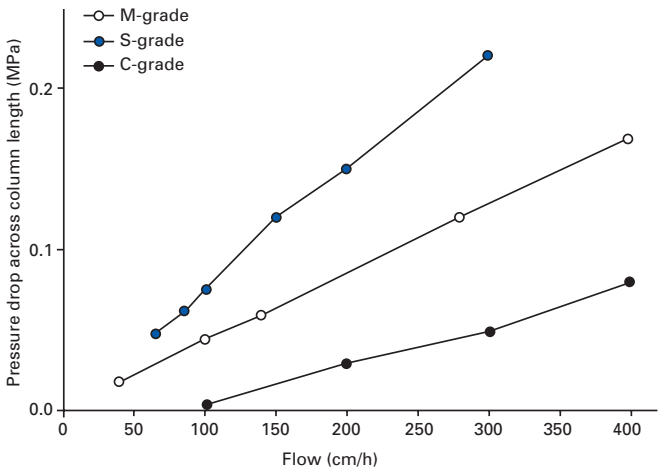


Figure 11

Resin: Toyopearl Butyl-650
Column size: 40 cm ID X 20 cm L
Eluent: Water
Temperature: Room temperature

Example of industrial mAb purification

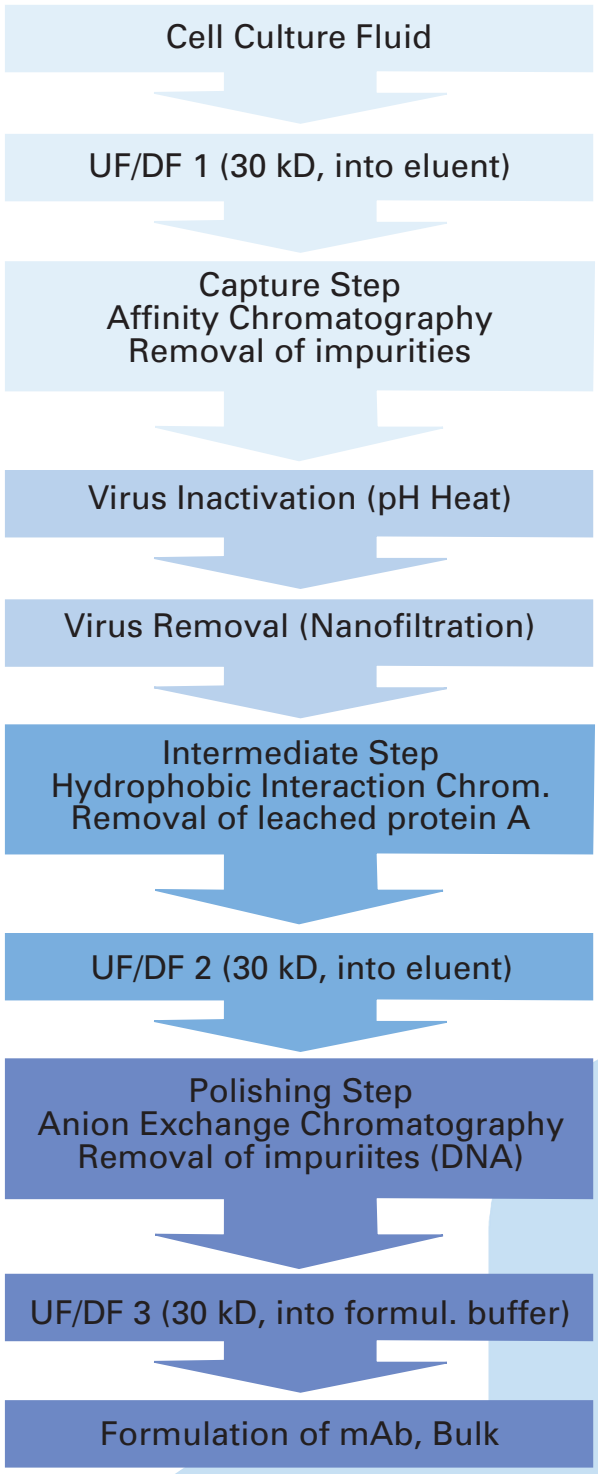


Figure 12

Applications

Applications

Toyopearl and TSK-GEL HIC resins are used in downstream purification of a variety of biopharmaceuticals. In capture steps HIC is often used following an ammonium sulphate precipitation, decreasing the salt concentration at the same time as conducting a purification step. In intermediate process steps HIC is a very useful technique for the purification of monoclonal antibodies. The HIC step is typically used for the removal of leached Protein A subsequent to an affinity chromatography step. A typical industrial purification scheme isolating mAbs from a cell culture supernatant is shown in Figure 12.

