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Predicting emulsion breakdown in the emulsion liquid membrane process: Optimization through response surface methodology and a particle swarm artificial neural network

Abdelhalim Fetimi [a,i], Attef Dâas [b], Slimane Merouani [c], Abdullah M. Alswieleh [d], Mourad Hamachi [a], Oualid Hamdaoui [e], Ounissa Kebiche-Senhadji [a], Krishna Kumar Yadav [f], Byong-Hun Jeon [g], Yacine Benguerba [h,*]

[a] Laboratoire des Procédés Membranaires et des Techniques de Séparation et de Récupération, Faculté de Technologie, Université de Bejaia, Bejaia 06000, Algeria
[b] Laboratory of Material Physics and Radiation, Faculty of Science and Technology, University of Mohamed Chérif Messaadia, P.O. Box 1553, Souk-Ahras 41000, Algeria
[c] Laboratory of Environmental Process Engineering, Department of Chemical Engineering, Faculty of Process Engineering, University Salah Boubnider-Constantine 3, P.O. Box 72, Constantine 25000, Algeria
[d] Department of Chemistry, College of Science, King Saud University, P.O. Box 2455, Riyadh 11451, Saudi Arabia
[e] Chemical Engineering Department, College of Engineering, King Saud University, P.O. Box 800, Riyadh 11421, Saudi Arabia
[f] Faculty of Science and Technology, Madhyanchal Professional University, Ratibad, Bhopal 462044, India
[g] Department of Earth Resources & Environmental Engineering, Hanyang University, 222-Wangsimni-ro, Seongdong-gu, Seoul 04763, Republic of Korea
[h] Department of process engineering, Faculty of technology, Ferhat ABBAS Sétif-1 University, Setif 19000, Algeria
[i] Department of process engineering, Faculty of Technology, University Batna 2, 05076, Batna, Algeria

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ABSTRACT

To anticipate emulsion breakdown in the ELM process, the Box–Behnken design was used with an artificial neural network (ANN) and a metaheuristic approach, namely particle swarm optimization (PSO) and response surface methodology (RSM). Membrane stability testing began with an experimental component to collect data. The following parameters were used to estimate membrane breakdown: emulsification time (3–7 min), surfactant loadings (2–6% v/v), internal phase concentration ([Na_2CO_3]: 0.01–1 mg L^{-1}), external phase to w/o emulsion volume ratio (1–11), and internal aqueous phase to membrane volume ratio (0.5 to 1.5). The PSO algorithm was used to determine the optimal ANN parameter values. The hybrid ANN-PSO model outperformed the RSM in identifying optimal ANN parameters (weights and thresholds) and accurately forecasting emulsion breaking percentages throughout the ELM process. The hybrid ANN-PSO method may be a valuable optimization tool for predicting critical data for ELM stability under various operating conditions.

1. Introduction

Liquid membrane technology has proved to be more appropriate for selectively extracting valuable chemicals or eliminating harmful contaminants from an aqueous matrix in chemical and environmental engineering [1]. Some membrane approaches include the use of supported liquid membranes (SLM) as well as the use of bulk liquid membranes (BLMs) and emulsion liquid membranes (ELMs). The latter is a promising method that combines the extraction and stripping operations into a single step, resulting in simultaneous solute purification and concentration.

Emulsion liquid membranes (ELMs) have been utilized to separate a variety of solutes from aqueous solutions (e.g., heavy metals, pharmaceutical, and personal care products, organic dyes, and so on) since their invention [2,3,4–14]. When the targeted species are present in tiny quantities in the aqueous liquid, ELM may be competitive. Although the ELM approach offers numerous advantages over earlier physicochemical methodologies, it still has specific faults that must be solved before being used in a real-world application. Emulsion stability is the most severe issue with emulsion liquid membranes [13]. The stability of the emulsion globules (due to membrane rupture) is one of the most challenging elements of using the liquid surfactant membrane for industrial

* Corresponding author.
E-mail address: yacinebenguerba@univ-setif.dz (Y. Benguerba).

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