ION EXCHANGE RESINS IN FOOD APPLICATIONS

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Energizing Chemistry

ION EXCHANGE RESINS IN FOOD APPLICATIONS

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SUGAR

1.1 SOFTENING OF THIN JUICE

Depending on its origin, thin juice contains varying amounts of non-sugar substances, e.g. ash. During evaporation from 15 bx to 65-70 bx, there is a risk of scale formation. To prevent scale forming in the evaporation station, to produce soft molasses or to prevent precipitation of thick juices during storage, the alkaline earth ions can be removed with Lewatit cation exchange resins of differing acid strengths. Various methods can be used for this.

PROCESS FOR SOFTENING THIN JUICE

	CONVENTIONAL	WAC	NRS	GRYLLUS
LEWATIT	S 1468	S 8528	S 1468	S 2528
	S 2528			S 2568
	S 2568			
REGENERANT	NaCl	H_2SO_4	NaOH	Thick juice
QUANTITY [%]	250	105	150	- / -
FLOW RATE [BV/H]				
EXHAUSTION	20	60	20	10
REGENERATION	3	35	1	3
TEMPERATURE [°C]				
EXHAUSTION	90	80	90	90
REGENERATION	90	80	50	50
CAPACITY [EQ/L]	0.8 - 1.2	2.5 - 3.5	0.5 - 0.9	0.6 - 1.6

SUGAR

1.2 DECOLORIZATION OF SUGAR SYRUP

The color of sugar juice from beet and cane increases during the production process. Colorants such as caramel color bodies, melanoidines and melanine-polyphenol-iron complexes are formed. When producing refined sugar, various Lewatit adsorber resins based on styrene or acrylic polymers can be used to decolorize sugar syrups with more than 1000 ICU to meet all quality requirements in the sugar industry.

SELECTION OF LEWATIT RESIN DEPENDING ON COLOR LEVEL OF FEED SOLUTION

FEED COLOR	RECOMMENDED LEWATIT RESIN	EFFLUENT COLOR
50 - 100 ICU	S 6268	15 - 35 ICU
50 - 200 ICU	S 6368 or S 6328 A	15 - 60 ICU
200 - 600 ICU	OC 1074 - S 6368	60 - 200 ICU
600 - 1200 ICU	OC 1074 - OC 1074 - S 6368	80 - 600 ICU

PROCESS FOR DECOLORIZATION OF SUGAR SYRUP

LEWATIT	S6268	S 6328 A	S 6368	OC 1074
TYPE	Styrene gel	Styrene macro	Styrene macro	Acrylic macro
BEAD SIZE [MM]	0.6	0.3 - 1.2	0.6	0.3 - 1.6
REGENERANT	NaCl / NaOH	NaCl / NaOH	NaCl / NaOH	NaCl
QUANTITY [G/L]	200 / 20	200 / 10	200 / 10	200
FLOW RATE [BV/H]				
EXHAUSTION	2	2	2	2
REGENERATION	2	2	2	2
TEMPERATURE [°C]				
EXHAUSTION	85	85	85	75
REGENERATION	80	80	80	70

1.3 INVERTED LIQUID SUGAR

Decolorization and demineralization of raw sugar solutions with Lewatit ion exchange resins is essential for economical production of high-grade inverted liquid sugar syrups. Resins suitable for different operating conditions are required, depending on the application.

It is advisable to use the resin arrangements outlined below.

PROCESS FOR INVERTED LIQUID SUGAR (E.G. 66 % INVERSION)

ARRANGEMENT	DECOLORIZ.	DECATIONIZ.	INVERSION	DEANIONIZ.
LEWATIT	S 6328 A	S 2528	S 2328	S 4328
	S 6368	S 2568	K 1221	S 4428
	OC 1074			
REGENERANT	NaCl / NaOH	HCl	HCl	NaOH
QUANTITY [G/L]				
CO-CURRENT	200 / 10	80 - 100	80 - 100	60 - 80
COUNTER-CURRENT	200 / 10	50 - 60	50 - 60	50 - 60
FLOW RATE [BV/H]				
EXHAUSTION	2 - 3	3 - 5	0.5 - 2	3 - 5
REGENERATION	2	2	2	2
TEMPERATURE [°C]				
EXHAUSTION	70 - 80	30 - 40	30 - 40	30 - 40
REGENERATION	20 - 80	20 - 40	20 - 40	20 - 40
CAPACITY [EQ/L]	20,000 ds*IC	0.9 - 1.2	- / -	0.8 - 1.0