Monoclonal antibodies

The diverse hydrophobic nature of mAbs is shown in Figure 13. The retention time as an indicator of hydrophobicity was measured for 51 different mouse IgGs on a TSKgel Phenyl-5PW analytical column. The elution time differs by a factor of 2-3 indicating very different hydrophobicities. The Toyopearl series of HIC ligands with different hydrophobicities offers a range of options for finding the right resin for the target molecule.

For the highly hydrophobic mouse anti-chicken 14 kDa lectin the hydrophilic Ether ligand works well. Figure 14 shows the purification of this antibody from ascites fluid with a TSKgel Ether-5PW column (10 µm particle size). The scale-up with the corresponding 65 µm Toyopearl Ether-650M material shows that by using larger particles only resolution is compromised, but not selectivity.

Aggregate removal

HIC in flow through mode is often used to remove aggregates generated in Protein A purification steps for monoclonal antibodies. These impurities have chemical properties very similar to the target but they will generally be more hydrophobic than the native protein. Therefore they bind at relatively low salt concentrations to Butyl or Phenyl resins allowing the target to flow through the column.

In addition to the mentioned examples HIC is used successfully for a variety of other applications such as the purification of plasmids or for endotoxin removal. Even glycoproteins, which often bind irreversibly to saccharide-based media, can be purified by HIC on polymer based resins.

Hydrophobic diversitiy of mouse mAbs

Plot of chromatographic elution times for 51 different mouse mAbs

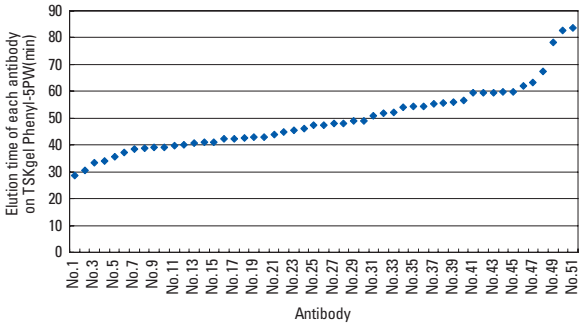


Figure 13
Column: TSKgel Phenyl-5PW
Eluent:: (A) 0.1 M phosphate buffer containing 1.8 M ammonium sulfate (pH 7.0)
(B) 0.1 M phosphate buffer (pH 7.0)
Flow rate: 1 mL/min
Gradient: (B) 0% (0 min)--0% (5 min)--100% (65 min) linear
Samples: 51 kinds of mouse monoclonal antibodies

Purification of mAbs from ascites fluid

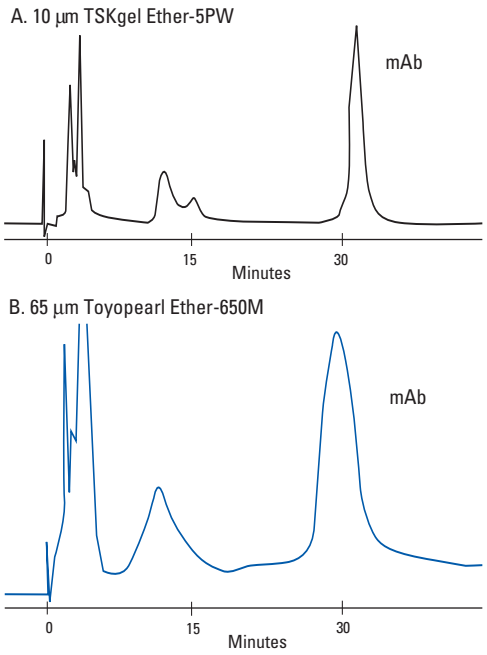


Figure 14
Column: A. TSKgel Ether-5PW, 7.5 mm ID x 7.5 cm L
B. Toyopearl Ether-650M, 7.5 mm ID x 7.5 cm L
Sample: anti-chicken 14 kDa lectin, diluted ascites fluid,
A. 1.5 mg in 100 µl; B. 0.76 mg in 50 µl
Elution: 60 min. linear gradient from 1.5 M to 0 M $(NH_4)_2SO_4$ in 0.1 M phosphate buffer (pH 7.0)
Flow rate: 136 cm/h
Detection: UV @ 280 nm

