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Providing CO_2 as a C1 building block by chemical absorption: Ionic liquid-based CO_2 separation technology

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PURPOSE OF THE ABSTRACT

Introduction

CO_2 separation from gases either with the aim of CO_2 sequestration (carbon dioxide capture and storage, CCS) or for its further utilization (carbon dioxide capture and utilization, CCU) has been a vivid field of research where also the use of ILs as solvents has been discussed [1]. State-of-the-art processes for chemical absorption of CO_2 mainly use solutions of amines such as monoethanolamine (MEA), diethanolamine (DEA) or methyldiethanolamine (MDEA) [2]. However, these processes generally suffer from the high thermal energy demand for CO_2 desorption at elevated temperature. Recently, we have presented a new absorption process based on ionic liquids (ILs) which allows for efficient separation of CO_2 in biogas upgrading [3]. Contrary to other approaches, key feature of this process is the regeneration of the solvent at reduced pressure. Owing to the negligible vapour pressure of ILs, evaporative loss of solvent is largely avoided. The quasi-isothermal process design results in a distinctly reduced energy demand (ca. 50 %) compared to conventional chemical scrubbing systems.

In this contribution, we give an overview over physico-chemical characterization data of different ILs relevant for CO_2 absorption and present details of a mini-plant operation. The versatility of our approach is demonstrated in the light of two recent research projects where upscale of the system to pilot scale with the target amount of treated gas of 50 m^3/h is planned.

Physico-chemical characterization of ILs

Characteristics of different imidazolium-based room temperature ILs and amine-functionalised ILs were investigated with regard to thermal stability, chemical absorption capacity, rate of absorption and heat of reaction. Mixtures of the two classes of ILs exhibited synergetic effects, thus compensating drawbacks of functionalised ILs for a technical application such as high viscosity and slow mass transfer.

Lab-scale mini plant

A mini-plant was developed to test promising IL candidates. Here, details on the plant design and results from its operation under quasi-isothermal conditions are presented. Absorption and desorption were carried out at a constant temperature of only 80 °C while pressure was reduced in the desorption step from ambient pressure to typically 50 to 100 mbar. Promising results from an experimental campaign at a German biogas plant illustrate that the system achieves constant performance over more than 100 h under real gas conditions.

In the framework of the European research project RECODE ("Recycling carbon dioxide in the cement industry to produce added-value additives"), integration of the technology in a pilot plant is currently prepared to provide CO_2 from flue gases for further chemical utilization on-site [4].

FIGURES

FIGURE 1

FIGURE 2

KEYWORDS
carbon capture | functionalised ionic liquids | chemical absorption | pressure-swing

BIBLIOGRAPHY

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