AG® 1, AG MP-1 and AG 2 Strong Anion Exchange Resin

Instruction Manual

BIO-RAD

Table of Contents

Section 1
Introduction

AG 1, AG MP-1 and AG 2 resins are strongly basic anion exchangers. They are capable of exchanging anions of acidic, basic, and neutral salts, and ampholytes on the basic side of their pI. Strong anion exchange resins are used for sample preparation, enzyme assays, metal separations, and peptide, protein, and nucleic acid separations.

Section 2
Technical Description

Strongly basic anion exchange resins are available as Analytical Grade AG 1 and AG 2 resins, AG MP-1 macroporous resin, and Biotechnology Grade AG 1 resin. The Analytical Grade AG 1, AG MP-1 and AG 2 resins have been exhaustively sized, purified, and converted to make them suitable for accurate, reproducible analytical techniques. Biotechnology Grade AG 1 resin is analytical grade resin which is certified to contain less than 100 microorganisms per gram of resin.

AG 1 and AG 2 resins are strongly basic anion exchangers with quaternary ammonium functional groups attached to the styrene divinylbenzene copolymer lattice. The amount of resin crosslinkage determines the bead pore size. A resin with a lower percentage of crosslinkage has a more open structure permeable to higher molecular weight substances than a highly crosslinked resin. It also has a lower physical resistance to shrinking and swelling, so that it absorbs more water and swells to a larger wet diameter than a highly crosslinked resin of equivalent dry diameter. For example, the lower crosslinked resins, particularly AG 1-X2 2% crosslinked resin, are useful for the sorption and fractionation of relatively high molecular weight substances such as peptides, ribo- and deoxyribonucleotides, and uranium. The higher crosslinked resins, particularly AG 1-X8 8% crosslinked resin, are used for sorption, exchange, and separation of low molecular weight inorganic anions, and in applications such as cyclic nucleotide assays and fractionation of organic acids. Table 1 shows the approximate molecular weight exclusion limits in water for resins of various crosslinkages.

Table 1. Approximate Molecular Weight Exclusion Limits for Ion Exchange Resins in Water

Percent Crosslinking	Approximate MW Exclusion Limit for Globular Molecules
2%	2,700
4%	1,400
8%	1,000
10%	800
12%	400

AG 2 resin is similar to AG 1 resin, but is slightly less basic and slightly less resistant to oxidation due to differences in the structure of the quaternary functional group. It offers advantages in certain applications. For example, it is capable of separating sugars, sugar alcohols, and glycosides using a step gradient and borate buffers without isomerizing some sugars, as AG 1 resin tends to do.

Each AG 1 resin is supplied in the chloride form. Selected resins are available in the acetate, formate, and hydroxide form. These ionic forms may be considered more activated forms than the chloride form, as may be deduced from the order of selectivity information given in Tables 2 and 3. AG 1 resins purchased in the more active forms may be converted to any other form. The chloride ion, because of its higher selectivity for the resin, is relatively difficult to replace with formate, acetate, hydroxide, or fluoride. Thus, if various ionic forms are to be used, the formate or acetate forms provide flexibility and convenience (see Table 3). Formate and acetate forms may be used to separate most low molecular weight biological compounds, such as nucleotides, hormones, peptides, and carboxylic acids. AG MP-1 resin is the macroporous equivalent of AG 1 resin. Its effective surface area approximates 23 square meters per dry gram, 20% porosity.

The physical properties of the resins are listed in Table 2. The anion exchange resins are thermally stable and resistant to solvents (alcohols, hydrocarbons, etc.), reducing agents, and oxidizing agents.

Table 2. Guide to Analytical Grade Anion Exchange Resins

Resin Type	Active Group	Order of Selectivity	Thermal Stability	Solvent Stability	Resistance to Oxidizing Agents
AG 1 and AG MP-1 Resins	$R\text{-}CH_2N^+(CH_3)_3$	>phenolate >HSO_4^->ClO_3^- >NO_3^->Br> CN>HSO_3^-> NO_2^->Cl> HCO_3^->IO_3^-> H_2COO^->Ac> OH>F	OH^- form, fair to 50 °C; Cl^- and other forms, good to 150 °C	Very good	Slow solution in hot 15% HNO_3 or conc. H_2O_2
AG 2 Resin	$R\text{-}CH_2N^+(CH_3)_2C_2H_4OH$	phenolate>I >HSO_4^->ClO_3^- >NO_3^->Br> CN>HSO_3^-> NO_2^->Cl>OH >IO_3^->H_2COO^- >Ac>F	OH^- form, to 30 °C; Cl^- forms, good to 150 °C	Very good	Slow solution in hot 15% HNO_3 or conc. H_2O_2

