

# HIC HYDROPHOBIC INTERACTION CHROMATOGRAPHY

HIC PRODUCTS

- Toyopearl SuperButyl-550
- Toyopearl Hexyl-650
- Toyopearl Butyl-650
- Toyopearl Phenyl-650
- Toyopearl Butyl-600
- Toyopearl Phenyl-600
- Toyopearl PPG-600
- Toyopearl Ether-650

- TSKgel Phenyl-5PW
- TSKgel Ether-5PW

≡ TOSOH FACT

Tosoh Bioscience offers a range of technical support services to our TSKgel, ToyoScreen, and Toyopearl chromatography products.

Whether you need help developing an HPLC assay for the analysis of a new therapeutic target, want to know how to monitor drug metabolites in the human body or need regulatory files to support a submission to the FDA, our technical support specialists will provide assistance in all of these areas and more.

We offer on-site training and application-specific seminars and are committed to providing prompt and courteous service for these and other requests.





# HYDROPHOBIC INTERACTION CHROMATOGRAPHY

## TOYOPEARL RESINS FOR HYDROPHOBIC INTERACTION CHROMATOGRAPHY

Hydrophobic interaction chromatography (HIC) is a powerful tool for the process purification of biomolecules. The technique utilizes the accessible hydrophobic regions located on protein surfaces and their interactions with a weakly hydrophobic stationary phase. HIC is an excellent complement to ion exchange (IEC) and size exclusion chromatography (SEC) particularly when protein isoforms exist or when feedstock impurities are of similar isoelectric point or molecular weight. The selectivity differences exploited by HIC can also be used after affinity separations in which closely related proteins with similar recognition sites are not distinguishable by the affinity ligand.

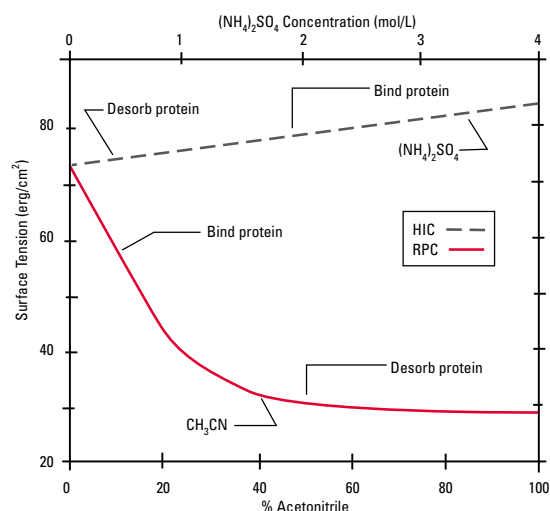
### HOW DOES HIC WORK?

Proteins and other molecules with hydrophobic surfaces are attracted to the hydrophobic ligands of both reversed phase (RPC) and HIC resins. RPC resins have higher surface coverage and/or more hydrophobic ligand compared to HIC resins. Because of this, in a RPC separation the target binding readily occurs in an aqueous solution, and desorption is promoted by the addition of an increasing amount of organic solvent.

In HIC, proteins are bound to the resin by employing an aqueous high salt mobile phase. The salt conditions contribute to a lyotropic effect which allows the proteins to bind to the lower surface coverage of a hydrophobic ligand. Proteins are eluted by the simple technique of decreasing the salt concentration. Most therapeutic targets are eluted in a low salt or a no salt buffer.

During elution the energy of interaction for a HIC step is less than that of a RP step. One means of gauging the relative binding energy between the two techniques is to measure the surface tension of the two sets of binding and elution conditions. Figure 1 provides a comparison of the surface tension generated by HIC and RPC elution systems. Since HIC separates under milder eluting conditions, biological activity is typically retained.

**FIGURE 1** SURFACE TENSION OF AQUEOUS SOLUTIONS USED IN HIC & RPC



Mode	Gradient (typical)	Δ Surface tension (erg/cm <sup>2</sup> )
HIC	1.8 to 0 mol/L (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> / aqueous buffer	4
RPC	10 to 50% ACN/ 0.1%TFA	23

C. Horvath et. al., Separation Processes in Biotechnology, (J. Asenjo, Ed.) 9, 447 (1990) Marcel Dekker

### FEATURES

➤ hydrophilic polymer resin matrix

➤ good mechanical stability

### BENEFITS

- robust chemical stability between pH 1 - 13
- temperature range 4 - 60°C
- autoclavable at 121°C
- compatible with organic solvents
- constant bed volume over a wide range of salt concentrations
- low non specific protein binding
- superior protein recovery
- excellent flow characteristics in large industrial size columns
- direct scale-up from TSKgel HIC HPLC columns