For a deeper insight into HIC applications and all questions related to the practical use of TSK-GEL and Toyopearl check, our website www.toyopearl.de and related catalogues or instruction manuals. Our technical experts are happy to discuss your specific separation needs.

Ordering Information

Toyopearl HIC resins:

Hydrophobicity	*Chemical Structure*	*Product description*	*Container size (mL)*	*Part #*	*Particle size (µm)*	*Pore Size (Å)*
weak	HW65-(OCH_2CH_2)n-OH	Ether-650S	25	43151	20-50	1000
			100	16172		
			1,000	16174		
			5,000	16176		
		Ether-650M	25	19805	40-90	1000
			100	16173		
			1,000	16175		
			5,000	16177		
medium	HW60-$(OCH(CH_3)-CH_2)$n-OH	PPG-600M	25	21301	40-90	750
			100	21302		
			1,000	21303		
			5,000	21304		
	HW65-OC_6H_5	Phenyl-650S	25	43152	20-50	1000
			100	14477		
			1,000	14784		
			5,000	14935		
		Phenyl-650M	25	19818	40-90	1000
			100	14478		
			1,000	14783		
			5,000	14943		
		Phenyl-650C	25	43126	50-150	1000
			100	14479		
			1,000	14785		
			5,000	14944		
strong	HW65-O-$(CH_2)_3$-CH_3	Butyl-650S	25	43153	20-50	1000
			100	07476		
			1,000	14701		
			5,000	07975		
		Butyl-650M	25	19802	40-90	1000
			100	07477		
			1,000	14702		
			5,000	07976		
		Butyl-650C	25	43127	50-150	1000
			100	07478		
			1,000	14703		
			5,000	07977		
	HW60-O-$(CH_2)_3$-CH_3	Butyl-600M	25	21448	40-90	750
			100	21449		
			1,000	21450		
			5,000	21451		
	HW55-O-$(CH_2)_3$-CH_3	SuperButyl-550C	25	19955	50-150	500
			100	19956		
			1,000	19957		
			5,000	19958		
	HW65-O-$(CH_2)_5$-CH_3	Hexyl-650C	25	44465	50-150	1000
			100	19026		
			1,000	19027		
			5,000	19028		

TSK-GEL 5PW HIC resins for high resolution:

weak	5PW-(OCH_2CH_2)n-OH	Ether-5PW (20)	25	43276	10-30	1000
			250	16052		
			1,000	16053		
			5,000	18437		
		Ether-5PW (30)	25	43176	20-40	1000
			250	16050		
			1,000	16051		
			5,000	18439		
		Phenyl-5PW (20)	25	43277	10-30	1000
medium	5PW-OC_6H_5		250	14718		
			1,000	14719		
			5,000	18438		
		Phenyl-5PW (30)	25	43177	20-40	1000
			250	14720		
			1,000	14721		
			5,000	17210		

ToyoScreen process development columns for HIC:

Part #	*Product description*	*Package*
21372	ToyoScreen Ether-650M, 1 mL	1 mL x 6 each
21373	ToyoScreen Ether-650M, 5 mL	5 mL x 6 each
21374	ToyoScreen Phenyl-650M, 1 mL	1 mL x 6 each
21375	ToyoScreen Phenyl-650M, 5 mL	5 mL x 6 each
21376	ToyoScreen Butyl-650M, 1 mL	1 mL x 6 each
21377	ToyoScreen Butyl-650M, 5 mL	5 mL x 6 each
21378	ToyoScreen Hexyl-650C, 1 mL	1 mL x 6 each
21379	ToyoScreen Hexyl-650C, 5 mL	5 mL x 6 each
21380	ToyoScreen PPG-600M, 1 mL	1 mL x 6 each
21381	ToyoScreen PPG-600M, 5 mL	5 mL x 6 each
21495	ToyoScreen Butyl-600M, 1 mL	1 mL x 6 each
21494	ToyoScreen Butyl-600M, 5 mL	5 mL x 6 each
21382	ToyoScreen SuperButyl-550C, 1 mL	1 mL x 6 each
21383	ToyoScreen SuperButyl-550C, 5 mL	5 mL x 6 each
21398	ToyoScreen HIC Mix Pack, 1 mL	1 mL x 6 Grades x 1 each
21399	ToyoScreen HIC Mix Pack, 5 mL	5 mL x 6 Grades x 1 each