Section 3
Mechanism

In an ion exchange procedure, the counterions on the resin are replaced by sample ions that have the same charge. With anion exchange resins such as AG 1 and

AG MP-1, neutral species and cations do not interact with the resin. In the chloride form of AG 1, AG MP-1, and AG 2 resin, the counterion on the resin is Cl^-. A resin can be converted from one ionic form to another. Usually the resin is used in an ionic form with a lower selectivity for the functional group than the sample ions to be exchanged. The sample ions are then exchanged onto the resin when introduced, and can be eluted by introducing an ion with higher affinity for the resin or a high concentration of an ion with equivalent or lower affinity. Table 3 shows the relative selectivity of various counterions. In general, the lower the selectivity of the counterion, the more readily it exchanges for another ion of like charge. The order of selectivity can also be used to estimate the effectiveness for different ions as eluants, with the most highly selective being the most efficient. Finally, the order of selectivity can be used to estimate the difficulty of converting the resin from one form to another. Conversion from a highly selected to a less highly selected form requires an excess of the new ion.

Table 3. Relative Selectivity of Various Counterions

Counterion	Relative Selectivity for AG 1 and AG MP-1 Resins	Relative Selectivity for AG 2 Resin
OH^-	1.0	1.0
Benzene sulfonate	500	75
Salicylate	450	65
Citrate	220	23
I^-	175	17
Phenate	110	27
HSO_4^-	85	15
ClO_3^-	74	12
NO_3^-	65	8
Br^-	50	6
CN^-	28	3
HSO_3^-	27	3
BrO_3^-	27	3
NO_2^-	24	3
Cl^-	22	2.3
HCO_3^-	6.0	1.2
IO_3^-	5.5	0.5
HPO_4^-	5.0	0.5
Formate	4.6	0.5
Acetate	3.2	0.5
Propionate	2.6	0.3
F^-	1.6	0.3

The AG 1 and AG MP-1 resins are available in several particle size ranges. The flow rate in a chromatographic column increases with increasing particle size. However, the attainable resolution increases with decreasing particle size and narrower size distribution ranges. Particle size is given either in mesh size or micron size. The larger the mesh size number, the smaller the particle size. Table 4 shows wet mesh and equivalent micron diameters.

Table 4. Wet Mesh and Equivalent Micron Diameters

Wet Mesh (U.S. Standard)	16	20	40	50	80	100	140	200	270	325	400
Micron Diameter (1 µm = 0.001 mm)	1,180	850	425	300	180	150	106	75	53	45	38

Large mesh material (20-50 and 50-100 mesh) is used primarily for preparative applications and batch operations where the resin and sample are slurried together. Medium mesh resin (100-200) may be used in batch as well as column applications. Medium mesh is an ideal, general purpose particle size for use in analytical and preparative scale column chromatography. Fine mesh material (200-400 and minus 400 mesh) is used for high resolution analytical separations.

Section 4
Resin Conversion

Table 5 outlines common techniques for converting ion exchange resins from one ionic form to another. Resin conversion is most efficiently carried out in the column mode. However, when choosing a column, remember that the resin may shrink, or it may swell as much as 100%, depending on the conversion.

Table 5. Techniques for Resin Conversion

Resin	Conversion From→To[1]	Reagent Used	Volumes of Sol'n/Vol. of Resin	Linear Flow Rate[4] cm/min of Bed	Type of Exchange[3]	Test for Completeness of Conversion	Rinse:Vol. Dl Water/ Vol. Resin	Test for Completion of Rinsing
AG 1 and	$Cl^- \rightarrow OH^-$	1 N NaOH[2]	20		IX	Cl^-[5]	4	pH<9
AG MP-1	$OH^- \rightarrow$ formate	1 N formic acid	2	2	N	pH<2	4	pH>4.8
Resins	$Cl^- \rightarrow$ formate	Use $Cl^- \rightarrow OH^-$ and then $OH^- \rightarrow$ formate	20 2		IX-N			pH>4.8 pH>4.8
	$Cl^- \rightarrow$ acetate	same as formate except use 1 N HAc			IX-N	pH<2	4	pH>4.8
AG 2 Resin	$Cl^- \rightarrow OH^-$	1 N NaOH[2]	2	2	IX	Cl^-[5]	4	pH>9
	$Cl^- \rightarrow NO_3^-$	0.5 N $NaNO_3$	5		IX	Cl^-[5]	4	