# HYDROPHOBIC INTERACTION CHROMATOGRAPHY



## FIVE DIFFERENT HYDROPHOBIC SURFACES AND SELECTIVITIES

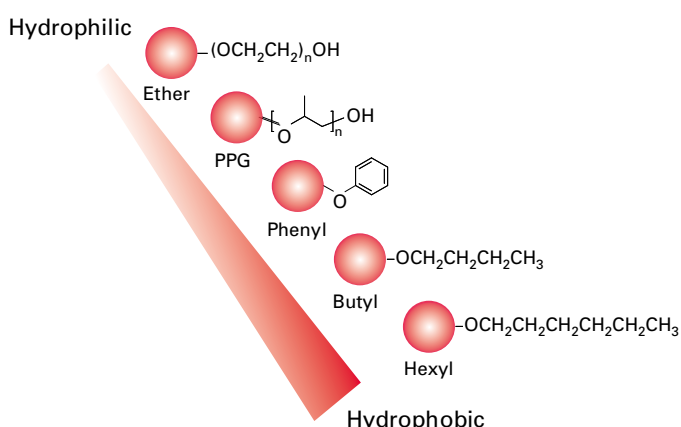
Tosoh Bioscience offers five HIC ligands featuring different degrees of hydrophobicity and selectivity. The hydrophobicity of Toyopearl HIC resins increases through the ligand series: Ether, PPG (polypropyleneglycol), Phenyl, Butyl, and Hexyl. (Figure 2)

Coordinating the hydrophobicity of the therapeutic target to the resin hydrophobicity is critical for the best overall purification performance. Too hydrophobic a resin for a given protein can result in its irreversible binding to the resin or a loss of enzymatic activity. Table I and II show typical mass recovery and biological activity recovery data for Toyopearl HIC resins.

An optimum HIC process step will balance high dynamic binding capacity, adequate selectivity, good mass recovery and retention of biological activity. The wide range of Toyopearl selectivities enables a developer to optimize protein separations at the extremes of the hydrophobic spectrum. Highly retentive Toyopearl Hexyl-type and Toyopearl Butyl-type resins are used to separate hydrophilic proteins. These two resins should also be considered for separations requiring a low salt environment. Toyopearl Ether-type resin is used for the purification of very hydrophobic targets such as certain monoclonal antibodies and membrane proteins. These proteins may bind irreversibly to other more hydrophobic resins. Toyopearl PPG-type and Toyopearl Phenyl-type phases complement the other HIC ligands available in the Toyopearl series and offer alternatives for mid-range hydrophobic proteins.

**FIGURE 2**

HIC LIGAND CANDIDATES



**TABLE I**

HIGH MASS RECOVERY (%) OF PROTEINS

	Toyopearl HIC resin		
	Ether-650M	Phenyl-650M	Butyl-650M
Bovine serum albumin	84	62	76*
$\alpha$ -chymotrypsinogen	96	88*	90
Cytochrome C	-	81*	87*
IgG	91	-	-
$\alpha$ -Lactalbumin	90	-	-
Lysozyme	94	92	85
Ovalbumin	83	88	73
Ribonuclease A	-	72*	82*

*Procedure: A 200 mL sample containing 200 mg of protein was loaded onto a 7.5 mm column and eluted with a 60 minute gradient of 1.8 mol/L (\*1.5 mol/L) to 0.0 mol/L ammonium sulfate in 0.1 mol/L sodium phosphate (pH 7.0). The mass recovery was determined spectrophotometrically at UV 280 nm and 25°C.*

**TABLE II**

RECOVERY OF ENZYMATIC ACTIVITY OF PROTEINS

Toyopearl HIC resin	Protein	% Activity recovery
Phenyl-650	Phytochrome	79
Butyl-650	Halophilic protease	85
Butyl-650	Poly (3-hydroxybutyrate) depolymerase	88
Butyl-650	Aculeacin-A acylase	82
Butyl-650	Opine dehydrogenase	81



# HYDROPHOBIC INTERACTION CHROMATOGRAPHY

The retention and selectivity of protein standards on Toyopearl HIC resins using the ToyoScreen process development columns are shown in Figure 3.

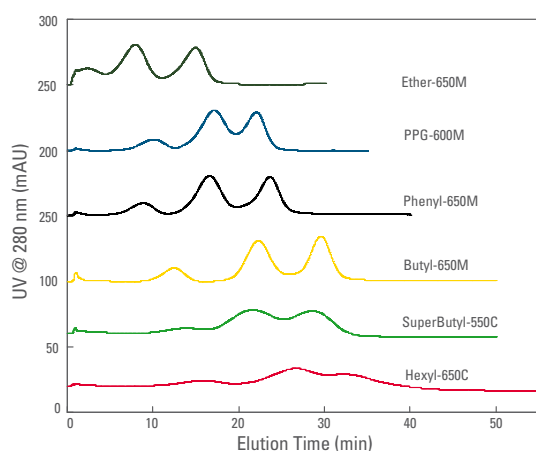
## INFLUENCE OF SALT TYPE

In addition to the hydrophobicity of the ligand, the selectivity in HIC is influenced by the eluent salt type. Figure 4 demonstrates the effect of salt type on the resolution factor of different protein pairs.

The Hofmeister lyotropic salt series shown in Figure 5 ranks anions and cations by their ability to promote protein precipitation. Ions on the left are referred to as “lyotropic” while the ions on the right are called “chaotropic”.

