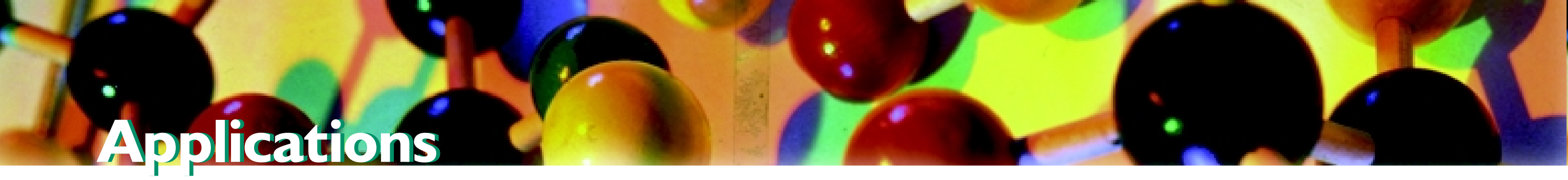

Applications

Ion Exchange Resins: Classification and Properties

Ion exchange resins are highly ionic, covalently cross-linked, insoluble polyelectrolytes supplied as beads. The beads have either a dense internal structure with no discrete pores (gel resins, also called microporous resins) or a porous, multichannelled structure (macroporous or macroreticular resins). They are commonly prepared from styrene and various levels of the cross-linking agent divinyl benzene, which controls the porosity of the particles. Porous beads can be made also by adding homopolystrene, which is soluble in the monomer mixture, and leaching it out later with, toluene, for instance. The PS-DVB precursor beads are post-functionalized to yield the finished resin. Acrylic based, ion exchange resins are also available (see Table I).

These ionic polymers contain two types of ions, those which are bound within the structure and the oppositely charged counter ions which are free. The property of ion exchange is a consequence of *Donnan exclusion* – when the resin is immersed in a medium in which it is insoluble, the counter ions are mobile and can be exchanged for other counter ions from the surrounding medium; ions of the same type of charge as the bound ions do not have free movement into and out of the polymer. Ion exchange resins have been classified based on the charge on the exchangeable counterion (cation exchanger or anion exchanger) and the ionic strength of the bound ion (strong exchanger or weak exchanger). Thus, there are four primary types of ion exchange resins:

1. Strong cation exchange resins, containing sulfonic acid groups or the corresponding salts.
2. Weak cation exchange resins, containing carboxylic acid groups or the corresponding salts.
3. Strong anion exchange resins, containing quarternary ammonium groups. Of these, there are two types: Type I resins contain trialkyl ammonium chloride or hydroxide and Type II resins contain dialkyl 2-hydroxyethyl ammonium chloride or hydroxide.
4. Weak anion exchange resins, containing ammonium chloride or hydroxide.

Additional types of ion exchange resins include blends of cation and anion exchange resins, called *mixed bed resins*. A resin which contains both an anion and a cation as bound ions is said to be *ampholytic*. Some ion exchange resins are prepared with *chelating* properties making them highly selective towards certain ions. In addition to their use in ion exchange, organic polymer supports, many of which are based on PS-DVB resins, are being used as *polymeric catalysts* in the expanding research area involving heterogenization of homogenous catalysts and as polymeric supports and reagents in combinatorial chemistry.

The internal structure of the resin beads, i.e., whether microporous (gel-type) or macroporous, is important in the selection of an ion exchanger. Macroporous resins, with their high effective surface area, facilitate the ion exchange process. Also, they give access to the exchange sites for larger ions, can be used with almost any solvent, irrespective of whether it is a good solvent for the uncrosslinked polymer, and take up the solvent with little or no change in volume. They make more rigid beads, facilitating ease of removal from the reaction system. In the case of the microporous resins, since they have no discrete pores, solute ions diffuse through the particle to interact with exchange sites. Despite diffusional limitations on reaction rates, these resins offer certain advantages: they are less fragile, requiring less care in handling, react faster in functionalization and applications reactions, and possess higher loading capacities.

In addition to being a function of bead morphology, the kinetics of the exchange depends on the particle size distribution of the resin. It is enhanced by a monodisperse resin, for example, see the Marathon® and Amberjet® resins in Table I; they permit faster elution and regeneration times with reduced back pressure.

To help you select an exchanger or combination of exchangers, Table I provides a compilation of ion exchange resins offered by Aldrich, classified by type, as defined above, along with characteristics of each resin such as particle size, functional group, ionic form (i.e., the counterion), exchange capacity, and operating conditions. For additional information on ion exchange resins from Aldrich, please request **Aldrich Technical Bulletin AL-142**. For additional information on polymeric supports, please refer to the *Applications* Section.