SUGAR

1.4 NON-INVERTED LIQUID SUGAR

If liquid sugar syrups only have to be demineralized to improve the quality of the sugar, inversion should be avoided. This can be achieved by avoiding the occurrence of H+ ions. The process can run at temperatures of up to 60°C, making it extremely suitable for tropical areas and plants where the dry substance is at least 60 brix. Subsequent inversion is possible on a case-by-case basis.

PROCESS FOR NON-INVERTED LIQUID SUGAR

ARRANGEMENT	DECOLORIZATION	DEANIONIZATION	DECATIONIZATION
LEWATIT	S 6328A	S S 6328A	S 8528
	S 6368	S 6368	S 8227
	OC 1074		
REGENERANT	NaCL / NaOH	NaOH	HCL
QUANTITY [G/L]			
CO-CURRENT	200/10	80 - 100	70 - 80
COUNTER-CURRENT	200/10	60 - 70	
FLOW RATE [BV/H]			
EXHAUSTION	2 - 3	2 - 3	4 - 6
REGENERATION	2	2	2
TEMPERATURE [°C]			
EXHAUSTION	70 - 80	50 - 60	50 - 60
REGENERATION	20 - 80	20 - 50	20 - 60
CAPACITY [EQ/L]	20,000 DS*IC	0.5 - 0.6	1.0 - 1.2

