DOWEX™ Ion Exchange Resins

Boron-Selective DOWEX Resin Controls Boron Discharge in Chemical Processing Plant

Site Information

Location:
Sevierville, Tennessee, USA

Purpose:
Reduce boron level in process stream to <1.5 ppm

Comparative Performance:
Boron level in process stream was reduced 90% from 14 ppm to <1.5 ppm.

Precious Metals Corporation conducted a laboratory experiment to determine the best ion-exchange resin for removal of boron from a process stream. DOWEX™ XUS-43594.00 resin was ultimately chosen. (Photo courtesy of Precious Metals Corporation)

Introduction

Precious Metals Corporation (PMC) specializes in the manufacture of supported and homogeneous precious metal catalysts and salts. These products are typically used in the pharmaceutical, electrochemical, and petrochemical industries in a wide range of chemical processes.

A new process at PMC uses sodium borohydride as a reactant and produces a borate-containing process stream of significant volume with a typical boron level of 14 ppm. This level must be reduced for either recycle or discharge. The local water discharge permit requires <1.5 ppm boron for discharge.

PMC considered two boron-selective resins for laboratory evaluation of boron removal, ultimately selecting DOWEX™ XUS-43594.00 resin. This resin was more readily available and, according to PMC, had very good technical assistance. The objective of the laboratory evaluation was to collect the borate in a resin bed, then release the borate via backwashing (regeneration) in a much condensed volume that could be solidified by simple evaporation.

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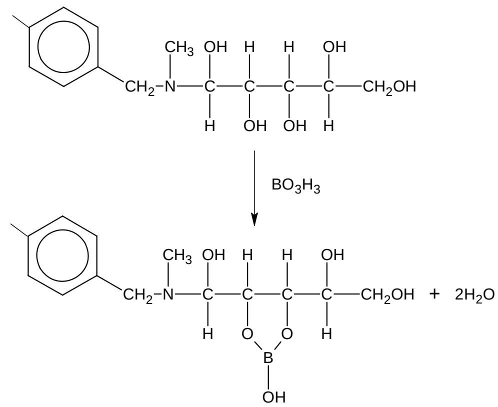
Resin Properties

DOWEX™ XUS-43594.00 resin selectively removes boron by binding through a chelation mechanism at the cis-diol active site.



The resin has a total boron capacity of 2.6 g B/L with a capacity at 10% breakthrough of 1.5–2.0 g B/L. Once the resin is loaded with boron it can be regenerated using a mineral acid like HCl. Table 1 lists the properties of the resin; Table 2 lists recommended operating conditions.

Table 1. Properties of DOWEX XUS-43594.00 resin.

Total exchange capacity, eq/L, min.	0.7
Water content, %	51–59
Bead size distribution	
Mean particle size, µm	550 ± 50
Uniformity coefficient	1.1
Whole uncracked beads, %, min.	90
Total swelling (FB → HCl), %	24–28
Boron capacity at 10% breakthrough, g B/L	1.5–2.0
Total boron capacity, g B/L	2.6

The data above represent typical physical properties and should not be construed as product specifications.

Table 2. Recommended operating conditions for DOWEX XUS-43594.00 resin.

Maximum operating temperature	60°C (140°F)
pH range (optimum)	6–10
Bed depth, min.	800 mm (2.6 ft)
Flow rates	
Service/fast rinse	5–60 m/h (2–24 gpm/ft^2)
Regeneration/displacement rinse: acid	1–10 m/h (0.4–4 gpm/ft^2) HCl or
	5–20 m/h (2–8 gpm/ft^2) H_2SO_4
Regeneration/displacement rinse: base	1–10 m/h (0.4–4 gpm/ft^2)NaOH
Total rinse requirement	2–4 bed volumes
Regenerant	
Acid	1–5% HCl or 0.5–0.8% H_2SO_4
Base	2–5% NaOH
Temperature	Ambient or up to 50°C (122°F)

Experimental Design

The column design was a 2.5-cm-diameter glass chromatography column with a coarse, sintered, glass frit to serve as the base plate for the resin bed. The resin bed was 10 cm high within the column. The effluent liquid level within the chromatography column was maintained at a constant level.

The process-stream effluent contained 14 ppm boron and was prefiltered to remove all visible catalyst particles. This was necessary to keep the column frit from clogging early in the elution.

The design involved passing the boron effluent downflow through the resin bed and measuring the resulting boron content in the elutant at given bed volume points via ICP-AES (inductively coupled plasma-atomic emission spectroscopy). When a specific resin bed was eluting >1.5 ppm boron, the bed was regenerated using a 2% HCl solution, 2% NaOH solution, and deionized water rinses. The regeneration process was monitored by ICP-AES and pH.

Once the bed was regenerated, it was again cycled to remove boron from the process-stream effluent. Boron removal and regeneration were examined through four cycles.

Results

Boron Effluent Treatment

The resin bed containing DOWEX™ XUS-43594.00 effectively removed boron to <1.5 ppm through up to 80 bed volumes of effluent. After 80 bed volumes, the boron level in the bed effluent ranged between 1.5 and 5 ppm through 300 bed volumes. Although this level would be too high for discharge in this case, it could be suitable for recycle.

After the first regeneration the resulting resin bed was able to remove boron from the process-stream effluent to <1.5 ppm for 175 bed volumes. Apparently, the first regeneration increased the activity of the resin bed.

After the second regeneration the resin bed was able to remove boron to <1.5 ppm for 70 bed volumes. For all the runs about 50 to 60 bed volumes could be passed without decreasing the effluent flow rate. At about 50 bed volumes the effluent rate began to slow due to a gelatinous material that plugged the glass frit. However, cleaning the frit with concentrated acid during bed regeneration restored the original flow rates.

After the third regeneration the resin bed was able to remove boron to <1.5 ppm for 75 bed volumes.

Regeneration of Beds

A mid-range (2% w/w) concentration for HCl and NaOH was chosen for regeneration. Four bed volumes of HCl treatment was very effective in removing boron from the resin for all regenerations. Increasing the concentration of the HCl could further increase the efficiency of boron removal from the resin. As soon as the HCl was stopped the boron removal also stopped. Water rinsing and treatment with 2% NaOH were used to help free the column of acid. Very little boron eluted during these post-treatments. Measurement of pH was used to follow the acid/base elution and water rinsing through the column.

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Conclusions

DOWEX™ XUS-43594.00 performed well in the laboratory evaluation. The initial boron content of 14 ppm in the initial waste stream was easily dropped below the 1.5 ppm boron limit for approximately 80 bed volumes. Resin bed regeneration was done with 2% HCl using four bed volumes of acid. The bed showed great resiliency after being regenerated. Recharging and reusing the resin bed over several cycles proved successful and gave similar or better bed volumes for boron removal. The resin was recommended for plant use and to date has performed satisfactorily in the laboratory process.

DOWEX XUS-43594.00 is an excellent candidate for controlling process-stream boron levels from processes using sodium borohydride.

DOWEX™ Ion Exchange Resins
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