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ScienceDirect

Energy Procedia 63 (2014) 1321 – 1328

Energy Procedia

GHGT-12

Systems Analysis of Ionic Liquids for Post-combustion CO_2 Capture at Coal-fired Power Plants

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Abstract

The main objective of this study is to investigate the feasibility and costs of ionic liquid (IL)-based CO_2 capture systems at pulverized coal-fired (PC) power plants. The IL selected for this assessment is trihexyl-(tetradecyl)phosphonium 2-cyanopyrrolide ([P66614][2-CNpyr]), achieving a 1:1 and reversible chemical reaction between $[2\text{-CNpyr}]^-$ and CO_2. A multi-stage equilibrium-based modeling framework is established to simulate the adiabatic absorption process, whereas a single-stage flash drum in equilibrium is employed for the stripping process. The performance model is linked to an engineering-economic model that estimates the capital cost, annual operating and maintenance (O&M) costs, and total levelized annual cost. The technical and cost models are applied to estimate the cost of CO_2 captured by an IL-based CCS system. The preliminary results show that for 90% CO_2 capture, the capture cost would be higher than the U.S. Department of Energy's target at $40 per metric ton of CO_2 captured for new generation technologies, mainly due to a large capital cost. However, current process designs are not yet optimized. Based on the cost of CO_2 captured, the most cost-effective capture cost is found to be at a removal efficiency of about 85% for CO_2.

Peer-review under responsibility of the Organizing Committee of GHGT-12

Keywords: Systems analysis; post-combustion CO_2 capture; ionic liquids

1. Introduction and Research Objective

Ionic liquids (ILs) are among the new materials being developed for carbon dioxide (CO_2) capture because of their many favorable properties: nonvolatile, high thermal stability, high CO_2 solubility and selectivity, and endless

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Peer-review under responsibility of the Organizing Committee of GHGT-12
doi:10.1016/j.egypro.2014.11.141