Electrodialysis with bipolar membranes for reagents recovery from dairy wastewater

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1. INTRODUCTION

India stands as one of the world's largest producers and consumers of dairy products. The dairy industry plays a crucial role in India's economy, providing a way of life for millions of people and meeting the country's significant dairy demand. However, the rapid growth of this industry has led to environmental concerns, particularly regarding the discharge of wastewater. This industry generates substantial volumes of wastewater primarily from cleaning processes such as Clean-In-Place. These effluents contain high levels of organic matter but also carry cleaning agents and sanitizers, contributing to chemical pollution if not properly treated (Veiga et al., 2022).

To mitigate these environmental impacts, various wastewater treatment processes can be employed in dairy facilities. These processes aim not only to treat wastewater to meet regulatory standards but also to recover added-value products such as water and chemicals for reuse. In this sense, electrodialysis with bipolar membrane (EDBM) emerges as a promising technology for treating dairy wastewater. This electrochemical process allows for the selective extraction of specific ions and compounds, facilitating the recovery of valuable chemicals and producing treated water. It offers advantages such as higher selectivity, energy efficiency, and the ability to operate under mild conditions compared to traditional methods. The use of bipolar membrane electrodialysis not only aids in treating wastewater but also enables the separation and recovery of valuable compounds, reducing the environmental footprint of dairy industry effluents (Song et al., 2021).

The present study aims to assess a treatment process based on the use of forward osmosis (FO) as pretreatment for solid removal, and an EDBM to recover cleaning reagents and, simultaneously, produce a treated effluent with a low pollutant concentration suitable for disposal.

2. MATERIALS & METHOD

In this study, a train of technologies composed of FO and EDBM was assessed for recovering reagents from a synthetic solution formulated with an initial concentration of 0.019 mol L^{-1} $NaNO_3$. The initial $NaNO_3$ concentration in EDBM depends on the FO performance. However, it is ranging from 0.09 to 0.117 mol L^{-1}. A voltage of 9.02 V was applied in the EDBM system to extract both reagents. Separate experiments were conducted for each system. The draw solutions (DS) used in the different experiments are shown in Table 1.

Table 1. Draw solutions used in the experiments of the study

Stage	Solute in DS	Solute concentration			
FO	$NaNO_3$	0.05M	0.125M	0.250M	0.500M
EDBM	HNO_3	0.05M	0.100M	0.200M	
	NaOH	0.05M	0.100M	0.200M	

3. RESULTS & DISCUSSION

In the case of FO, optimal performance was observed with an initial draw solution concentration of 0.5 M $NaNO_3$, leading to a $NaNO_3$ concentration in the feed solution, yielding an initial water flux of

7.62 LMH. The final water flux after 94% of water extraction was 5.05 LMH. At the same time, the difference in osmotic pressure between both solutions at the beginning of the experiment was 23.64 bar while final osmotic pressure was 6.47 bar (up to 73% reduction).

Regarding EDBM tests (Figure 1), optimal reagent extraction occurred with an initial concentration of 0.05 M of HNO_3 and NaOH as draw solutions (Figure 1a). This configuration concentrated the acids up to 62% w/w and the base up to 44% w/w of their initial concentrations. Additionally, monitoring the $NaNO_3$ concentration in the feed during experiments showed a 70% w/w reduction with the 0.05 M extractant. With >0.05 M of HNO_3 in DS, it was observed a reverse solute flux, reducing the efficiency of the process.

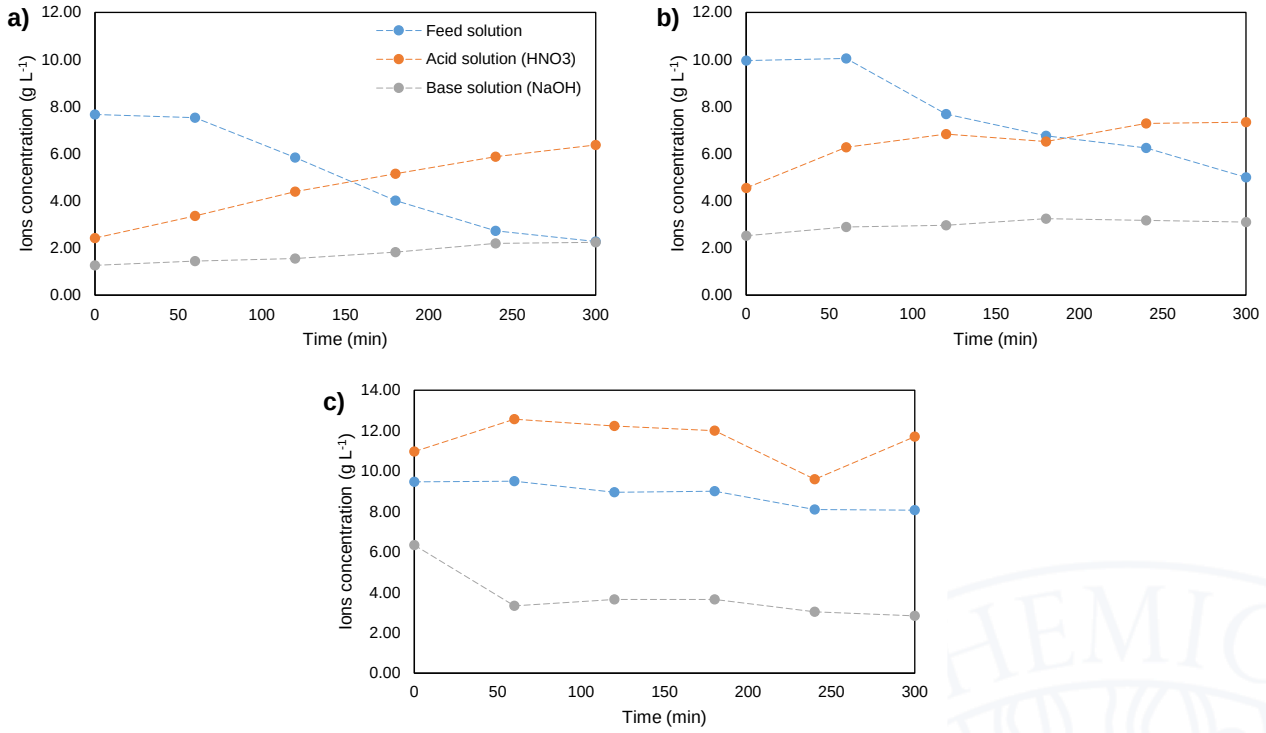

Figure 1. Performance of BMED system in terms of acid (HNO_3) recovery and base (NaOH) recovery in draw solutions. Initial concentration for acid and base in draw solutions: (a) 0.05M; (b) 0.1M and (c) 0.2M of HNO_3 and NaOH.

4. CONCLUSIONS

This study yielded promising results in concentrating solutions using FO with $NaNO_3$ as DS for improving the efficiency of the following selective recovery of acids and bases using EDBM using HNO_3 and NaOH as extractants. Therefore, the proposed train of technologies reported to be effective for resources recovery, but also for reducing the discharge of nitrates, preventing water bodies pollution and eutrophication.

REFERENCES

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