1. Typical conversions are listed. The same reagents can be used to convert from other ionic forms. Two steps regeneration, ion exchange followed by neutralization, is included because of ease of conversion and saving on expensive reagents.
2. Use U.S.P. or C.P. grade (low chloride).
3. N = Neutralization; IX = Ion exchange; IXN = two step process: Ion exchange to acid or base form followed by neutralization with appropriate base or acid of salt, example (Step 1) Resin-Cl^- + NaOH → Resin-OH (IX); (Step 2) Resin-OH + H-formate → resin-formate + H_2O (neutralization).
4. For 50-100 or finer mesh resin. For 20-50 mesh about ½ the flow rate is recommended
5. Test for Cl^- in effluent: Acidify sample with a few drops of conc. HNO_3. Add 1% Ag NO_3 solution. White ppt indicates Cl^-, yellow Br^- or too basic.

Conversions to ionic forms not listed in Table 5 can be achieved using the information supplied in Table 3, which lists relative selectivities of various counterions for AG 1, AG MP-1, and AG 2 resin. To convert a resin to an ionic form with a higher selectivity, wash the resin with 2-5 bed volumes of a 1 M solution of the desired counterion. For conversion to an ionic form with a lower relative selectivity for the resin, the necessary volume of counterion solution will depend on the difference in selectivity. As a general rule, use 1 bed volume of 1 M counterion solution for each unit difference in relative selectivity. For example, converting AG 1-X8 resin from the formate form (relative selectivity 4.6) to the hydroxide form (relative selectivity 1.0) would require 4-5 bed volumes of 1 M NaOH.

In some cases, it is more economical and more efficient to go through an intermediate counterion when converting to a counterion of much lower selectivity. One example of this is the conversion of AG 1-X8 resin from the chloride form (relative selectivity 22) to the formate form (relative selectivity 4.6). The resin is first converted to the hydroxide form (relative selectivity 1.0)

using 20 bed volumes of 1 N NaOH. The resin has a very low selectivity for hydroxide, making the conversion to the formate form relatively simple (2 bed volumes of 1 N formic acid). Another conversion method is to first convert to an ionic form of intermediate selectivity. When converting from the chloride form (relative selectivity 22) to the hydroxide form (relative selectivity 1), the resin can first be converted to the bicarbonate form (relative selectivity 6.0).

The easiest method to test for completeness of conversion depends on the particular conversion. Conversion is complete when the first ion is no longer detected in the effluent. In many cases, this can be monitored by pH or by simple qualitative tests. When conversion is complete, the resin should be rinsed with deionized water, then with starting buffer, until a stable pH is obtained. The resin is then equilibrated to the desired starting conditions.

Section 5
Instructions for Use

AG 1 and AG MP-1 resins may be used in a batch method or a column method. The batch method consists of adding the resin directly to the sample and stirring. The column method requires packing a column with resin, and passing the sample through.

5.1 Batch Method

The batch method is performed by adding the resin directly into the sample and stirring. The resin should be in the correct ionic form prior to beginning.

1. Weigh out about 5 grams of resin for every 100 ml of sample. For larger scale applications or when an exact amount of resin is needed, calculate the resin volume based on the resin capacity.
2. Add resin to the sample and stir or shake gently for 1 hour.
3. Filter or decant the sample from the resin.

5.2 Column Method

The column method involves pouring a column with the resin and passing the sample through to achieve the separation. Particle size will determine the flow rate, which will affect the separation. The resin should be in the correct ionic form and equilibrated prior to adding the sample.

1. Calculate the amount of resin required based on the expected resin capacity and sample concentration. If the sample ionic concentration is unknown, begin with 5 grams of resin for 100 ml of sample, and then optimize the volumes after looking at the results of the first separation.
2. Insure that the resin is in the proper ionic form to allow the sample ions to be exchanged onto the resin. If conversion of the resin into another ionic form is necessary, use the guidelines described for resin conversion (see Table 5).
3. Prepare the initial buffer so that the pH and ionic concentration will allow the sample ions to be

exchanged onto the column. For unknown solutions, use deionized water.

