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DOWEX™ Ion Exchange Resins

Using Ion Exchange Resin Selectivity Coefficients

Technical Information

Ion exchange resins, when placed in a solution, reach an equilibrium state between ions in solution and ions on the resin. From this equilibrium state, selectivity coefficients (equilibrium constants), can be defined based on the ratios of ions in solution vs. ions on the resin.

Effectively, these selectivity coefficients are a measurement of a resins preference for an ion. The greater the selectivity coefficient, the greater the preference for the ion. For example, a strong acid cation resin with 8% crosslink has a selectivity coefficient for sodium vs. hydrogen of 1.56, while the selectivity coefficient for calcium vs. hydrogen is 4.06. As a result, calcium is selectively removed by the ion exchange over the sodium.

In column operation, undesirable ions can be selectively removed by regenerating the resin with any ion of lower selectivity. For example, calcium can be removed from solution by a strong acid cation resin when the resin is regenerated by salt (Na-cycle operation) or by acid (H-cycle operation).

Selectivity coefficients can also be used to determine the order of elution in column operation. In a demineralizer (H-cycle operation), sodium with a selectivity coefficient of 1.56 will elute before ammonium with a selectivity coefficient of 2.01, which is followed by potassium, with a selectivity coefficient of 2.28.

Ionic leakage from demineralizers can also be predicted by the use of selectivity coefficients. With a knowledge of the degree of regeneration, solution pH and the selectivity coefficient, an estimate of leakage can be calculated.

For a complete treatment of the subject, numerous textbooks can be consulted. One excellent reference is *Ion Exchange*, by Friedrich Helferich, currently published by Dover Press under ISBN #61-15453.

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Table 1. Selectivity Coefficients of Various Anions (Compared with the Hydroxyl Ion) on Functionalized Styrene-Divinylbenzene Anion Exchange Resins of Different Base Strength

Ion	Type I	Type II
OH^-	1.0	1.0
Benzene sulphonate	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
Formate	4.6	0.5
Acetate	3.2	0.5
Propionate	2.6	0.3
F^-	1.6	0.3
$HSiO_3^-$	< 1.0	< 1.0
$H_2PO_4^-$	5.0	0.5

Table 2. Selectivity Coefficients of Various Cations (Compared with the Hydrogen Ion) on Sulfonated Polystyrene Cation Exchange Resins of Different Crosslinkage

	Degree of Crosslinking			
Counter Ion	4% DVB	8% DVB	10% DVB	16% DVB
Li^+	0.76	0.79	0.77	0.68
H^+	1.00	1.00	1.00	1.00
Na^+	1.20	1.56	1.61	1.62
NH_4^+	1.44	2.01	2.15	2.27
K^+	1.72	2.28	2.54	3.06
Rb^+	1.86	2.49	2.69	3.14
Cs^+	2.02	2.56	2.77	3.17
Ag^+	3.58	6.70	8.15	15.6
Tl^+	5.08	9.76	12.6	19.4
UO_2^{2+}	1.79	1.93	2.00	2.27
Mg^{2+}	2.23	2.59	2.62	2.39
Zn^{2+}	2.37	2.73	2.77	2.57
Co^{2+}	2.45	2.94	2.92	2.59
Cu^{2+}	2.49	3.03	3.15	3.03
Cd^{2+}	2.55	3.06	3.23	3.37
Ni^{2+}	2.61	3.09	3.08	2.76
Ca^{2+}	3.14	4.06	4.42	4.95
Sr^{2+}	3.56	5.13	5.85	6.87
Pb^{2+}	4.97	7.80	8.92	12.2
Ba^{2+}	5.66	9.06	9.42	14.2

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