Desalination of high NaCl wastewater using electrodialysis

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Abstract—Electrodialysis (ED) is a promising membrane process for recycling water from electrolyte solutions. The objective of this research is to remove ionic species from high salinity wastewater using ED as a primary treatment. As the NaCl concentration in the feed increased, the operating time and power consumption increased to achieve 99 % removal under the same current density operation. The operating time was reduced by half as the applied current density was doubled. The ED process removed the majority of the salt from high salinity wastewater.

I. INTRODUCTION

Water shortages have become an important issue in many countries. Among the many methods used to produce potable water, membrane technology is less energy-intensive than conventional methods for desalination and wastewater recovery. The electrodialysis (ED) process uses electrical potential as a driving force to remove ionic species from water streams. In some industrial effluent streams, wastewater can contain as high as 5 % NaCl concentration. The present paper reports on ED as an efficient way to remove salt from wastewater.

II. MATERIALS AND METHODS

Electrodialysis system

An ED stack housing 8 pairs of cation- (Ionac ® MC-3470, Sybron Chemicals Inc., Birmingham, NJ, USA) and anion-exchange membrane (Ionac ® MA-3475, Sybron Chemicals Inc., Birmingham, NJ, USA) was used with an effective area of 512 cm² (32x16 cm) in each membrane. The electrodes are made of platinum. Two to 5 % NaCl solutions were fed into the system. The concentration, dilute, and electrode rinse were placed in 10 L reservoirs and circulated at 1.0 L/min flow rate. The temperature was maintained at 20-35 °C. The operating variables were current (2 and 4 A), and NaCl concentration. The conductivity of the dilute solution was measured at various time intervals using a conductivity meter (SC-170, Suntex Instruments Co., Ltd., Taipei, Taiwan).

III. RESULTS AND DISCUSSION

The dilute conductivity directly depends on the salt content.

The dilute conductivity decreased with operating time. When the current was maintained at 2A to treat 2 % NaCl solution, the dilute conduction decreased from 34.6 to 0.0251 mS/cm in 600 minutes. When the feed concentration was increased to 3 or 4 %, the initial conductivity was higher, 44.8 or 67 mS/cm, respectively. The operating time was extended to 0.564 and 0.285 mS/cm for 99.5% salt removal. The conductivity decrease rates were similar 2, 3, and 4 % NaCl solutions.

The dilute conductivity lowered with operating time. When the current was kept at 4A to treat 4 % NaCl solution, the dilute conduction decreased from 66.1 to 0.625 mS/cm in 540 minutes. When the feed concentration was elevated to 5 or 6 %, the initial conductivity was higher, 88.3 or 93.3 mS/cm, respectively. The operating time was extended to 0.0512 and 0.1327 mS/cm for 99.8% salt removal. The conductivity decline rates were similar 4, 5, and 6 % NaCl solutions.

The electrical current effect on salt removal efficiency was studied using a 4 % NaCl solution. The initial conductivity was 67 mS/cm. After operating for 1080 minutes at 2 A, the conductivity was lowered to 0.285 mS/cm. When the current was doubled to 4 A, the operating time was shortened to 540 minutes at a comparable dilute concentration.

The power consumption increased linearly with operating time. The total power consumption for 4 % NaCl at current of 2 A was 20.54 kWh/m³. At 4A operation, the total power consumption was higher than 2A operation.

The salt rejection could achieve 99.5-99.9%. The operating time was longer with higher NaCl concentration and lower current. The electrical efficiency increased with NaCl concentration at the same current. It was observed, however, that the electrical efficiency at 2 A and 4 A applied current did not affect the electrical efficiency. As can be seen, at a constant NaCl concentration, the power consumption increased with increasing current. The power consumption was higher at a higher salt concentration using a constant current setting.

IV. CONCLUSION

The study demonstrates that ED is an effective desalination process for water recovery from high salinity wastewater. As high as 6 % NaCl solution can be processed to achieve 99.5 % salt removal within a reasonable time. This technique can be used alone or in combination with other unit operations to remove electrolytes from aqueous solutions.

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