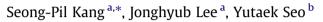
Contents lists available at SciVerse ScienceDirect

Chemical Engineering Journal

journal homepage: www.elsevier.com/locate/cej

Pre-combustion capture of CO₂ by gas hydrate formation in silica gel pore structure



^a Greenhouse Gas Research Department, Korea Institute of Energy Research, 102 Gajeong-ro, Yuseong-gu, Daejeon 305-343, Republic of Korea
^b Ocean Systems Engineering Division, Korea Advanced Institute of Science and Technology, 291 Daehak-ro, Yuseong-gu, Daejeon 305-701, Republic of Korea

HIGHLIGHTS

- ► Carbon dioxide (CO₂) hydrate formation in a fixed-bed type reactor.
- ▶ Enhanced CO₂ separation for pre-combustion capture.
- Efficient hydrate-based CO₂ separation process.

ARTICLE INFO

Article history: Received 2 October 2012 Received in revised form 29 November 2012 Accepted 30 November 2012 Available online 8 December 2012

Keywords: Gas hydrate CO₂ Separation Silica gel Pre-combustion Capture

ABSTRACT

This study presents an efficient hydrate-based CO₂ separation process from a binary mixture consisting of 40.3 mol% CO_2 and balanced H₂, which is a simulated fuel gas from the integrated gasification combined cycle (IGCC), in the presence of porous silica gel particles containing water. According to our previous work (Y. Seo, S.P. Kang, Enhancing CO₂ separation for pre-combustion capture with hydrate formation in silica gel pore structure, Chem. Eng. J. 161 (2010) 308-312), the cage occupancy of CO₂ in mixed gas hydrates with H₂ is enhanced by the use of a silica gel pore structure containing water. Based on that result, a simulated fuel gas is applied to form gas hydrates, and a richer CO₂ containing gas stream is thereby retrieved through dissociation of the hydrates from a single-stage reactor. Equilibrium dissociation pressures of CO₂ + H₂ gas mixtures were measured with silica gel particles with pore sizes of 25, 100, and 250 nm. The effect of CO₂ concentration on equilibrium dissociation pressures was also investigated at a silica gel pore diameter of 100 nm. The results indicate that when a simulated fuel gas has formed in 100 nm silica gel pores, a gas stream containing more than 96 mol% of CO₂ is achieved by one-stage gas hydrate formation in a silica gel pore structure, which is comparable to the result (88-92) from hydrate formation in bulk water. In addition to demonstrating enhanced distribution of CO₂ in coexisting phases, gas hydrate formation in a fixed-bed type reactor charged with silica gel particles containing water in pores is investigated. The formation of gas hydrates in silica gel pores occurred to a high extent and at a high rate, and the proposed method is thus expected to be a promising CO₂ capture tool for precombustion.

© 2012 Elsevier B.V. All rights reserved.

1. Introduction

 CO_2 emissions from the burning of fossil fuels have been identified as the main contributor to greenhouse gas emissions, which have led to global warming and subsequent climate change. In 2008, 43% of CO_2 emissions from fuel combustion were produced from coal, 37% from oil, and 20% from gas [1]. Coal is fulfilling much of the growing energy demand of developing countries, where energy-intensive industrial production is growing rapidly and is responsible for 80% of power generation. For these reasons, several techniques have been developed to reduce CO_2 emissions from fossil fuel power plants: oxyfuel combustion, post-combustion CO_2 capture from exhaust flue gas, and pre-combustion CO_2 capture. Oxyfuel combustion is related to improved combustion efficiency, subsequently reducing CO_2 emissions. Post-combustion capture can be achieved in the flue gas stream of power station and is accomplished using amine-based solvents at present. Precombustion CO_2 capture involves the removal of CO_2 prior to combustion and is concerned to produce hydrogen (H₂). H₂ combustion produces no CO_2 emission except water vapor and it is used in a gas turbine or a fuel cell. H₂ is considered an attractive future clean energy source. Even though H₂ production should ultimately be achieved from renewable energy sources, for example solar or wind power, production of H₂ from conventional fossil fuels is





Chemical

Engineering Journal

^{*} Corresponding author. Tel.: +82 42 860 3475; fax: +82 42 860 3034. *E-mail address*: spkang@kier.re.kr (S.-P. Kang).

^{1385-8947/\$ -} see front matter @ 2012 Elsevier B.V. All rights reserved. http://dx.doi.org/10.1016/j.cej.2012.11.131