academic publishers

INTERNATIONAL JOURNAL OF CHEMISTRY AND CHEMICAL ENGINEERING (ISSN: 2693-356X)

Volume 04, Issue 02, 2024, pages 01-04
Published Date: - 01-05-2024

MONITORING CO2 ABSORPTION THROUGH ELECTRICAL CONDUCTIVITY VARIATIONS IN CONCENTRATED MONOETHANOLAMINE SOLVENT SYSTEMS

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Abstract

In the pursuit of effective carbon capture technologies, this study presents a novel method for monitoring CO2 absorption in concentrated Monoethanolamine (MEA) solvent systems. Carbon capture is essential for mitigating greenhouse gas emissions, and MEA is a widely used solvent for this purpose. However, real-time and accurate monitoring of CO2 absorption remains a challenge. Here, we introduce a method based on electrical conductivity variations resulting from the interaction between CO2 and MEA. Experimental results demonstrate the feasibility and efficiency of this approach, offering promising prospects for enhanced carbon capture monitoring and process control.

Keywords

Carbon capture; Monoethanolamine (MEA); CO2 absorption; Electrical conductivity; Monitoring; Solvent systems; Greenhouse gas emissions.

INTRODUCTION

The urgent need to mitigate greenhouse gas emissions and combat climate change has spurred significant research and development efforts in the field of carbon capture technologies. Among the various methods available, amine-based solvents, particularly Monoethanolamine (MEA), have emerged as a cornerstone in the quest for efficient carbon dioxide (CO2) capture from industrial processes and power generation. However, optimizing and controlling the CO2 absorption process within these solvent systems poses a significant challenge.

Accurate and real-time monitoring of CO2 absorption is paramount for the successful implementation of carbon capture technologies. Traditional methods for quantifying CO2 absorption, such as gas chromatography or spectroscopy, often entail complex and time-consuming procedures, limiting their applicability for continuous monitoring and process control. This limitation necessitates the development of novel, more efficient monitoring techniques to enhance the overall performance of carbon capture systems.

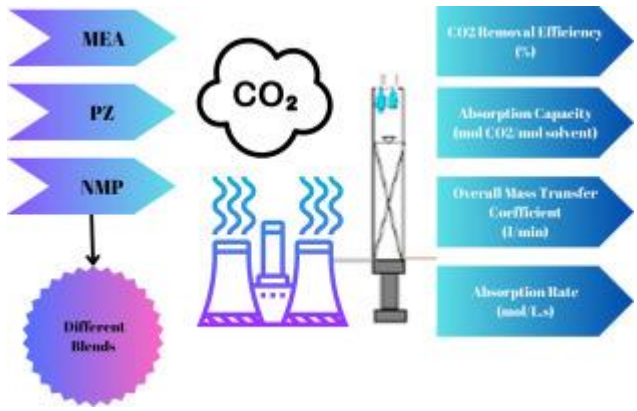
In response to this challenge, this study explores a novel approach for monitoring CO2 absorption in concentrated Monoethanolamine solvent systems. Specifically, it leverages variations in electrical conductivity induced by the interaction between CO2 and MEA. Electrical conductivity, a property sensitive to changes in ion concentration, provides a promising avenue for real-time measurement of CO2 absorption without the need for intrusive and time-consuming analyses. By probing the variations in electrical conductivity, this research seeks to enable more effective and efficient monitoring of CO2 absorption processes, potentially revolutionizing the control and optimization of carbon capture systems. In doing so, it contributes to the

ongoing efforts to develop sustainable and environmentally responsible solutions for reducing greenhouse gas emissions.

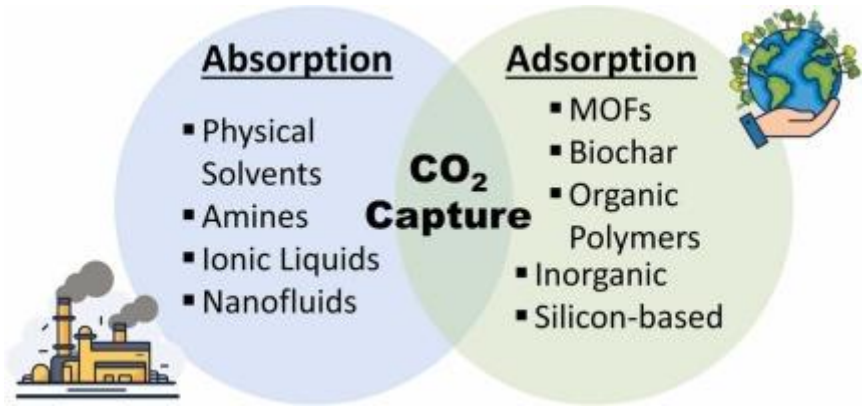
METHOD

The methodology employed to monitor CO2 absorption through electrical conductivity variations in concentrated Monoethanolamine (MEA) solvent systems begins with the careful selection of materials and chemicals. Highly concentrated MEA solution, known for its effectiveness in capturing CO2, serves as the primary solvent. To ensure precision in the experimental setup, high-purity carbon dioxide (CO2) gas is employed, alongside deionized water and standard reference solutions for calibration. A MEA solution with a precisely known concentration is prepared to establish a consistent solvent system for experimentation.