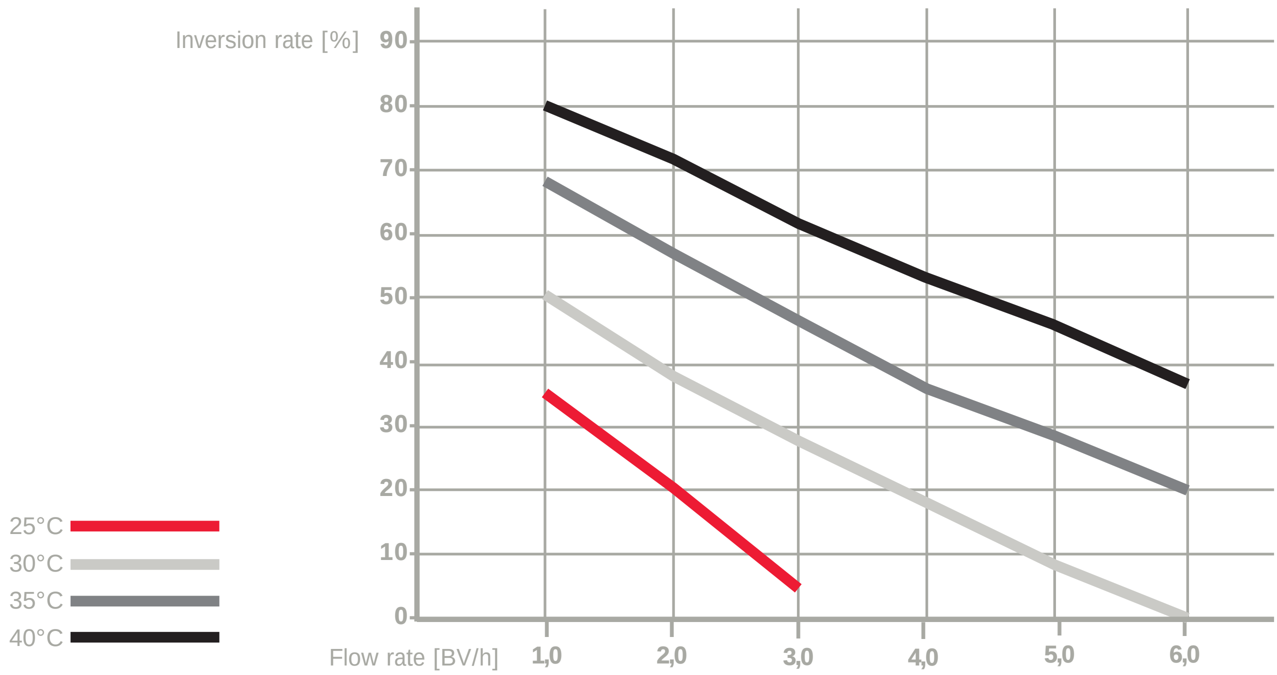
1.5 INVERSION OF SACCHAROSE

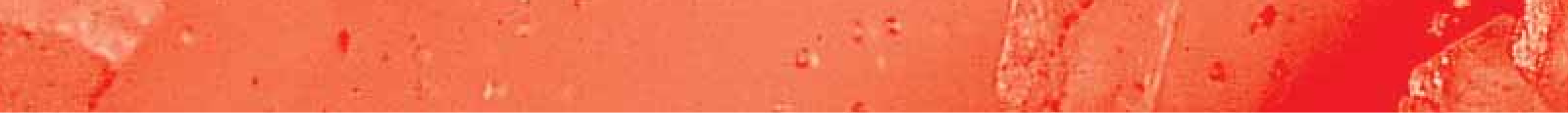
Hydrolysis of polysaccharides and oligosaccharides is catalyzed by H+ ions. Splitting sucrose leads to a mixture of glucose and fructose which rotates polarized light to the left. Consequently, this process is also referred to as inversion. The resultant mixture is inverted sugar which is processed into artificial honey and liquid sugar. Liquid sugar, in particular, has become more important as it is widely used to sweeten soft drinks.

PROCESS FOR INVERTING SUCROSE

The sugar syrup is passed through the resin bed at different flow rates and temperatures. The inversion rate is shown in the graph below.

LEWATIT S 2328 / INVERSION OF SUGAR SYRUP (60°BX)





SUGAR

1.6 DEMINERALIZATION OF INULIN

Inulin (polyfructose) is a valuable sweetener for functional foodstuffs. It can also be used to produce fructose after enzymatic splitting of the polyfructose into its component parts (fructose). Inulin can be extracted from the beets of, for example chicory and tropinambur. The salt-rich raw thin juices have to be demineralized by ion exchange resins. Mixed bed arrangements with Lewatit resins are used for subsequent polishing of the fructose.

PROCESS FOR DEMINERALIZATION OF INULIN THIN JUICE (15 BX) AND MB POLISHING OF FRUCTOSE (60 BX)

ARRANGEMENT	DECATIONIZATION	DEANIONIZATION	MIXED BED
LEWATIT	S 1468	S 4268 S 4228	S 2568 / S 6368
REGENERANT	HCl	NaOH	HCl / NaOH
QUANTITY [G/L]			
CO-CURRENT	100	80	100 / 100
COUNTER-CURRENT	55 - 65	45 - 60	- / -
FLOW RATE [BV/H]			
EXHAUSTION	3	3	2
REGENERATION	2	2	2
TEMPERATURE [°C]			
EXHAUSTION	20 - 25	20 - 25	40 - 45
REGENERATION	20 - 25	20 - 25	20 - 40
CAPACITY [EQ/L]	0.8 - 1.1	0.7 - 0.8	- / -

1.7 QUENTIN PROCESS

It is known that the solubility of sucrose in molasses depends on the availability of different cations. Sucrose has higher solubility in alkali-ion-rich molasses (e.g. potassium) than in earth-alkali-rich molasses (magnesium). To take advantage of this principle, Na and K ions are exchanged for Mg ions using a strongly acidic macroporous cation resin. The exchange takes place before final crystallization of the thick juice. The Quentin process is mainly used for beet sugar and can increase the sugar yield by 0.3 - 0.5%.

QUENTIN PROCESS

LEWATIT		S 2528	
		S 2568	
REGENERANT		$MgCl_2$	
QUANTITY [G/L]	CO-CURRENT	90	130 % theor.
	CONCENTRATION	5 - 6%	
FLOW RATE [BV/H]			
EXHAUSTION		1.5	
REGENERATION		1	
TEMPERATURE [°C]			
EXHAUSTION		90	
REGENERATION		80	
CAPACITY [EQ/L]	S 2528	1.5 - 1.6	
	S 2568	1.4 - 1.5	

SUGAR

1.8 CHROMATOGRAPHY ION EXCLUSION

Lewatit MDS types are monodisperse ion exchange resins with an uniformity coefficient < 1.1 and a particle size ranging between 320 and 370 µm. The resins are commercially used in chromatographic separation processes e.g. simulated moving bed equipment.