Lyotropic salts will precipitate or “salt out” proteins at high salt concentrations due to increased hydrophobic interaction, while chaotropic salts will promote protein denaturation at high salt concentrations. Figure 5 indicates that different salt systems may generate a variety of adsorption and desorption selectivities for each resin. This feature of HIC provides an additional parameter for the optimization of a process step.

**FIGURE 3** SCREENING OF TOYOPEARL HIC RESINS - STANDARD PROTEINS



Column: ToyoScreen (1 mL)  
 Mobile phase A: 0.1 mol/L phosphate buffer + 1.8 mol/L sodium sulfate (pH 7.0); Eluent B: 0.1 mol/L phosphate buffer (pH 7.0);  
 Gradient: 30 min linear gradient from A to B; Flow rate: 1 mL/min;  
 Inj. vol.: 50 µL; Detector: UV @ 280 nm; Samples: Ribonuclease A, Lysozyme, α-Chymotrypsinogen, 1 mg/mL

**FIGURE 5** HOFMEISTER LYOTROPIC SALT SERIES

For anions  
 $\text{SO}_4^{2-} > \text{HPO}_4^{2-} > \text{CH}_3\text{COO}^- > \text{halide} > \text{NO}_3^- > \text{ClO}_4^- > \text{SCN}^-$

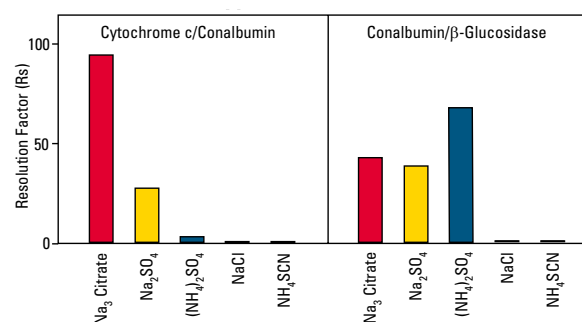
For cations  
 $(\text{CH}_3)_4\text{N}^+ > \text{NH}_4^+ > \text{K}^+ > \text{Na}^+ > \text{Cs}^+ > \text{Li}^+ > \text{Mg}^{2+} > \text{Ca}^{2+} > \text{Ba}^{2+}$

*Ammonium sulfate and sodium sulfate are the most commonly used salts in HIC. NaCl is often used as well.*

**FIGURE 6** METHACRYLIC BASE BEADS AVAILABLE FOR HIC

Pore size (Å)	50	125	400-500	750	1000	>1000	>1700
Product name							
Toyopearl HW-type	40	50	55	60	65	75	80
TSKgel PW-type	G1000	G2000	G4000	-	G5000	G6000	-

**FIGURE 4** INFLUENCE OF SALT-TYPE ON RESOLUTION



Chromatography on a Toyopearl Butyl-substituted support  
 Column dimensions: 4.1 mm ID x 4 cm L  
 Mobile phase: Linear gradient, 20 min, 1.0 mol/L to 0 mol/L of indicated salt in 20 mmol/L phosphate buffer (pH 7.0);  
 Flow rate, 1 mL/min; Detector: UV @ 280 nm

*J. Fausnaugh, L. Kennedy and F. Regnier, J. Chromatography 317, 141 (1984)*

# HYDROPHOBIC INTERACTION CHROMATOGRAPHY



## PARTICLE SIZE OPTIMIZATION

Toyopearl and TSKgel PW-type methacrylic base beads incorporate the same polymer chemistry (see Figure 6 or refer to SEC section for a more detailed discussion) and are available in a variety of particle sizes:

100 µm	Toyopearl C-grade	Capture
65 µm	Toyopearl M-grade	Intermediate Purification
35 µm	Toyopearl S-grade	Intermediate Purification/Polishing
30 & 20 µm	TSKgel PW-type	High Resolution

In many cases analytical columns are available packed with 10 micron particles having the same selectivity as the process media. Figure 7 shows the variety of ligands and particle sizes available for HIC process-scale applications. This figure also depicts where each particle size is used in a chromatographic manufacturing train (i.e. for capture, intermediate purification, or polishing).

## MECHANICAL STABILITY

The semi-rigid polymeric backbone of Toyopearl and TSKgel HIC resins permits high flow rates for maximum throughput and productivity. Toyopearl resins may be operated up to 3 bar and TSKgel PW-type resins may be operated up to 20 bar. The pressure-flow characteristics for each particle size grade of Toyopearl Phenyl-650 resins are shown in Figure 8. The beads are compatible with both fixed bed and dynamic axial compression columns.

## CHEMICAL STABILITY

The polymeric structure of these products also makes them resistant to a wide range of pH conditions and ionic strengths. In addition, the hydroxylated surface of the base bead reduces non-specific binding of proteins.

