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A Study of CO_2 Removal: Controlling of CO_2 in Pipe-line Transportation Process

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Several experiments were conducted to investigate the removal of CO_2 during transportation process in pipe-line. The use of adsorption technology by process of carbonation in natural CaO obtained from crushed shell-fishes (CSFs) was explored. Acid treatment of CSFs by HCl was introduced. The setup on online CO_2 monitoring was assembled. Results is that ambient temperature play important role on the adsorption capacity of CO_2 on CSFs. In winter season, highest CO_2 removal efficiency can be obtained during the day time while in the night time resulted on decreasing of 30-40% in CO_2 removal efficiency. In addition, increasing concentration of HCl during acid treatment of CSFs resulted on increasing of adsorption capacity on CSFs.

Key words: Carbon dioxide (CO_2); separation technologies; adsorption; pipe-line transportation

1. Introduction

The role of carbon dioxide (CO_2) in global warming is one of the most important contemporary environmental issues and it is therefore necessary to have available technology which minimizes the discharge of CO_2 into the atmosphere.[1,2,3] Increasing atmospheric CO_2 concentration and its effect on the Earth is a powerful driving force for the development of new advanced energy cycles incorporating CO_2 capture.[4] Amongst the anthropogenic sources of CO_2, electric power stations utilizing fossil fuels (especially coal and heavy hydrocarbons), petroleum refineries, natural gas plants and certain chemical plants are the largest single-point sources of CO_2.

Now a day, several technologies are being tested fro separating CO_2 such as absorption by amine solution and adsorption by solids (such as zeolites), adsorption systems capture CO_2 on a bed of adsorbent materials (such as molecular sieves or activated carbon). In addition, CO_2 can also be separated from flue gases by condensing it out at cryogenic temperatures. Polymers, metals such as palladium, and molecular sieves are also being evaluated for membrane-based separation processes.[5] However, it is generally accepted that the cost associated with the separation of CO_2 from flue gases introduces the largest economic penalty to these mitigation options.[2] This justifies development of a range of emerging approaches to separate CO_2 by more cost-effective processes.

The possibility of using the carbornation reaction for the removal of CO_2 from the gas stream was already considered in the late 19^{th} century and it was widely proof as the low cost technology for capturing CO_2.[4] In this study, the experiment is aimed to explored the use of natural CaO obtained from crushed shell-fished (CSFs) for removing of CO_2 during transportation by pipe-line process, and to produce the knowledge necessary to make a selection and management of aquatic plants in phytoremediation process.

2. Methodology

2.1. Preparation of the CSFs Particle

Raw CSFs used in this experiment were oyster shell from Haesung Co., Ltd. The production processes of CSFs are crushing and passing the heat treatment under 700°C. The pre-treatment procedure was as

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follows:

a) *Acid treatment* of CSFs with 0.1 and 1 N of Hydrochloric acid (HCl). To eliminate CO_2 formed in $CaCO_3$ of CSFs and to produce the microporous on CSFs.

b) *CSFs particle preparation* – CSFs from acid treatment were washed and dried under 105°C, afterward dried CSFs were grinding and sieved with wire screens of ∅ 1.00 and 1.18 mm to maintain the size distributrion of particle.

2.2. Preparation of the Transportation and CO_2 Feeding Gas

The reactor used in this experiment was made of PVC tube with a dimension of 25 mm×900 mm (diameter × length), accommodating a volume of 0.25-0.45 L. Fig. 1 illustrates the schematic diagram of the experiment. Approximately, 200 g of CSFs are weighted and filled into the transportation reactor (35% of total reactor volume).

CO_2 feeding in this experiment is prepared from dilution of pure 99% CO_2 with ambient air. The moisture column reactor was built contained silica gel inside for maintaining humidity less than 20%. Flowrate of CO_2 fed to reactor is controlled at 2.0 mL/min with approximate CO_2 concentration of 0.95-1.1% (vt.) The measurement of influent and effluent CO_2 used hand-held carbon dioxide meter GM70 contained GMP221 sensors and GMH70 detector from Vaisala Co.,Ltd, Finland. Fig. 2 depicts the setup of transportation reactor in Laboratory.