4. Slurry and pour the resin into the column. Equilibrate the resin in the initial buffer using 3 bed volumes of buffer. Poorly equilibrated resin will not give reproducible results. Alternatively, equilibration can be done by the batch technique, prior to pouring the column. First, convert the resin to the appropriate form, then suspend it in the starting buffer. Check the pH with a pH meter while stirring continuously. Adjust the pH by adding acid or base dropwise to the buffer until the desired pH is obtained. Then transfer the resin to the column, and pass 1 bed volume of the starting buffer through the column.
5. Slurry the resin in the initial buffer and pour the column. Allow excess buffer to pass through the column, leaving enough buffer to just cover the top of the resin bed.
6. Apply the sample dropwise to the top of the column without disturbing the resin bed. Drain the sample into the top of the bed and apply several small portions of starting eluant, being very careful to rinse down the sides of the column and to avoid stirring up the bed. Drain each portion to the level of the resin bed before the next portion is added. Never allow the liquid level to drain below the top of the resin bed sample.
7. The actual flow rate that is used will depend upon the application, the resin, and the column cross-section. To obtain flow rates for any given size column, multiply the suggested flow rates in Table 6 by the column cross-sectional area. Table 6 gives typical flow rates of analytical grade resins.
8. If an anion free solution is the goal, collect the effluent. If the concentrated anions are of interest, allow all of the sample to pass through the column, then elute the anions off the resin with a solution containing a counterion of higher selectivity than the bound anion.

Table 6. Suggested Flow Rates for Ion Exchange Resin Columns

Application	Linear Flow Rate (cm/min)
Removing trace ions	5-10
Separations with very few components	1-3
Separations of multi-component samples	0.3-1.0
Using high resolution resins with small particle size	1-2

Section 6
Sample Protocols for Anion Exchange Resins

6.1 Separation of Metal Ions

This experiment was suggested by Professor Harold Walton, University of Colorado, and Professors Charles Koch and George Pimental, University of California at Berkeley. It is a modification of Experiment 32, Volume

2, Trail Edition, Laboratory Manual of the Chemical Education Material Study.

Materials

AG 1-X8 resin, 50-100 mesh, 10 grams

Glass column approximately 12 mm ID, 30-40 cm long, and resistant to 9 N HCl

HCl approximately 9 N, 5 N, and 0.5 N

Sample solution - 0.1 meq Co^{2+}, Ni^{2+}, and Fe^{3+} prepared from 238 mg $CoCl_2 \cdot 6H_2O$; 238 mg $NiCl_2 \cdot 6H_2O$; and 271 mg $FeCl_3 \cdot 6H_2O$ in 10 ml 9 N HCl

Cobalt test solution - 10% NH_4SCN in acetone

Nickel test solution - 1% KSCN or 1% NH_4SCN

Test tubes or vials, 12

Procedure

1. Slurry the resin in distilled water.
2. Pour the resin into a column that is resistant to 9 N HCl. The resin bed should be approximately 10 cm deep.

3. Equilibrate the resin by passing approximately 15 ml of 9 N HCl over the resin bed.
4. Adjust the flow rate to no faster than 1 drop/second or 4 ml/min.
5. When the level of 9 N HCl has reached the top of the resin bed, either shut the screw clamp, or add 2 ml of sample (0.2 meq of each ion).
6. Do not allow air into the resin bed because air may cause channeling with uneven flow of subsequent solutions.
7. After the sample has soaked into the resin bed, add approximately 20 ml of 9 N HCl.
8. Begin collecting 5 ml aliquots.
9. The color of the eluant should intensify and then the eluant should become nearly colorless in the third or fourth aliquot.
10. Continue elution using 20 ml of 5 N HCl, and then 20 ml of 0.5 N HCl, in the manner described above.
11. In each case, 5 to 10 ml more of the eluant may be added if the eluant is still strongly colored after 20 ml of acid has soaked into the resin bed.

12. Observe and record the colors in the resin bed and in the eluant.
13. Test each aliquot for each of three ions:

    Co^{+2} test - 1 drop eluant plus 1 drop cobalt test solution. Strong test is a bright blue color.

    Ni^{+2} test - 1 drop eluant plus 1 drop nickel test solution. Neutralize with concentrated NH_3. A bright red ppt is a positive test for nickel.