FIGURE 7

Process step	Bead size	Process media
Capture	100 µm	Toyopearl SuperButyl-650C Toyopearl Hexyl-650C Toyopearl Butyl-650C Toyopearl Phenyl-650C
	65 µm	Toyopearl Butyl-600M Toyopearl Phenyl-600M Toyopearl PPG-600M
Intermediate Purification	35 µm	Toyopearl Butyl-650M Toyopearl Phenyl-650M Toyopearl Ether-650M
	30 µm	TSKgel Phenyl-5PW (30) TSKgel Ether-5PW (30)
Polishing	20 µm	TSKgel Phenyl-5PW (20) TSKgel Ether-5PW (20)
	10 µm	TSKgel Phenyl-5PW 2 mm ID x 7.5 cm L TSKgel Ether-5PW 2 mm ID x 7.5 cm L

Same selectivity HPLC columns are available for most process media



# HYDROPHOBIC INTERACTION CHROMATOGRAPHY

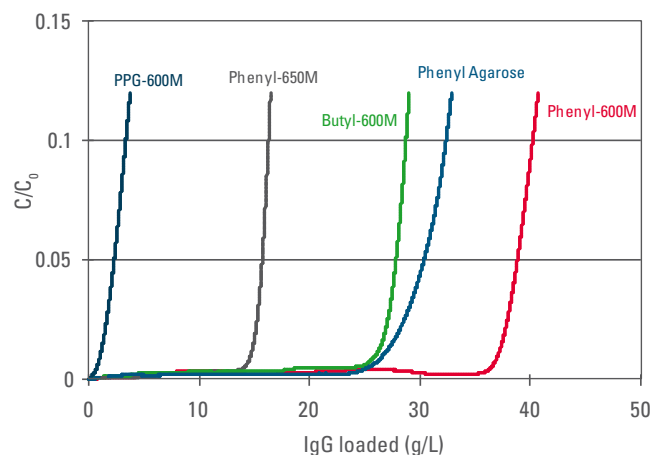
## PORE SIZE OPTIMIZATION

Most Toyopearl HIC products are derived from the versatile size exclusion resin, Toyopearl HW-65 (1,000 Å mean pore size), as the base bead for the majority of protein separations. But the pore size and accessible surface area of Toyopearl resins can be optimized for a given protein. More accessible surface area increases the dynamic binding capacity (DBC) of the bead for a particular therapeutic target. This has led to the development of two specialty lines of HIC materials with higher dynamic binding capacities.

## HIGH DYNAMIC BINDING CAPACITY TOYOPEARL PROCESS RESINS

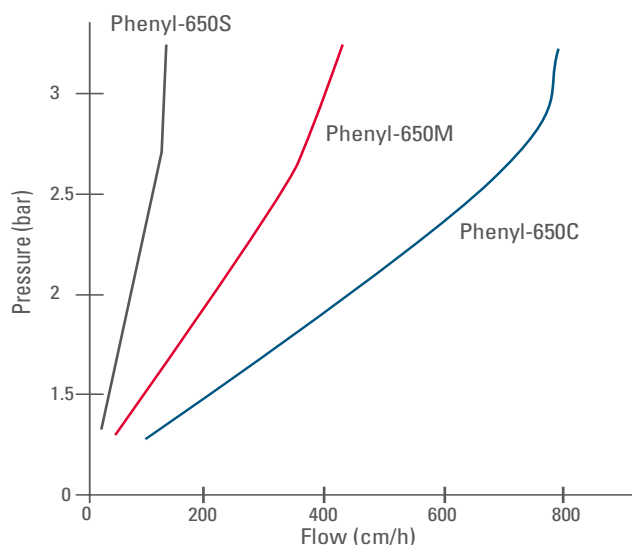
For monoclonal antibodies a pore size of 750 Å is optimum. A specially made base resin, Toyopearl HW-60, has this pore size. Three ligands are available on Toyopearl HW-60: polypropylene glycol (PPG), phenyl, and butyl. A comparison of their DBCs with Toyopearl Phenyl-650M resin is shown in Figure 9. The selectivities of Toyopearl Butyl-600M, Toyopearl PPG-600M and the Toyopearl Phenyl-600M resins, are shown in Figure 10.

**FIGURE 9** BREAKTHROUGH CURVES OF POLYCLONAL IgG ON VARIOUS HIC RESINS



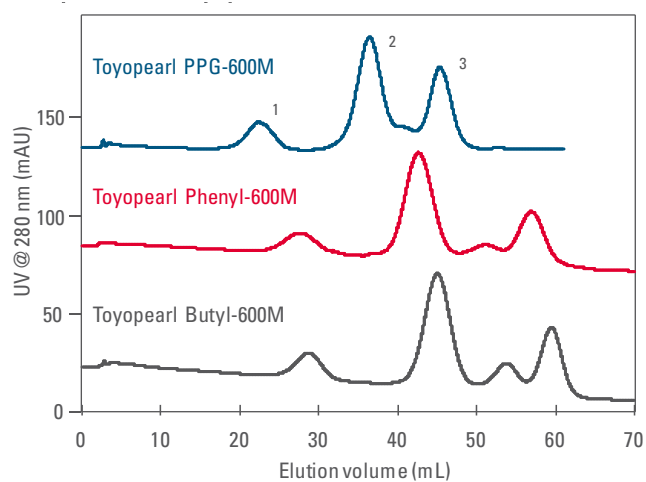
Column: 7.8 mm ID X 20 cm L; Sample: polyclonal human IgG  
Binding buffer: 1 g/L IgG in 0.8 mol/L  $(\text{NH}_4)_2\text{SO}_4$  + 0.1 mol/L sodium phosphate (pH 7.0); Linear velocity: 300 cm/hr  
Temperature: 25 °C; Detector: UV @ 280 nm  
DBC was calculated at 10% of breakthrough.

