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Statistical Analysis and Optimization of a Process for CO2 Capture

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Abstract : CO₂ capture and storage technologies play a significant role in contributing to the control of climate change through the reduction of carbon dioxide emissions into the atmosphere. The present study evaluates and optimizes CO₂ capture through a process, where carbon dioxide is passed into pH adjusted high salinity water and reacted with sodium chloride to form a precipitate of sodium bicarbonate. This process is based on a modified Solvay process with higher CO₂ capture efficiency, higher sodium removal, and higher pH level without the use of ammonia. The process was tested in a bubble column semi-batch reactor and was optimized using response surface methodology (RSM). CO₂ capture efficiency and sodium removal were optimized in terms of major operating parameters based on four levels and variables in Central Composite Design (CCD). The operating parameters were gas flow rate (0.5–1.5 L/min), reactor temperature (10 to 50 ^oC), buffer concentration (0.2-2.6%) and water salinity (25-197 g NaCl/L). The experimental data were fitted to a second-order polynomial using multiple regression and analyzed using analysis of variance (ANOVA). The optimum values of the selected variables were obtained using response optimizer. The optimum conditions were tested experimentally using desalination reject brine with salinity ranging from 65,000 to 75,000 mg/L. The CO₂ capture efficiency in 180 min was 99% and the maximum sodium removal was 35%. The experimental and predicted values were within 95% confidence interval, which demonstrates that the developed model can successfully predict the capture efficiency and sodium removal using the modified Solvay method.

Keywords : CO2 capture, water desalination, Response Surface Methodology, bubble column reactor
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