    Fe^{+3} test - 1 drop eluant plus 1 drop iron test solution. A bright red color is a positive test.

6.2 Glucose Binding on AG 1-X8 Resin

This procedure demonstrates the binding and elution of glucose on AG 1-X8 resin.

Materials

Poly-Prep® disposable chromatography column, 2 ml

1 N NaOH

AG 1-X8 resin, 200-400 mesh, formate form, 2-3 ml

Glucose sample, 100 mg/ml

Ames Keta-Diastix test for glucose

1 M NaCl

Procedure

1. Pack the Poly-Prep chromatography column with 2 ml AG 1-X8 resin, 200-400 mesh, formate form.
2. Convert the resin to the OH form by washing it with 10 bed volumes of 1 N NaOh, then with 5 bed volumes of distilled water.
3. Add 1 ml of the glucose sample.
4. Wash with 3 bed volumes of water.
5. Check for the presence of glucose.
6. Elute the glucose with 1 M NaCl.
7. Check for glucose.

Section 7
Applications

Strong anion exchange resins are used for sample preparation, enzyme assays, metal separations, and peptide, protein, and nucleic acid separations. The tables below summarize the applications.

Table 7. Anion Exchange Resins for Sample Preparation

Application	Resin	Reference
Recovery of P_i from glucose-phosphate	AG 1-X4 resin	Stroop, S. D. and Boyer, P. D., *Biochem.*, **24,** 6, 2304 (1985).
Extraction of 5-hydroxy-indole acetic acid from CSF and urine	AG 1-X8 resin	Dombro, R. S. and Hutson, D. G., *Clin. Chim. Acta*, **100,** 231 (1980).
Anion removal from porphyrin in urine	AG 1-X8 resin	Torben, K. and Penderson, J. S., *Scand. J. Clin. Lab. Invest.*, **38,** 279 (1978).
Purification of cyclic nucleotides	AG 1-X8 resin	Shanfield, J., Jones, J. and Davidovitch, Z., *Anal. Biochem.*, **113,** 256 (1981).

Application	Resin	Reference
Purification of carboxylated pepsinogen	AG 1-X8 resin	Rajagopalan, T. G., Moore, S. and Stein, W. J., *J. Biol. Chem.*, **241,** 4940, (1966).
Separation of cAMP from cGMP	AG 1-X8 resin	Kuehl, F. A., Jr., Ham, E. A. and Zanetti, M. E, et al., *Proc. Nat. Acad. Sci. USA*, **71,** 1866 (1974); Fallon, A. M. and Wyatt, G. R., *Anal. Biochem.*, **63,** 614 (1975).
Concentration of amines	AG 1-X8 resin	Minkler, P. E., Ingalls, S. T., Kormos, L., et al., *J. Chromatog.*, **336,** 271 (1984).
Removal of triiodide	AG 1-X8 resin	Basciano, L. K., Berenstein, E. H., Kmak, L. and Siraganian, R. P., *J. Biol. Chem.*, **261,** 11823 (1986).
Concentration of niacin prior to HPLC analysis	Ag 1-X8 resin	Tyler, T. A. and Shrago, R. R., *J. Liq. Chromatog.*, **3,** 269 (1980).
Removal of organic acids and carbohydrates from guanidino compounds	AG 1-X8 resin	Marescau, B., De Deyn, P., Van Gorp, L. and Lowenthal, A., *J. Chromatog.*, **377,** 334 (1986).

Application	Resin	Reference
Removal of thyroid hormone from serum	AG 1-X8 resin	Stanley, F., Tsai, J. R. and Samuels, H. H., *J. Biol. Chem.*, **261,** 9400 (1966).
	AG 2-X8 resin	Stringer, B. M. J. and Wynford-Thomas, D., *Hormone Res.*, **16,** 392 (1982).
Concentration of phytate	AG 1-X8 resin	Ellis, R. and Morris, E. R., *Cereal Chem.*, **63,** 58 (1986).
Removal of ATP from proteoliposomes	AG 1-X8 resin	Woldegiorgis, G. and Shrago, E., *J. Biol. Chem.*, **260,** 7585 (1985).
Removal or concentration of organic acids	AG 1-X8 resin	Chen, P. M., Richardson, D. G. and Mellenthin, W. M., *J. Amer. Soc. Hort. Sci.*, **107,** 807 (1982).