Different resin types are available for various separation processes mentioned below:

CHROMATOGRAPHY	LEWATIT TYPE	FORM	BEAD SIZE
SUGAR RECOVERY FROM MOLASSES	MDS 1368	Na	350 µm
	MDS 1368	Na	320 µm
SEPARATION OF GLUCOSE & FRUCTOSE	MDS 1368	Ca	350 µm
	MDS 1368	Ca	320 µm
SIZE SEPARATION OF SUGAR MOLECULES	MDS 2368	Na	370 µm
SEPARATION OF ORGANIC ACID	MDS 4368	FB/chloride	340 µm
SEPARATION OF AMINO ACIDS	TP 207 fine	H	350 µm

SWEETENERS

2.1 REFINING OF SYRUPS

The starch industry produces a variety of sweetener products from raw materials such as corn, wheat, potatoes, rice, cassava, etc. by enzymatic hydrolysis of starch. After adjusting the conversion level, Lewatit resins are used to refine the syrup. In the refinery the syrup is de-ashed and decolorized. Proteins and residual by-products can also be removed. For syrups with a low conversion level such as glucose, maltose and maltodextrin, as well as for syrups with a high conversion level such as dextrose or fructose (after isomerization) Lewatit resins are used in co-current or counter-current arrangements, preferably in double-pass, merry-go-round systems.

PROCESS FOR DEMINERALIZATION OF SYRUPS

ARRANGEMENT	DECATIONIZATION	DEANIONIZATION	MIXED BED (ON DEM.)
LEWATIT	S 2528	S 4228	S 2568 / MP 600 WS
	S 2568	S 4328	
	S 2568	S 4528*	
	S 2528	S 4428**	
REMOVAL OF	Cations	Anions	Polishing
	Proteins	Organic acid	
REGENERANT	HCl	NaOH	HCl/NaOH
QUANTITY [G/L]			
CO-CURRENT	80 - 100	70 - 80	100 / 100
COUNTER-CURRENT	55 - 65	60 - 70	- / -
FLOW RATE [BV/H]			
EXHAUSTION	3 - 4	3 - 4	3 - 4
REGENERATION	2	2	2
TEMPERATURE [°C]			
EXHAUSTION	40 - 60	40 - 60	40 - 45
REGENERATION	40 - 60	40 - 60	20 - 40
CAPACITY [EQ/L]			
SINGLE-PASS	0.9 - 1.0	0.7 - 0.8	- / -
DOUBLE-PASS	1.1 - 1.3	1.0 - 1.2	- / -

*no isomerization | **low isomerization

2.2 REFINING OF POLYOLS

Sugar alcohol from various Ni-catalyzed hydrogenated mono- and di-saccharides is of enormous commercial interest for sweetening a wide range of products because it has low calorific value and does not cause dental caries. After hydrogenation, the raw polyol solution is decolorized and demineralized with ion exchange resin. Various arrangements can be used.

PROCESS FOR REFINING POLYOLS

ARRANGEMENT	NI RECOVERY	DECATIONIZATION	DEANIONIZATION	REMOVAL OF ORGANIC ACID
LEWATIT	S 8528	S 2528	S 4328	S 6368
		S 2568	S 4428	S S 6328 A
REGENERANT	Special	HCl	NaOH	NaOH
	regeneration			
	process required			
QUANTITY [G/L]				
CO-CURRENT	- / -	80 - 100	70 - 80	80 - 100
COUNTER-CURRENT	- / -	50 - 60	40 - 50	60 - 70
FLOW RATE [BV/H]				
EXHAUSTION	2 - 3	1.5 - 2.5	2 - 3	2 - 3
REGENERATION	2	2	2	2
TEMPERATURE [°C]				
EXHAUSTION	40 - 60	40 - 60	40 - 60	40 - 60
REGENERATION		20 - 60	20 - 60	20 - 60
CAPACITY [EQ/L]	- / -	0.9 - 1.0	0.5 - 0.7	0.3 - 0.4

