Chemical Engineering Journal 220 (2013) 311–319

Contents lists available at SciVerse ScienceDirect

Chemical Engineering Journal

journal homepage: www.elsevier.com/locate/cej

Preparation of highly pure tetrapropyl ammonium hydroxide using continuous bipolar membrane electrodialysis

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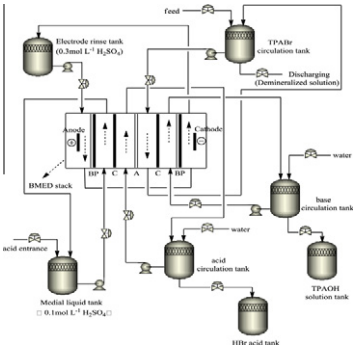
HIGHLIGHTS

- BMED in a novel configuration was adopted for TPAOH production.
- A high purity TPAOH solution of concentration 25% was obtained.
- Continuous pilot experiments demonstrate the feasibility of manufacturing TPAOH.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 17 November 2012
Received in revised form 10 January 2013
Accepted 11 January 2013
Available online 29 January 2013

Keywords:
Bipolar membrane electrodialysis
Tetrapropyl ammonium hydroxide
Ion-exchange membrane
Cell configuration

ABSTRACT

Conventional methods of tetrapropyl ammonium hydroxide (TPAOH) production via electrolysis, reaction of tetrapropyl ammonium halide with silver oxide, and ion-exchange suffer from high production costs, low quality, and environmental pollution. In this work, continuous bipolar membrane electrodialysis (BMED) is employed for the preparation of TPAOH from its halide as a sustainable alternative process. Novel ion-exchange membranes were developed for lab and pilot scale experiments, which indicate an acceptable current efficiency and energy consumption. The results indicate that a cell configuration with four compartments yielded the best results when the salt concentration was 0.3 mol L^{-1} and the current density was 200 A m^{-2}. The highest conversion in electrodialysis was 91.6%, with a high purity of trace alkali metal ions and low Br^- content (176 ppm) at a TPAOH concentration of 25%. The energy consumption is 1.897 kW h kg^{-1}. Continuous pilot experiments demonstrate the feasibility of manufacturing TPAOH by direct splitting its halide for industrial application.

1. Introduction

As a strong quaternary ammonium alkali compound, tetrapropyl ammonium hydroxide (TPAOH) is widely used as the template agent for synthesis of molecular sieves [1]. The TPAOH purity is critical since it enhances its catalytic performance [2]. However, TPAOH is not easily obtainable as a pure compound. Attempts were made to synthesize pure TPAOH by the reaction of tetramethyl ammonium halide with silver oxide (Ag_2O) [3], ion-exchange [4], electro-electrodialysis [5], electrochemical membrane reactors [6], and bipolar membrane electrodialysis (BMED) [7].

The method using Ag_2O is not applicable on larger scale because of the high cost of silver, and the pollution from silver chloride ions [7]. The production of TPAOH by ion exchange generates secondary wastewater due to the alkali-washing of the anion exchange resin. An electro-electrodialysis process gave a low synthesis rate of

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1385-8947/$ - see front matter
http://dx.doi.org/10.1016/j.cej.2013.01.040