**FIGURE 8** PRESSURE-FLOW CURVE FOR TOYOPEARL PHENYL-650 RESINS OF VARIOUS PARTICLE SIZE



Column: Toyopearl Phenyl-650C, M and S, 25 mm ID x 25 cm L  
Mobile phase: 2 mol/L  $(\text{NH}_4)_2\text{SO}_4$

**FIGURE 10** COMPARISON OF TOYOPEARL 600M SERIES RESINS



Column: 7.5 cm ID X 7.5 cm L; Sample: 1 g/L RNase A (1), lysozyme (2) and  $\alpha$ -chymotrypsinogen A (3)  
Sample load: 100  $\mu$ L; Gradient: 60 min linear gradient from buffer A to B; Buffer A: 1.8 mol/L  $(\text{NH}_4)_2\text{SO}_4$  + 0.1 mol/L sodium phosphate (pH 7.0); Buffer B: 0.1 mol/L sodium phosphate (pH 7.0)  
Linear velocity: 136 cm/hr; Temperature: 25 °C  
Detector: UV @ 280 nm

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Figure 11 compares the selectivities of the Toyopearl Phenyl-600M, Toyopearl Phenyl-650M and an Agarose Phenyl resin.

For smaller molecules such as lysozyme (12,000 Da) the even narrower pore diameter Toyopearl SuperButyl-550C resin (derived from the 500 Å pore diameter Toyopearl HW-55) is recommended. A comparison of the DBC of Toyopearl SuperButyl-550C with other Toyopearl HIC resins is shown in Figure 12.

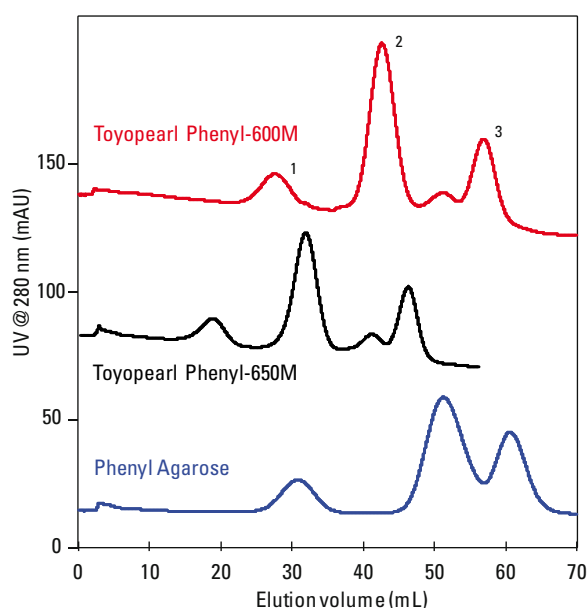
The Toyopearl Phenyl-600M resin also has a high DBC for lysozyme (Figure 13). The engineered higher dynamic binding capacity of the 600 and 550 series HIC products for their specific targets and the selectivity differences induced by the smaller mean pore size of the respective beads can have a dramatic impact on process economics.

## TOYOSCREEN PREPACKED COLUMNS FOR PROCESS DEVELOPMENT

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

**FIGURE 11**

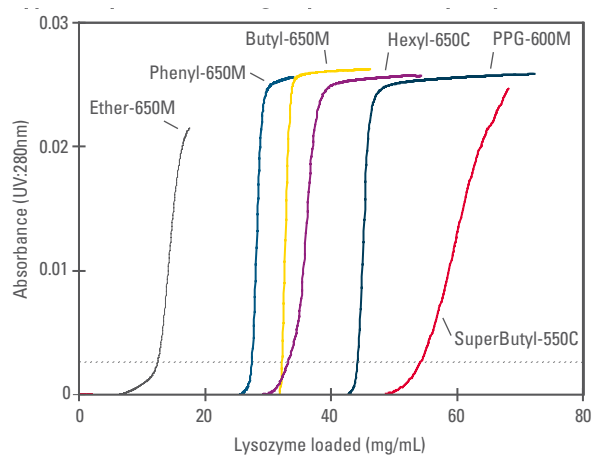
SELECTIVITY COMPARISON OF PHENYL-TYPE RESINS



Column: 7.5 cm ID X 7.5 cm L  
 Sample: 1 g/L RNase A (1), lysozyme (2) and α-chymotrypsinogen A (3); Sample load: 100 µL; Gradient: 60 min. linear gradient from buffer A to B; Buffer A: 1.8 mol/L (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> + 0.1 mol/L sodium phosphate (pH 7.0); Buffer B: 0.1 mol/L sodium phosphate (pH 7.0)  
 Linear velocity: 136 cm/hr; Temperature: 25°C; Detector: UV @ 280 nm