Table I: Classification and Properties of Numerous Ion Exchange Resins offered by Aldrich

Cat. No.	Exchanger	% cross-linking	Matrix[1]	Mesh/ Bead size	Ionic Form	% Moisture	Max.Op. Temp. °C	Total Exchange Capacity[2] meq/ml	meq/g	pH range
Strong Cation Exchangers on Polystyrene										
Amberlite®/Amberlyst®/Amberjet®		**(Sulfonic Acid)**								
21,653-4	IR-120 Plus(H)	8	G	16-50	H	45	120	1.9	4.4	0-14
22,435-9	IR-120 Plus	-	G	16-50	Na	45	120	1.9	4.4	0-14
27,427-5	IRP-69	-	-	25-150µm	Na	10	-	-	-	-
21,638-0	15	-	Mp	16-50	H	<1	120	2.8	4.7	0-14
43,673-9	1200(H)	-	G	20-35	H	52	120	1.8	4.7	0-14

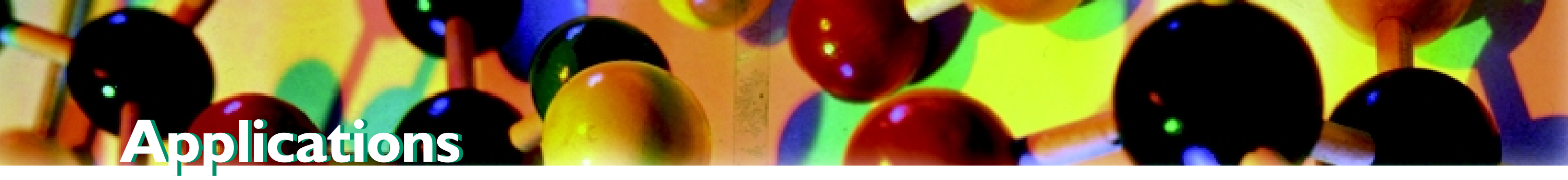

Table I: Classification and Properties of Numerous Ion Exchange Resins offered by Aldrich (continued)

Cat. No.	Exchanger	% cross-linking	Matrix[1]	Mesh/ Bead size	Ionic Form	% Moisture	Max.Op. Temp. °C	Total Exchange Capacity[2]		pH range
								meq/ml	meq/g	
Strong Cation Exchangers on Polystyrene (continued)										
Dowex® (Sulfonic Acid)										
21,744-1	50WX2-100	2	G	50-100	H	78	150	0.6	4.8	0-14
21,746-8	50WX2-200	2	G	100-200	H	78	150	0.6	4.8	0-14
21,747-6	50WX2-400	2	G	200-400	H	78	150	0.6	4.8	0-14
42,882-5	50WX4-50	4	G	20-50	H	68	150	1.1	4.8	0-14
42,866-3	50WX4-100	4	G	50-100	H	68	150	1.1	4.8	0-14
42,209-6	50WX4-200	4	G	100-200	H	68	150	1.1	4.8	0-14
42,867-1	50WX4-200R	4	G	100-200	H	68	150	1.1	4.8	0-14
21,748-4	50WX4-400	4	G	200-400	H	68	150	1.1	4.8	0-14
21,749-2	50WX8-100	8	G	50-100	H	53	150	1.7	4.8	0-14
21,750-6	50WX8-200	8	G	100-200	H	54	150	1.7	4.8	0-14
21,751-4	50WX8-400	8	G	200-400	H	54	150	1.7	4.8	0-14
42,872-8	HCR-S	8	G	20-50	H	53	150	1.8	4.8	0-14
42,870-1	HCR-W2	8	G	16-40	H	52	150	1.8	4.8	0-14
43,668-2	88	-	Mp	16-40	Na	45	150	1.8	1.8	0-14
43,661-5	650C	-	G	25-30	H	50	150	1.9	1.9	0-14
43,395-0	Marathon C	-	G	30-40	H	53	149	1.8	2.6	0-14
42,878-7	MSC-1	-	-	20-50	Na	47	150	1.7	4.5	0-14
Duolite® (Sulfonic Acid)										
43,669-0	C-26	-	Mp	520µm	Na	50	150	1.8	-	0-14
Weak Cation Exchangers on Polyacrylic										
Amberlite® (Carboxylic Acid)										
21,635-6	CG-50 Type I	4	Mp	100-200	H	5	120	3.5	10.0	5-14
42,883-3	IRC-50	4	Mp	16-50	H	48	120	3.5	10.0	5-14
21,657-7	IRC-50S	-	Mp	400µm	H	48	120	3.5	-	5-14
27,426-7	IRP-64	-	Mp	100-400	H	5	-	-	10.0	-
Dowex® (Carboxylic Acid)										
42,881-7	CCR-3	-	-	20-50	H	50	120	3.9	-	-
Strong Anion Exchangers on Polystyrene										
Amberlite® Strong Anion Exchangers, Type I (Trialkylbenzyl Ammonium)										
24,766-9	IRA-400(Cl)	8	G	16-50	Cl	45	77	1.4	3.8	0-14
21,644-5	IRA-743	-	G	450µm	OH	58	77	0.6	-	-
21,658-5	IRA-900	-	Mp	16-50	Cl	60	77	1.0	4.2	0-14
43,674-7	4200(Cl)	-	G	25-25	Cl	53	50	1.2	3.7	0-14
Dowex® Type I (Trimethylbenzyl Ammonium)										
21,737-9	1X2-100	2	G	50-100	Cl	70	66	0.7	3.5	0-14
21,738-7	1X2-200	2	G	100-200	Cl	75	66	0.6	3.5	0-14
21,739-5	1X2-400	2	G	200-400	Cl	75	66	0.6	3.5	0-14
42,861-2	1X4-50	4	G	20-50	Cl	50	66	1.0	3.5	0-14
42,858-2	1X4-100	4	G	50-100	Cl	50	66	1.0	3.5	0-14
42,859-0	1X4-200	4	G	100-200	Cl	59	66	1.0	3.5	0-14
42,860-4	1X4-400	4	G	200-400	Cl	59	66	1.0	3.5	0-14
21,740-9	1X8-50	8	G	20-50	Cl	46	66	1.2	3.5	0-14
21,741-7	1X8-100	8	G	50-100	Cl	46	66	1.2	3.5	0-14
21,742-5	1X8-200	8	G	100-200	Cl	46	66	1.2	3.5	0-14
21,743-3	1X8-400	8	G	200-400	Cl	46	66	1.2	3.5	0-14
42,876-0	MSA-1	-	Mp	20-50	Cl	60	66	1.0	4.0	0-14
43,665-8	21K	-	G	16-30	Cl	54	60	1.2	3.8	0-14
43,660-7	550A	-	G	25-35	OH	48	60	1.1	3.4	0-14
43,394-2	Marathon A	-	G	30-40	Cl	57	60	1.2	4.0	0-14
Amberlite®, Type II (Dimethyl-2-hydroxyethylbenzyl Ammonium)										
21,656-9	IRA-410	-	G	20-50	Cl	42	41-77	1.4	3.4	0-14
Dowex® Type II (Dimethyl-2-hydroxyethylbenzyl Ammonium)										
42,862-0	2X8-100	8	G	50-100	Cl	38	66	1.2	-	0-14
42,863-9	2X8-200	8	G	100-200	Cl	37	66	1.2	-	0-14
42,864-7	2X8-400	8	G	200-400	Cl	37	66	1.2	-	0-14
42,877-9	MSA-2	-	Mp	16-50	Cl	56	77	1.0	3.7	0-14
43,393-4	Marathon A2	-	G	30-40	Cl	42	35-80	3.2	3.2	0-14
43,662-3	22	-	Mp	20-40	Cl	54	46	1.2	-	-