3. Results and Discussion

In this experiment, the reactor was operated during winter season of Korea (December 2003-current). Variation of temperature and humidity within reactor was recordation using temperature and humidity sensors. The observation of temperature was found in the range of 13-24°C (minimum and maximum daily temperature). The influent CO_2 concentration of 9,500-11,000 ppm was fed to reactor with approximate flowrate of 2.0 mL/min. The online monitoring of CO_2 was started for 90 hours. During the experiment, CO_2 concentration at influent and effluent will be detected every 15 minutes. Fig. 3 shows the variation of influent and effluent CO_2

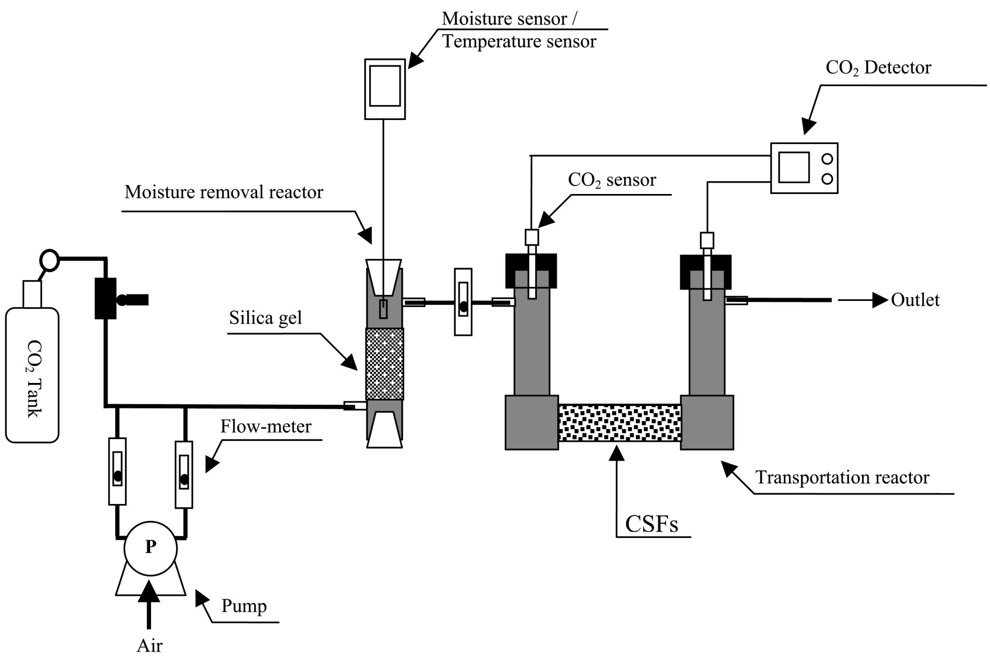

Fig. 1. Schematic diagram of the experiment.

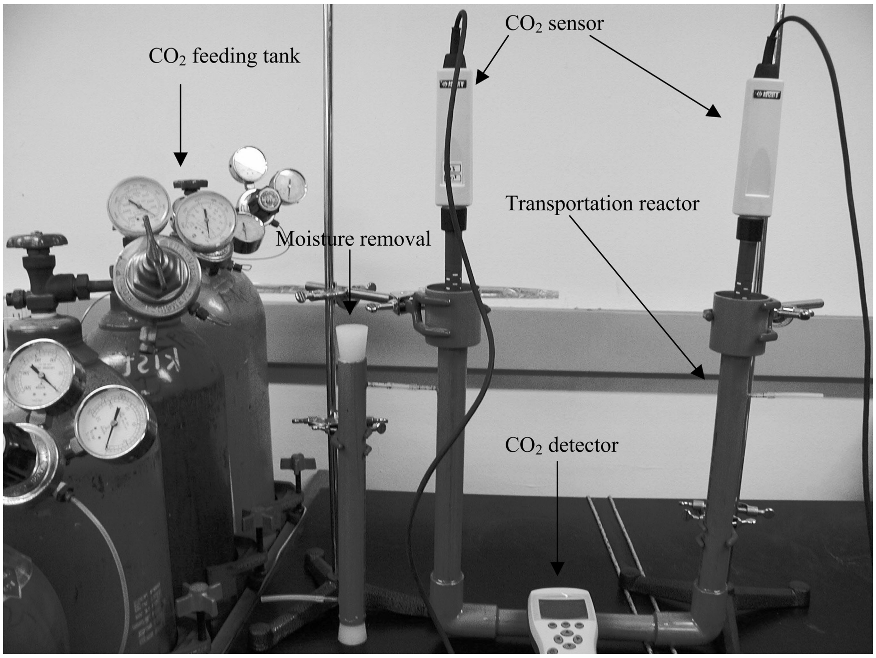

Fig. 2. Experimental setup.