**FIGURE 12**

TYPICAL DYNAMIC BINDING CAPACITIES FOR LYSOZYME



Resin	Binding capacity (mg/mL) (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; Sample: 1 mg/mL Lysozyme in 0.1 mol/L phosphate buffer + 1.8 mol/L sodium sulfate (pH 7.0); Linear Velocity: 100 cm/h; Detection: UV @ 280 nm



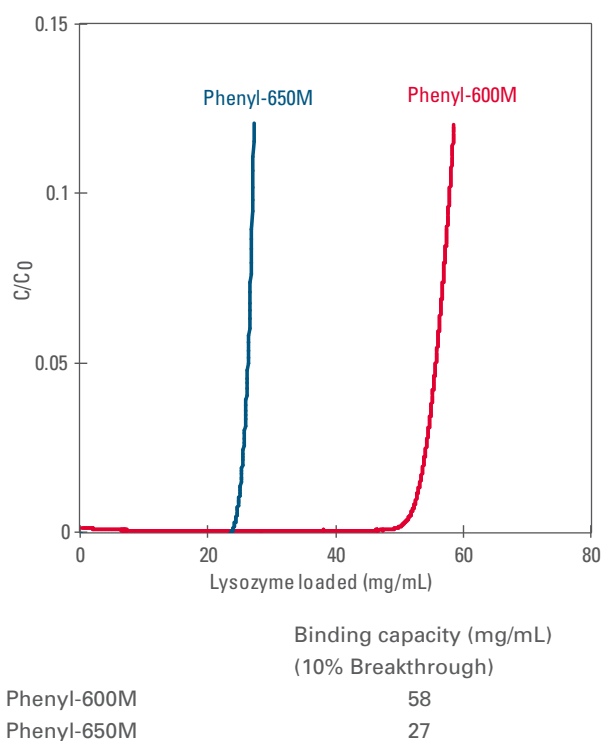
# HYDROPHOBIC INTERACTION CHROMATOGRAPHY

## MONOCLONAL ANTIBODIES

Hydrophobic interaction is a very useful technique for the purification of monoclonal antibodies. The diverse hydrophobic nature of mAbs is seen in Figure 14. This figure measures the hydrophobicity (using elution time as a surrogate measurement) of 51 different mouse IgGs on a TSKgel Phenyl-5PW analytical column. Some of the IgGs have elution times 2-3 times longer than others indicating greater hydrophobicity. The Toyopearl series of HIC ligands (Figure 2, page 33) with their different hydrophobicities gives chromatographic developers a range of options for finding the right ligand for their target molecule.

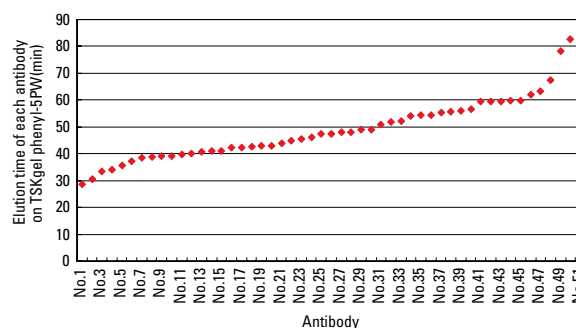
For a very hydrophobic mAb, such as mouse anti-chicken 14 kDa lectin, the less hydrophobic Toyopearl Ether ligand works quite well. The purification from ascites fluid (Figure 15) was performed with a 10  $\mu\text{m}$  TSKgel Ether-5PW semi-preparative column. Identical selectivity for scale-up was found with corresponding 65  $\mu\text{m}$  Toyopearl Ether-650M resin.

**FIGURE 13** TOYOPEARL PHENYL-600M BREAKTHROUGH CURVE (LYSOZYME)



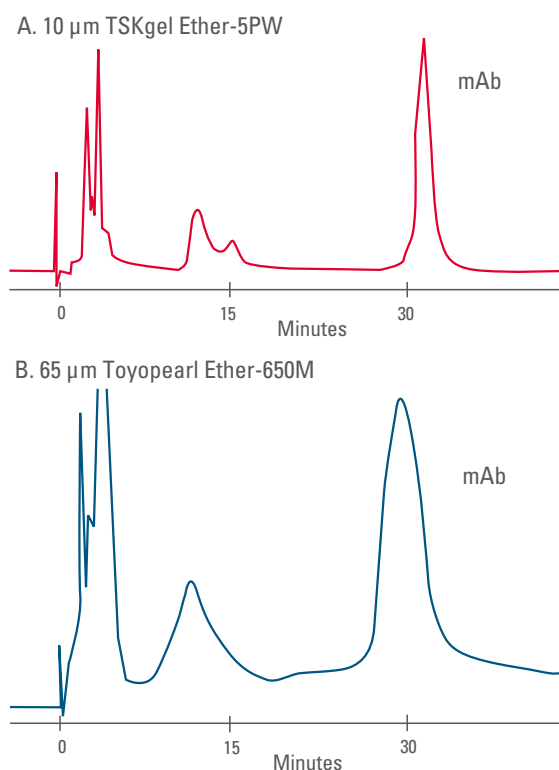
Column: 7.8 mm ID x 20 cm L; Sample: 1 mg/mL lysozyme in 0.1 mol/L phosphate buffer (pH 7.0) + 1.8 mol/L  $(\text{NH}_4)_2\text{SO}_4$   
 Linear velocity: 300 cm/h; Detector: UV @ 280 nm