ToyoScreen column accessories

21400	ToyoScreen Column Holder

Toyopearl hydrophobic interaction chromatography MD-G columns:

Part #	*Product description*	*ID (mm)*	*Length (cm)*	*Particle size (µm)*	*Notes*
22237	Toyopearl MD-G Ether-650S	10	6.8	35	*Weakly hydrophobic. Excellent for MAB purification.*
22236	Toyopearl MD-G Phenyl-650S	10	6.8	35	*Moderately hydrophobic. Good all-purpose resin.*
22235	Toyopearl MD-G Butyl-650S	10	6.8	35	*Strongly hydrophobic.*
22247	TSKgel MD-G Ether-5PW (20)	10	6.8	20	
22246	TSKgel MD-G Phenyl-5PW (20)	10	6.8	20	

TSK-GEL LABPAK:

Part #	*Product description*	*Container size (mL)*	*Particle size (µm)*
43278	HICPAK PW (20) (Ether-5PW, Phenyl-5PW)	2 x 25 mL	10-30
43175	HICPAK PW (30) (Ether-5PW, Phenyl-5PW)	2 x 25 mL	20-40

Complete Tosoh Bioscience portfolio of prepacked columns and respective bulk polymeric media

Mode	*TSK-GEL columns for analysis*	*ToyoScreen Process Development columns*	*Bulk polymeric media for scale-up and production*	
SEC	G2000PW - G6000PW			Toyopearl HW-40 - HW-75
IEC	SP-5PW	ToyoScreen SP-650M	TSKgel SP-5PW	Toyopearl SP-650S, M or C,
		ToyoScreen SP-550C		Toyopearl SP-550C
		ToyoScreen GigaCap S-650M		Toyopearl GigaCap S-650M
		ToyoScreen MegaCap II SP-550EC		Toyopearl MegaCap II SP-550EC
	CM-5PW	ToyoScreen CM-650M		Toyopearl CM-650S, M or C
	DEAE-5PW	ToyoScreen DEAE-650M	TSKgel DEAE-5PW	Toyopearl DEAE-650S, M or C
	SuperQ-5PW	ToyoScreen SuperQ-650M	TSKgel SuperQ-5PW	Toyopearl SuperQ-650S, M or C,
		ToyoScreen QAE-550C		Toyopearl QAE-550C
HIC	Ether-5PW	ToyoScreen Ether-650M	TSKgel Ether-5PW	Toyopearl Ether-650S, M or C
	Phenyl-5PW	ToyoScreen Phenyl-650M	TSKgel Phenyl-5PW	Toyopearl Phenyl-650S, M or C
		ToyoScreen Butyl-650M		Toyopearl Butyl-650S, M or C
		ToyoScreen Hexyl-650C		Toyopearl Hexyl-650C
		ToyoScreen PPG-600M		Toyopearl PPG-600M
		ToyoScreen Butyl-600M		Toyopearl Butyl-600M
		ToyoScreen SuperButyl-550C		Toyopearl SuperButyl-550C
AFC	Chelate-5PW	ToyoScreen AF-Chelate-650M		Toyopearl AF-Chelate-650M
	Tresyl-5PW		TSKgel Tresyl-5PW	Toyopearl AF-Tresyl-650M
		ToyoScreen AF-BlueHC-650M		Toyopearl AF-BlueHC-650M
		ToyoScreen AF-Red-650M		Toyopearl AF-Red-650M
		ToyoScreen AF-HeparinHC-650M		Toyopearl AF-HeparinHC-650M

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