FRUIT JUICE

3.1 DEMINERALIZATION OF GRAPE MOST

The production of both red and white grape most requires extensive decolorization and demineralization to prevent the salts overriding the typical taste of the reduced sugar content (15 - 20%). Refined most can be added to wine most before fermentation to produce high-quality wine. It is also used to blend fruit drinks, wine supplements and carbonated soft drinks. Non-functionalized adsorber resins are used to reduce polyphenolic colors, while conventional SBA types are used for non-selective color removal.

PROCESS FOR GRAPE MOST REFINING

ARRANGEMENT	DECOLORIZATION	DECATIONIZATION	DEANIONIZATION	BUFFER
LEWATIT	OC 1062	S 1468	S 4268 / S 6368	S1468
	S 7768	S 2568	S 4228 / S 6368	
REGENERANT	NaOH / HCl	HCl	NaOH	HCl
QUANTITY [G/L]				
CO-CURRENT	80 / 2	80 - 100	60 - 80 / 100	80 - 100
COUNTER-CURRENT	80 / 2	55 -65	50 - 60 / 40 - 50	55 - 65
FLOW RATE [BV/H]				
EXHAUSTION	3 - 5	3 - 5	3 - 5 / 5 - 8	10
REGENERATION	2	2	2	2
TEMPERATURE [°C]				
EXHAUSTION	20 - 30	20 - 30	20 - 30	20 - 30
REGENERATION	20 - 30	20 - 30	20 - 30	20 - 30
CAPACITY [EQ/L]	- / -	0.9 - 1.2	1.0 / 0.4	1.0

FRUIT JUICE

3.2 DEMINERALIZATION OF APPLE AND PEAR JUICE

Apple and pear juice are used as blending juice in carbonated soft drinks. The juice contains approximately 12 % sugar as di- or mono-saccharides. Apple and pear juices also contain polyphenolic color components which are formed enzymatically during extraction. They can be removed with activated carbon or adsorber resins. Afterwards the clarified juice is demineralized with ion exchange resins. These juices are passed through a weakly anionic resin prior to demineralization because of their high free acid content.

PROCESS FOR DEMINERALIZATION OF APPLE AND PEAR JUICE

ARRANGEMENT	DECOLORIZ.	NEUTRALIZ.	DECATIONIZ.	DEANIONIZ.
LEWATIT	OC 1062	S 4328	S 1468	S 4528
		S 4528	S 2568	
REGENERANT	NaOH / HCl	NaOH	HCl	NaOH
QUANTITY [G/L]				
CO-CURRENT	80 / 2	70 - 80	80 - 100	70 - 80
COUNTER-CURRENT	80 / 2	60 - 70	55 - 65	60 - 70
FLOW RATE [BV/H]				
EXHAUSTION	3 - 5	3 - 5	3 - 5	3 - 5
REGENERATION	2	2	2	2
TEMPERATURE [°C]				
EXHAUSTION	20 - 30	20 - 30	20 - 30	20 - 30
REGENERATION	20 - 30	20 - 30	20 - 30	20 - 30
CAPACITY [EQ/L]	- / -	1.2	1.0 - 1.2	1.0 - 1.2

3.3 DEMINERALIZATION OF PINEAPPLE JUICE

Pineapple juice, primarily from waste trimmings, contains roughly 10 % sugar and extremely high quantities of citric acid and nitrogenous components. To allow use as canning syrup, demineralization and partial decolorization are necessary. In view of the high concentration of acid and salts, double-pass filtration is recommended.