**FIGURE 14** HYDROPHOBIC DIVERSITY OF MOUSE MONOCLONALS



Plot of chromatographic elution times for 51 different mouse mAbs  
 Column: TSKgel Phenyl-5PW; Mobile phase: (A) 0.1 mol/L phosphate buffer containing 1.8 mol/L ammonium sulfate (pH 7.0); (B) 0.1 mol/L phosphate buffer (pH 7.0);  
 Flow rate: 1 mL/min; Gradient: (B) 0% (0 min)--0% (5 min)--100% (65 min) linear; Detector: UV @ 280 nm; Samples: 51 kinds of mouse monoclonal antibodies

**FIGURE 15** PURIFICATION OF MABS FROM ASCITES FLUID



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  $\mu\text{L}$ ; B. 0.76 mg in 50  $\mu\text{L}$   
 Mobile phase: 60 min linear gradient from 1.5 mol/L to 0 mol/L  $(\text{NH}_4)_2\text{SO}_4$  in 0.1 mol/L phosphate buffer (pH 7.0)  
 Linear velocity: 136 cm/h; Detection: UV @ 280 nm

# HYDROPHOBIC INTERACTION CHROMATOGRAPHY



## PROTEIN AGGREGATE REMOVAL

The larger pore Toyopearl products such as Toyopearl Butyl-650 and Toyopearl Phenyl-650 resins are very useful for protein aggregate separation and removal. Early work by Karger et al<sup>1</sup> in 1989 involving proteins and aggregates larger than 200 kDa demonstrated the effectiveness of HIC for this application.

## GLYCOPROTEINS

Toyopearl HIC resins can purify glycoproteins, which often bind irreversibly to saccharide-based chromatographic media. Figure 16 shows the purification of a large glycoprotein on Toyopearl Butyl-650S resin.

## DNA PLASMID PURIFICATION AND ENDOTOXIN REMOVAL

Toyopearl Hexyl-650C resin was successfully used for plasmid DNA purification by Cambrex, Baltimore, MD (US patent 6,953,686). Hexyl-650C was shown to be the most effective among HIC resins for endotoxin removal with capacities exceeding 2 million EU/mL of resin. Additionally, RNA and protein impurities were effectively eliminated. Hexyl-650C was also effective in separating the supercoiled and open circular forms of plasmid DNA.

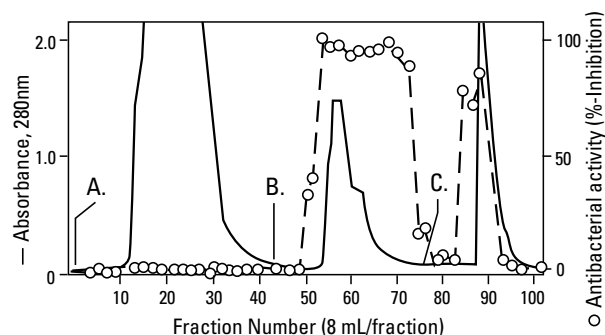
## REMOVAL OF MISFOLDED PROTEINS

Because misfolded proteins will generally be more hydrophobic than the native protein, Toyopearl Butyl-650M resin is used frequently for the removal of misfolded proteins. In many cases flow through chromatography can be accomplished under eluent conditions binding the misfolds while allowing the target to flow through the column.

Go to [www.separations.eu.tosohbioscience.com](http://www.separations.eu.tosohbioscience.com), to check our database on the website for additional applications.

<sup>1</sup> Grinberg, N. Blanco, R. Yarmush, D. Karger, B. L. Protein Aggregation in High Performance Liquid Chromatography: Hydrophobic Interaction Chromatography of  $\beta$ -Lactoglobulin, Anal. Chem. 1989, 61, 514-520.