Table 8. Metal Separation on Anion Exchangers

Metals	Recommended Resin	Eluant and Eluted Ions	Reference
Ni, Mn (ii), Co (ii), Cu (ii), Fe (iii), Zn (ii)	AG 1-X8 resin	Ni - 12 M HCl: Mn - 6 M HCl; Cu - 2.5 M HCl; Fe - 0.5 M HCl; Zn - 0.005 M HCl	Kraus, K. A., and Moore, G. E., *J. Amer. Chem. Soc.*, **75,** 1460 (1953).

Metals	Recommended Resin	Eluant and Eluted Ions	Reference
Ni, Co, Cu, Zn	AG 1-X8 resin	Ni - 96% MeOH, 0.2 M HCl; Co - 55% IPA, 1.3 M HCl; Cu - 55% IPA, 0.1 M HCl; Zn - 0.005 M HCl	Fritz, J. S. Pietrzyk, D. J., *Talanta*, 8, **143** (1961).
Mn, Co, Ni Fe, Mo, (also Cr, Zn, Cd, Hg)	AG 1-X8 resin	Mn, Co, Ni - 8.5 x 10^{-2} M tartrate; Fe - tartaric acid in 0.1 M HCl; Mo - 3 M NaOH	Morie, G. P., and Sweet, T. R., *J. Chromatog.*, **16,** 201 (1964).
Th, Hf, Zr, Mo	AG 1-X8 resin	Th - 0.7 N H_2SO_4; Hf - 1.25 N H_2SO_4; Zr - 2.0 N H_2SO_4; Mo - 2.0 N NH_4; NO_3, 0.5 N NH_3	Strelow, F. W. E. and Bothma, C. J. C., *Anal. Chem.*, **39,** 595 (1967).
V, Th, Fe	AG 1-X8 resin	Absorbed as citrate complexes; Th - 8 M HCl; Fe - IBMK, acetone, 1 N HCl (1:8:1 v/v); V - 1 M HCl	Korkisch, J. and Krivanec, H., *Anal. Chim. Acta*, **83,** 111 (1976).

Metals	Recommended Resin	Eluant and Eluted Ions	Reference
Bi, Pb, Cd, Zn	Ag 1-X8 resin	Pb, Cd, Zn - HBr-HNO_3; Bi - EDTA	Strelow, F. W. E., *Anal. Chem.*, **50,** 1359 (1978).

Table 9. Peptide and Protein Separations on Anion Exchangers

Application	Resin	Reference
Separation of small peptides from rabbit muscle	AG 1-X2 resin	Titani, K., Koide, A., Ericsson, L. H., et al., *Biochem.*, **17,** 5680 (1978).
Separation of peptides from horse liver cytochromes	AG 1-X2 resin	Ozuls, J., Craig, G. and Nobrega, F. G., *J. Biol. Chem.*, **251,** 6767 (1976).
Purification of fungal glucoamylase	AG 1-X4 resin	Bhella, R. S. and Altosaar, I., *Anal. Biochem.*, **140,** 200 (1984).

Table 10. Anion Exchange Resins in Enzymatic Assays

Enzyme	Substrate	Product	Resin	Reference
NADase	NAD	Nicotinamide	AG 1-X2 resin	Moss, J., Manganiello, V. C. and Vaughn, M., *Proc. Nat. Acad. Sci. USA*, **73,** 4424 (1976).
Cyclic 3',5' - nucleotide phosphodiesterase	cAMP	Adenosine	AG 1-X2 resin	Brooker, G., Thomas, L. J., Jr. and Appelman, M. M., *Biochem.*, **12,** 4177 (1968); Ong, K. K. and Rennie, P. I. C., *Anal. Biochem.*, **76,** 53 (1976); Thompson, W. J., Teraski, W. L., Epstein, P. M. and Strada, S. J., *Advan. Cyclic Nucleotide Res.*, **9,** 69 (1978).
Sucrose synthetase; sucrose phosphate synthetase	UDP-glucose and fructose; UDP-glucose and fructose-6-P	Sucrose + UDP; UDP + sucrose -6-P	AG 1-X4 resin	Salerno, G. L., Gamundi, S. S. and Pontis, H. G. *Anal. Biochem.*, **93,** 196 (1979).
Guanylate cyclase	GTP	cGMP	AG 1-X8 resin; neutral alumina	Krishnan, N. and Krishna, G., *Anal. Biochem.*, **70,** 18 (1976).