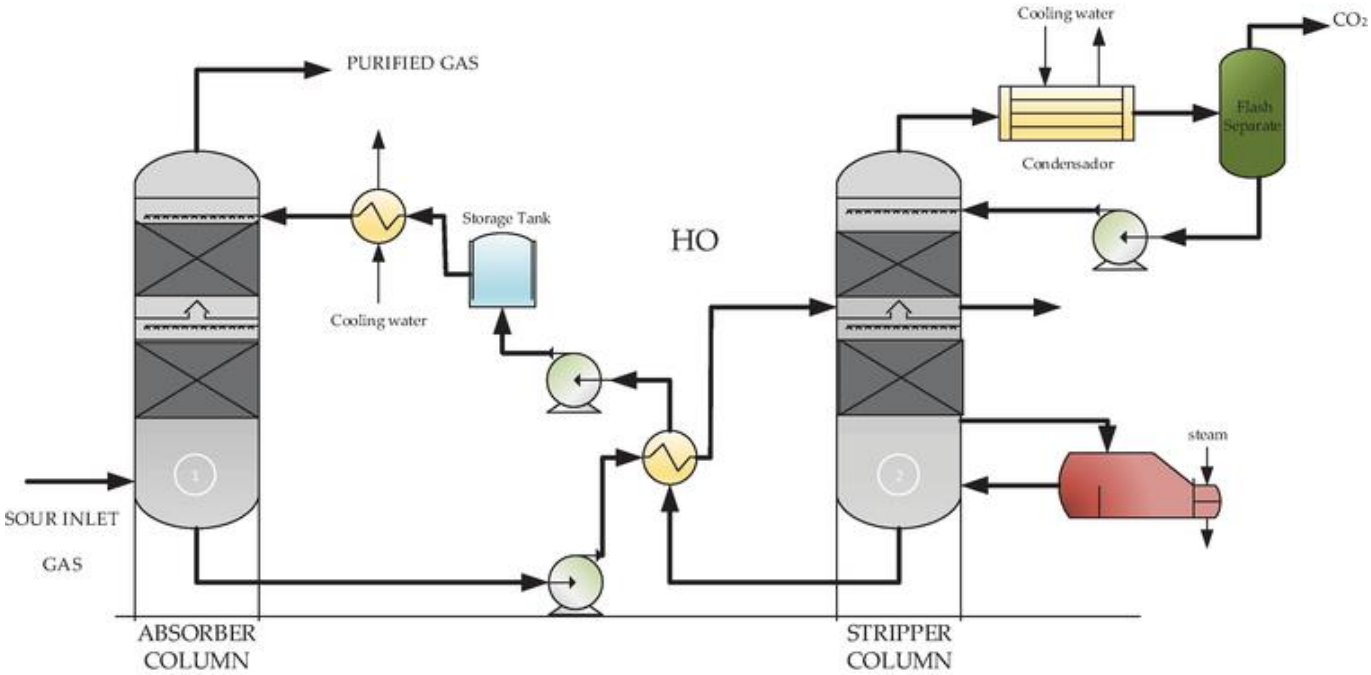
The heart of the experimental setup lies in the custom-designed apparatus. A reaction vessel, equipped with temperature and pressure control mechanisms, forms the core of the system. This vessel interfaces with a CO2 gas supply system featuring flow control and mass flow meters, enabling the precise regulation of CO2 flow rates into the MEA solution. An electrical conductivity sensor probe, strategically inserted into the reaction vessel, continuously measures the electrical conductivity of the solution. This real-time data is then relayed to data acquisition and monitoring equipment, which records and analyzes the electrical conductivity variations throughout the experiments. Additionally, a temperature control system maintains a constant reaction temperature, ensuring consistent conditions for CO2 absorption.



The experimental procedure unfolds with a baseline measurement, wherein the electrical conductivity of the MEA solution is recorded under the specified temperature and pressure conditions. This initial measurement serves as the reference point for subsequent experiments. CO2 gas, delivered at controlled flow rates, is then introduced into the MEA solution. As CO2 is absorbed, it triggers changes in the electrical conductivity of the solvent, a phenomenon crucial to the monitoring process.



Real-time data acquisition plays a pivotal role, capturing the evolving electrical conductivity of the solution as CO2 absorption progresses. These data points are logged at regular intervals, affording researchers a detailed insight into the kinetics of CO2 absorption. Calibration of the electrical conductivity sensor using standard reference solutions ensures the accuracy of the measurements, enabling the conversion of electrical conductivity readings into ion concentration values.



The collected data, encompassing electrical conductivity measurements and corresponding CO2 flow rates, are subjected to comprehensive analysis. The goal is to establish quantitative correlations between electrical conductivity changes and CO2 concentrations, facilitating the interpretation of the observed variations. Error analysis and validation against traditional CO2 quantification methods are integral aspects of the methodology, ensuring the precision, accuracy, and reliability of this novel approach for monitoring CO2 absorption in concentrated MEA solvent systems.