PROCESS FOR PINEAPPLE JUICE

ARRANGEMENT	DECATIONIZ.	DEANIONIZ.	DECATIONIZ.	DEANIONIZ.
LEWATIT	S 2528	S 4328	S 2528	S 4528
	S 2568	S 4528	S 2568	
REGENERANT	HCl	NaOH	HCl	NaOH
QUANTITY [G/L]				
CO-CURRENT	80 - 100	70 - 80	80 - 100	70 - 80
COUNTER-CURRENT	55 - 65	60 - 70	55 - 65	60 - 70
FLOW RATE [BV/H]				
EXHAUSTION	3 - 5	3 - 5	3 - 5	3 - 5
REGENERATION	2	2	2	2
TEMPERATURE [°C]				
EXHAUSTION	20 - 30	20 - 30	20 - 30	20 - 30
REGENERATION	20 - 30	20 - 30	20 - 30	20 - 30
CAPACITY [EQ/L]	1.4	1.4	1.0 - 1.2	1.0 - 1.2

FRUIT JUICE

3.4 DEBITTERING AND DEACIDIFICATION OF ORANGE JUICE

Orange juice, either freshly extracted or reconstituted juice, is neutralized using weak anion resins. The resin reduces free citric acid as well as more weakly dissociated acid such as ascorbic acid and folic acid. To recover valuable ascorbic and folic acid, it is advisable to »overload« the resin in order to ensure displacement by the stronger citric acid.

Another specific application for adsorber resin is debittering of orange juice. Orange juice contains 20-30 ppm bitter components like limonin or hesparadin which could otherwise be tasted.

PROCESS FOR DEMINERALIZATION OF ORANGE JUICE

ARRANGEMENT	DEBITTERING	NEUTRALIZATION
LEWATIT	OC 1064	S 4528*
REMOVAL OF	Limonin	Organic acid
	Hesparadin	
REGENERANT	NaOH / HCl	NaOH
QUANTITY [G/L]		
CO-CURRENT	80 / 2	70 - 80
COUNTER-CURRENT	80 / 2	60 - 70
FLOW RATE [BV/H]		
EXHAUSTION	2 - 4	5 - 6
REGENERATION	2	2
TEMPERATURE [°C]		
EXHAUSTION	40 - 60	40 - 60
REGENERATION	40 - 60	40 - 60
CAPACITY [EQ/L]	- / -	1.0 - 1.1

FOODSTUFFS

4.1 REFINING OF FOOD ACIDS

Food acids such as citric- and lactic acid need to be demineralized after fermentation, mainly to eliminate sulfuric acid and sulfate ions. The typical dry substance content is 20 - 40 %. Additional freeboard is required as weakly basic anion resins can swell by up to 40 % (the resin is fully preloaded with food acid). During demineralization the food acid is displaced by sulfate ions. To improve resin capacity and utilize the full resin capacity, a double-pass system is recommended.

PROCESS FOR REFINING CITRIC ACID

ARRANGEMENT	DECATIONIZATION	DEANIONIZATION
LEWATIT	S 1468	S 4428
	S 2568	
REGENERANT	HCl / H_2SO_4	NaOH / NH_3
QUANTITY [G/L]		
CO-CURRENT	80 - 100 / 160	70 - 80 / 35
COUNTER-CURRENT	55 - 60 / 120	60 - 70 / 30
FLOW RATE [BV/H]		
EXHAUSTION	1	1
REGENERATION	2	2
TEMPERATURE [°C]		
EXHAUSTION	50	50
REGENERATION	20 - 30	20 - 30
CAPACITY [EQ/L]	1.0 - 1.1	0.8 - 1.0

4.2 SOFTENING OF PECTIN JUICE

Pectin is usually extracted from citrus peel by nitric acid. The acidic thin juice contains approximately 1% pectin, 2 % nitric acid and 300 - 400 ppm calcium ions. Calcium ions impair the quality of the pectin so the concentration of such ions needs to be reduced by ion exchange. Calcium ions can easily be removed with Lewatit S 1468 in the following process conditions.

PROCESS FOR SOFTENING PECTIN JUICE

	SOFTENING
LEWATIT	S 1468
REGENERANT	NaCl
QUANTITY [G/L]	100 - 250
FLOW RATE [BV/H]	
EXHAUSTION	1.5 - 3
REGENERATION	2 - 3
TEMPERATURE [°C]	
EXHAUSTION	45 - 55
REGENERATION	45 - 55
CAPACITY [EQ/L]	1.0 - 1.2

4.3 DEMINERALIZATION OF GELATINE JUICE

The purpose of the refining process is to produce a high-purity gelatine (protein) with a molecular weight between 20,000 and 360,000 g/mol. This is achieved by chemical or thermal hydrolysis of collagen (chain of 18 different amino acids) into gelatine. The end-product should be soluble in warm water and have a reversible gelling effect. To meet the specifications of the photographic, food and pharmaceutical industries, demineralization with ion exchange resins is normally used.