Table 10. Anion Exchange Resins in Enzymatic Assays (*continued*)

Enzyme	Substrate	Product	Resin	Reference
Hexokinase	Mannose	Mannose 6-P	AG 1-X8 resin	Li, E., Jabas, I. and Kornfeld, S., *J. Biol. Chem.*, **253,** 7762 (1978).
Choline kinase	ACh + ATP	Phosphoryl-choline	AG 1-X8 resin	Kato, A. C., Collier, B. Ilson, D. and Wright, J. M., *Can. J. Physiol. Pharmacol.*, **53,** 1050 (1975).
HMG-CoA reductase	HMG-CoA	Mevalonolactone	AG 1-X8 resin	Edwards, P. A., Lemongello, D. and Fogelman, A. M., *J. Lipid. Res.*, **20,** 40 (1979)
Glutamine synthetase	Glutamate	Glutamine	AG 1-X8 resin	Pishak, M. R. and Phillips, A. T., *Anal. Biochem.*, **94,** 88 (1979).

Section 8
Product Information

Catalog Number	Ionic Form	Dry Mesh Size	Wet bead Diameter (µm)	Capacity (meq/ml)	Pkg. Size	Nominal Density (gm/ml)
AG 1-X2 Resin, Analytical Grade						
140-1231	Chloride	50-100	180-500	0.6	500 g	0.65
140-1241	Chloride	100-200	106-250	0.6	500 g	0.65
140-1251	Chloride	200-400	75-180	0.6	500 g	0.65
140-1253	Acetate	200-400	75-180	0.6	500 g	0.65
AG 1-X4 Resin, Analytical Grade						
140-1331	Chloride	50-100	180-425	1.0	500 g	0.70
140-1341	Chloride	100-200	106-250	1.0	500 g	0.70
140-1351	Chloride	200-400	63-150	1.0	500 g	0.70
AG 1-X8 Resin, Analytical Grade						
140-1421	Chloride	20-50	300-1,180	1.2	500 g	0.75
140-1422	Hydroxide	20-50	300-1,180	1.2	500 g	0.75

Catalog Number	Ionic Form	Dry Mesh Size	Wet bead Diameter (µm)	Capacity (meq/ml)	Pkg. Size	Nominal Density (gm/ml)
AG 1-X8 Resin, Analytical Grade (cont.)						
140-1431	Chloride	50-100	180-425	1.2	500 g	0.75
140-1441	Chloride	100-200	106-180	1.2	500 g	0.75
140-1443	Acetate	100-200	106-180	1.2	500 g	0.75
140-1444	Formate	100-200	105-180	1.2	500 g	0.75
140-1451	Chloride	200-400	45-106	1.2	500 g	0.75
140-1453	Acetate	200-400	45-106	1.2	500 g	0.75
140-1454	Formate	200-400	45-106	1.2	500 g	0.75
AG MP-1 Resin, Analytical Grade						
141-0831	Chloride	50-100	150-300	1	500 g	0.7
141-0841	Chloride	100-200	75-150	1	500 g	0.7
141-0851	Chloride	200-400	38-75	1	500 g	0.7

Catalog Number	Ionic Form	Dry Mesh Size	Diameter (micron)	Capacity (meq/ml)	Pkg. Size	Density (gm/ml)
AG 2-X8 Resin, Analytical Grade						
140-2421	Chloride	20-50	300-1,180	1.2	500 g	0.75
140-2441	Chloride	100-200	90-250	1.2	500 g	0.75
140-2451	Chloride	200-400	45-106	1.2	500 g	0.75
AG 1-X2 Resin, Biotechnology Grade						
143-1255	Hydroxide	200-400	75-180	0.6	100 g	0.65
AG 1-X4 Resin, Biotechnology Grade						
143-1345	Hydroxide	100-200	106-250	1.0	100 g	0.70
AG 1-X8 Resin, Biotechnology Grade						
143-2445	Hydroxide	100-200	106-180	1.2	100 g	0.75
AG 1-X8 Resin, Biotechnology Grade						
143-2446	Hydroxide	200-400	45-106	1.2	100 g	0.75

Section 9
Technical Information

If you need additional technical assistance in using ion exchange resins, contact your local Bio-Rad representative.

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LIT212 Rev C