**FIGURE 16** LARGE GLYCOPROTEIN PURIFIED ON TOYOPEARL BUTYL-650S



Column: Toyopearl Butyl-650S, 22 mm ID x 26 cm L  
 Sample: crude protein from sea hare *Aplysia kurodai*;  
 Mobile phase: multi-step  $(\text{NH}_4)_2\text{SO}_4$  in 50 mmol/L phosphate buffer (pH 7.0); A. load & wash: 40% saturated  $(\text{NH}_4)_2\text{SO}_4$ ; B. 20% saturated  $(\text{NH}_4)_2\text{SO}_4$ ; C. 0% saturated  $(\text{NH}_4)_2\text{SO}_4$ ; Detector: UV @ 280 nm



# HYDROPHOBIC INTERACTION CHROMATOGRAPHY

## ORDERING INFORMATION

### TOYOSCREEN PROCESS DEVELOPMENT COLUMNS FOR HIC

PART #	PRODUCT DESCRIPTION	PACKAGE
21372	ToyoScreen Ether-650M	1 mL x 6 each
21373	ToyoScreen Ether-650M	5 mL x 6 each
21374	ToyoScreen Phenyl-650M	1 mL x 6 each
21375	ToyoScreen Phenyl-650M	5 mL x 6 each
21376	ToyoScreen Butyl-650M	1 mL x 6 each
21377	ToyoScreen Butyl-650M	5 mL x 6 each
21378	ToyoScreen Hexyl-650C	1 mL x 6 each
21379	ToyoScreen Hexyl-650C	5 mL x 6 each
21380	ToyoScreen PPG-600M	1 mL x 6 each
21381	ToyoScreen PPG-600M	5 mL x 6 each
21892	ToyoScreen Phenyl-600M	1 mL x 6 each
21893	ToyoScreen Phenyl-600M	5 mL x 6 each
21382	ToyoScreen SuperButyl-550C	1 mL x 6 each
21383	ToyoScreen SuperButyl-550C	5 mL x 6 each
21494	ToyoScreen Butyl-600M	1 mL x 6 each
21495	ToyoScreen Butyl-600M	5 mL x 6 each
21398	ToyoScreen HIC Mix Pack, (PPG-600M, Butyl-600M, Phenyl-650M, Butyl-650M, Phenyl-600M, Hexyl-650C)	1 mL x 6 Grades x 1 each
21399	ToyoScreen HIC Mix Pack, (PPG-600M, Butyl-600M, Phenyl-650M, Butyl-650M, Phenyl-600M, Hexyl-650C)	5 mL x 6 Grades x 1 each

### TOYOSCREEN COLUMN ACCESSORIES

PART #	PRODUCT DESCRIPTION
21400	ToyoScreen Column Holder

### TSKgel 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

### TOYOPEARL HIC RESINS

PART #	PRODUCT DESCRIPTION	CONTAINER SIZE (mL)	PARTICLE SIZE (µm)	TYPICAL CAPACITY (mg LYSOZYME/mL RESIN)
43151	Toyopearl Ether-650S	25	20-50	10-30
16172		100		
16174		1,000		
16176		5,000		
19805	Toyopearl Ether-650M	25	40-90	10-30
16173		100		
16175		1,000		
16177		5,000		
21301	Toyopearl PPG-600M	25	40-90	45-55
21302		100		
21303		1,000		
21304		5,000		
21305		50,000		
21887	Toyopearl Phenyl-600M	25	40-90	45-65
21888		100		
21889		1,000		
21890		5,000		
21891		50,000		
43152	Toyopearl Phenyl-650S	25	20-50	30-50
14477		100		
14784		1,000		
14935		5,000		

# HYDROPHOBIC INTERACTION CHROMATOGRAPHY



## ORDERING INFORMATION

PART #	PRODUCT DESCRIPTION	CONTAINER SIZE (mL)	PARTICLE SIZE (μm)	TYPICAL CAPACITY (mg LYSOZYME/mL RESIN)
19818	Toyopearl Phenyl-650M	25	40-90	30-50
14478		100		
14783		1,000		
14943		5,000		
18364		50,000		
43126	Toyopearl Phenyl-650C	25	50-150	30-50
14479		100		
14785		1,000		
14944		5,000		
43153	Toyopearl Butyl-650S	25	20-50	30-50
07476		100		
14701		1,000		
07975		5,000		
18826		50,000		
19802		Toyopearl Butyl-650M		
07477	100			
14702	1,000			
07976	5,000			
18355	50,000			
43127	Toyopearl Butyl-650C	25	50-150	30-50
07478		100		
14703		1,000		
07977		5,000		
21448	Toyopearl Butyl-600M	25	40-90	40-60(g/L (γ-globulin))
21449		100		
21450		1,000		
21451		5,000		
21452		50,000		
19955	Toyopearl SuperButyl-550C	25	50-150	52-70
19956		100		
19957		1,000		
19958		5,000		
19959		50,000		
44465	Toyopearl Hexyl-650C	25	50-150	30-50
19026		100		
19027		1,000		
19028		5,000		
TSKgel 5PW HIC RESINS FOR HIGH RESOLUTION				
43276	TSKgel Ether-5PW (20)	25	10-30	10-30
16052		250		
16053		1,000		
18437		5,000		
43176	TSKgel Ether-5PW (30)	25	20-40	10-30
16050		250		
16051		1,000		
18439		5,000		
43277	TSKgel Phenyl-5PW (20)	25	10-30	10-30
14718		250		
14719		1,000		
18438		5,000		
43177	TSKgel Phenyl-5PW (30)	25	20-40	10-30
14720		250		
14721		1,000		
17210		5,000		