PROCESS FOR DEMINERALIZATION OF GELATINE

ARRANGEMENT	DECATIONIZATION	DEANIONIZATION
LEWATIT	S 1468	S 4528
	S 2568	S 4328
		OC 1072
REGENERANT	HCl	NaOH
QUANTITY [G/L]		
CO-CURRENT	80 - 100	70 - 80
COUNTER-CURRENT	55 - 60	60 - 70
FLOW RATE [BV/H]		
EXHAUSTION	5 - 10	5 -10
REGENERATION	2	2
TEMPERATURE [°C]		
EXHAUSTION	50 - 65	50 - 65
REGENERATION	20 - 30	20 - 30
CAPACITY [EQ/L]	1.0 - 1.1	0.8 - 1.0

FOODSTUFFS

4.4 REFINING OF GLYCEROL

The function of the ion exchange resins in glycerine purification is to remove dissolved salts, acids and bases from the solution, which contains approx. 35-45% glycerol. Fatty substances, aldehydes, alcohols and other non-ionic impurities are not completely removed in this process. Macroporous Lewatit resins have greatly improved this situation: virtually all colored matter is adsorbed without irreversible fouling of the resins.

PROCESS FOR REFINING GLYCEROL

ARRANGEMENT	DECOLORIZ.	DECATIONIZ.	DEANIONIZ.	BUFFER
LEWATIT	S 6328 A	S 1468	S 4268/S 6368	S 1468
	S 6368	S 2568	S 4228/S 6368	
REGENERANT	NaCl / NaOHl	HCl	NaOH	HCl
QUANTITY [G/L]				
CO-CURRENT	200 / 20	80 - 100	60 - 80 / 100	80 - 100
COUNTER-CURRENT	200 / 20	55 - 65	50 - 60 / 40 - 50	55 - 65
FLOW RATE [BV/H]				
EXHAUSTION	2 - 3	3 - 4	3 - 4 / 2 - 4	10
REGENERATION	2	2	2	2
TEMPERATURE [°C]				
EXHAUSTION	30 - 50	30 - 50	30 - 50	30 - 50
REGENERATION	20 - 30	20 - 30	20 - 30	20 - 30
CAPACITY [EQ/L]	- / -	0.9 - 1.2	1.0 / 0.4	1.0

4.5 DEMINERALIZATION OF WHEY

Alongside large amounts of interfering salts, whey contains valuable proteins and lactose. The recovery and processing of these substances is becoming more and more important. However, the whey has to undergo suitable treatment in order for the protein and lactose to be extracted and used. Effective resins for the demineralization of whey are the strongly acidic, gel-type Lewatit S 1468 combined with the weakly basic anion resin Lewatit S 4528 or Lewatit OC 1072. Because of its macroporous structure, Lewatit S 4528 also adsorbs voluminous, large-molecular anions. In addition, for full demineralization Lewatit Monoplus M 600 is used in the final position.

PROCESS FOR DEMINERALIZATION OF WHEY

ARRANGEMENT	DECATIONIZ.	DEANIONIZ.	DECATIONIZ.	DEANIONIZATION
LEWATIT	S 1468	S 4528 OC 1072	S 1468	M+ M 600
REGENERANT	HCl	NaOH	HCl	NaOH
QUANTITY [G/L]				
CO-CURRENT	80 - 100	70 - 80	80 - 100	80 - 100
COUNTER-CURRENT	55 - 65	60 - 70	55 - 65	50 - 70
FLOW RATE [BV/H]				
EXHAUSTION	5 - 10	5 -10	5 -10	5 -10
REGENERATION	2	2	2	2
TEMPERATURE [°C]				
EXHAUSTION	5 -15	5 -15	5 -15	5 - 15
REGENERATION	20	20	20	20
CAPACITY [EQ/L]	1.2	1.1 / 1.2	1.2	0.7