Table I: Classification and Properties of Numerous Ion Exchange Resins offered by Aldrich (continued)

Cat. No.	Exchanger	% cross-linking	Matrix[1]	Mesh/ Bead size	Ionic Form	% Moisture	Max.Op. Temp. °C	Total Exchange Capacity[2]		pH range
								meq/ml	meq/g	
Weak Anion Exchangers on Polystyrene										
Amberlite® (Polyamine)										
47,663-3	IRA-67	-	G	16-50	FB	60	60	1.6	5.6	7-9
Dowex® (Polyamine)										
42,879-5	WGR-2	-	Mp	20-50	FB	55	93	1.9	6.1	0-7
43,667-4	66	-	Mp	16-50	FB	45	60	1.4	4.0	0-7
43,666-6	Marathon WBA	-	Mp	25-50	FB	54	60	1.25	4.2	0-7
Duolite® (Polyamine)										
43,670-4	A-7	-	Mp	16-50	FB	56	40	2.2	13.9	0-6
Mixed Bed Resins on Polystyrene										
Dowex® Mixed Bed Resins										
42,873-6	MR-3	-	G	20-50	H,OH	50	50	-	1.7	0-14
42,874-4	MR-3C	-	G	16-45	H,OH	50	50	-	1.7	0-14
42,869-8	11A8 Retardion	-	G	35-80	Na	45	70	Na	Na	0-14
Chelating Resins										
Amberlite® (Iminodiacetic Acid)										
21,645-3	IRC-718	-	Mp	16-50	Na	65	90	1.1	4.4	1.5-14
Polymeric Catalysts										
Amberlyst® Strong Acid (Sulfonic Acid)										
21,638-0	15 Dry	250	120	<1.5	45	0.30	1.8	4.7		
21,639-9	15 Wet	250	120							
43,671-2	36 Wet	200	140	55	35	0.30	1.9	5.4		
DOWEX® Strong Acid (Sulfonic Acid)										
44,648-3	DR-2030			3					2.6	
Amberlyst® Weak Base (Alkyl Amine)										
21,641-0	A-21 Wet	400	100	64	25	0.20	1.1	4.7		

[1] G = gel (or microporous); Mp = macroporous (or macroreticular)

[2] NA = not applicable