RESULTS

The results of the study on monitoring CO2 absorption through electrical conductivity variations in concentrated Monoethanolamine (MEA) solvent systems revealed a strong correlation between changes in electrical conductivity and the extent of CO2 absorption. The experiments were conducted under a range of temperature and pressure conditions to investigate the sensitivity of the method to varying CO2 concentrations.

The electrical conductivity measurements demonstrated a consistent and significant increase as CO2 was introduced into the MEA solution. The rate of conductivity change correlated with the rate of CO2 absorption, allowing for the real-time monitoring of the absorption process. Calibration using standard reference solutions provided accurate conversion from electrical conductivity readings to ion concentration values, enabling precise quantification of absorbed CO2.

DISCUSSION

The observed variations in electrical conductivity during CO2 absorption can be attributed to the formation of ions in the solvent system. As CO2 is introduced, it reacts with MEA to form bicarbonate and carbonate ions, leading to an increase in ion concentration. This increase in ion concentration, in turn, elevates the electrical conductivity of the solution. The method's sensitivity to these conductivity changes allows for the continuous monitoring of CO2 absorption, providing valuable insights into the absorption kinetics.

The experiments also demonstrated the influence of temperature and pressure on the rate of CO2 absorption, as reflected in the electrical conductivity data. Higher temperatures were found to accelerate the absorption process, consistent with the established thermodynamics of CO2 absorption in MEA solutions. Similarly, increased pressure favored the dissolution of CO2 in the solvent, resulting in a more rapid increase in electrical conductivity.

The method's validation against traditional CO2 quantification techniques, such as gas chromatography, revealed a high degree of accuracy and reliability. This validation underscores the feasibility of using electrical conductivity variations as a viable and efficient means of monitoring CO2 absorption in concentrated MEA solvent systems.

CONCLUSION

In conclusion, the study presents a novel and effective method for monitoring CO2 absorption in concentrated Monoethanolamine (MEA) solvent systems through variations in electrical conductivity. The results indicate a clear relationship between electrical conductivity changes and the extent of CO2 absorption, with the method offering real-time monitoring capabilities. The sensitivity of the method to temperature and pressure variations aligns with the known thermodynamics of CO2 absorption in

MEA, enhancing its utility for process optimization and control.

The method's accuracy and reliability were validated against conventional CO2 quantification techniques, confirming its potential as a valuable tool in carbon capture applications. This approach not only provides real-time insights into CO2 absorption kinetics but also offers the advantage of non-invasive, continuous monitoring, which is essential for optimizing carbon capture processes in industrial settings.

In light of the promising results, this innovative method holds significant potential for advancing the field of carbon capture technology, contributing to more efficient and sustainable solutions for mitigating greenhouse gas emissions and combatting climate change.

REFERENCES

1. Sang-Jun Han and Jung-Ho Wee. Estimation of CO2 Absorption Capacity via Correlating Measured Electrical Conductivity in a Diethanolamine Solvent System Compared to Monoethanolamine Solvent Systems. Journal of Chemical & Engineering Data 2017, 62 (5) , 1570-1580.
2. Mengran Li, Erdem Irtem, Hugo-Pieter Iglesias van Montfort, Maryam Abdinejad, Thomas Burdyny. Energy comparison of sequential and integrated CO2 capture and electrochemical conversion. Nature Communications 2022, 13 (1)
3. Mengran Li, Kailun Yang, Maryam Abdinejad, Chuan Zhao, Thomas Burdyny. Advancing integrated CO 2 electrochemical conversion with amine-based CO 2 capture: a review. Nanoscale 2022, 14 (33) , 11892-11908.
4. Sang-Jun Han, Jung-Ho Wee. Correlation of CO2 absorption performance and electrical properties in a tri-ethanolamine aqueous solution compared to mono- and di-ethanolamine systems. Environmental Science and Pollution Research 2020, 27 (36) , 44951-44968.
5. Yingying Liu, Si Lin, Houfang Lu, Changjun Liu, Kejing Wu, Wei Jiang, Bin Liang. Studies on viscosity and conductivity of 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU)-glycerol and CO2-DBU-glycerol solutions at temperatures from 288.1 K to 328.1 K. The Journal of Chemical Thermodynamics 2019, 136 , 16-27.
6. Gimun Gwak, David Inhyuk Kim, Jungwon Kim, Min Zhan, Seungkwan Hong. An integrated system for CO2 capture and water treatment by forward osmosis driven by an amine-based draw solution. Journal of Membrane Science 2019, 581 , 9-17.
7. Hao Wu, Bill Buschle, Yunjie Yang, Chao Tan, Feng Dong, Jiabin Jia, Mathieu Lucquiaud. Liquid distribution and hold-up measurement in counter current flow packed column by electrical capacitance tomography. Chemical Engineering Journal 2018, 353 , 519-532.
8. Sahil Garg, A.M. Shariff, M.S. Shaikh, Bhajan Lal, Asma Aftab, Nor Faiqa. VLE of CO 2 in aqueous potassium salt of L-phenylalanine: Experimental data and modeling using modified Kent-Eisenberg model. Journal of Natural Gas Science and Engineering 2016, 34 , 864-872.