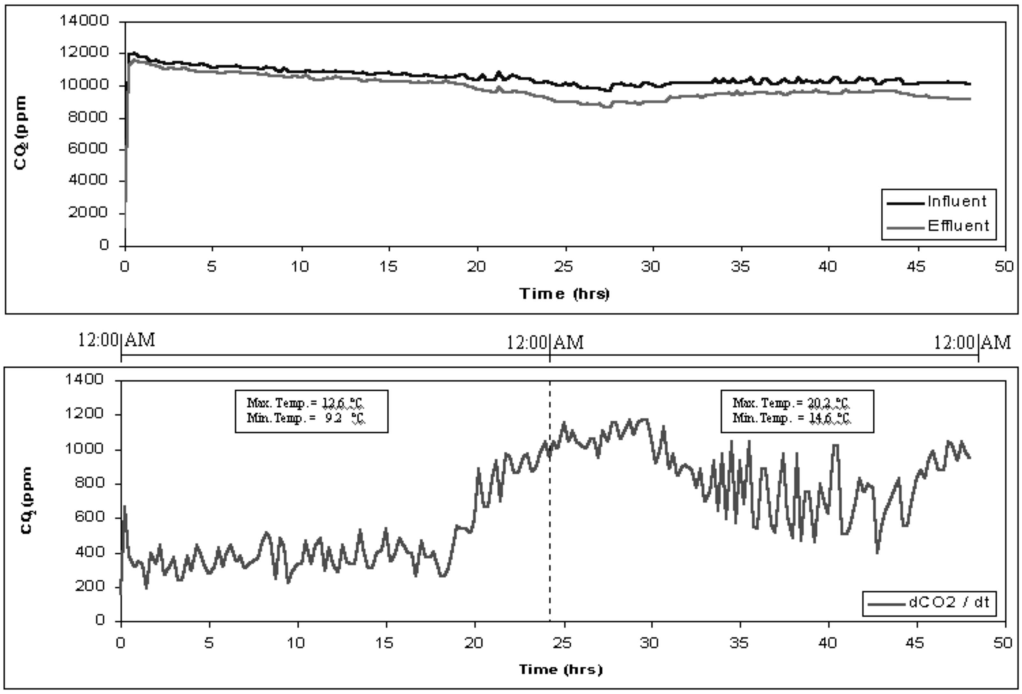

Fig. 3. Influent and effluent CO_2 concentration vs. CO_2 removal (dCO_2/dt) Using 1.0 N HCl.

concentration and amount of CO_2 reduced (dCO_2/dt) by using CSFs treating by of 1 N HCl with time, while Fig. 4 shows the variation of influent and effluent CO_2 concentration and amount of CO_2 reduced (dCO_2/dt) by using CSFs treating by of 0.1 N HCl with time. The results shown that during winter season the removal

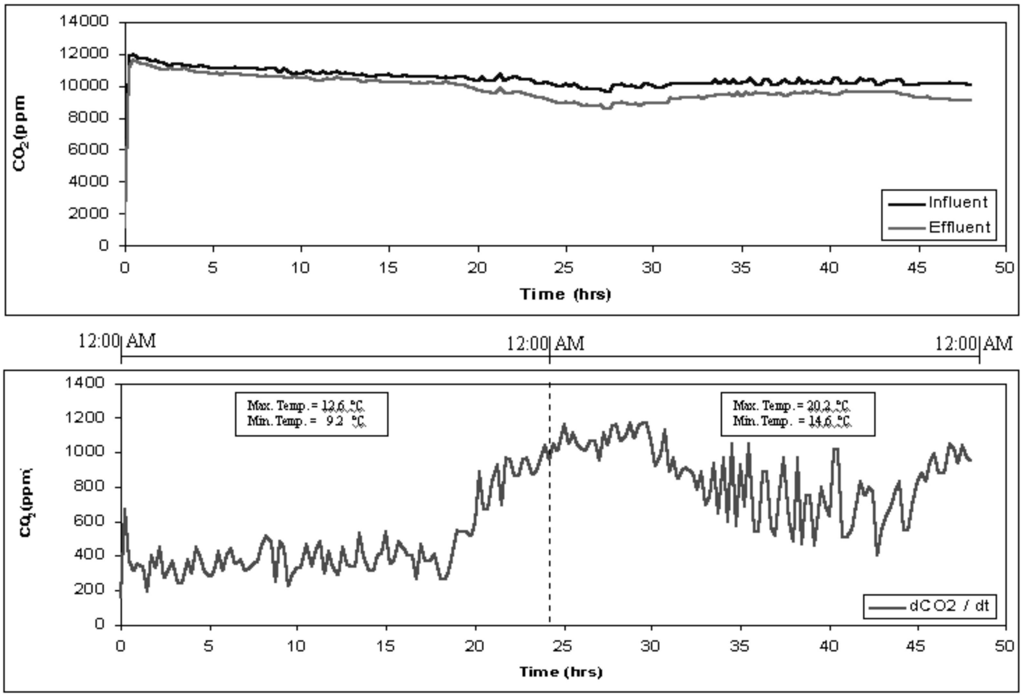

Fig. 4. Influent and effluent CO_2 concentration vs. CO_2 removal (dCO_2/dt) Using 0.1 N HCl.

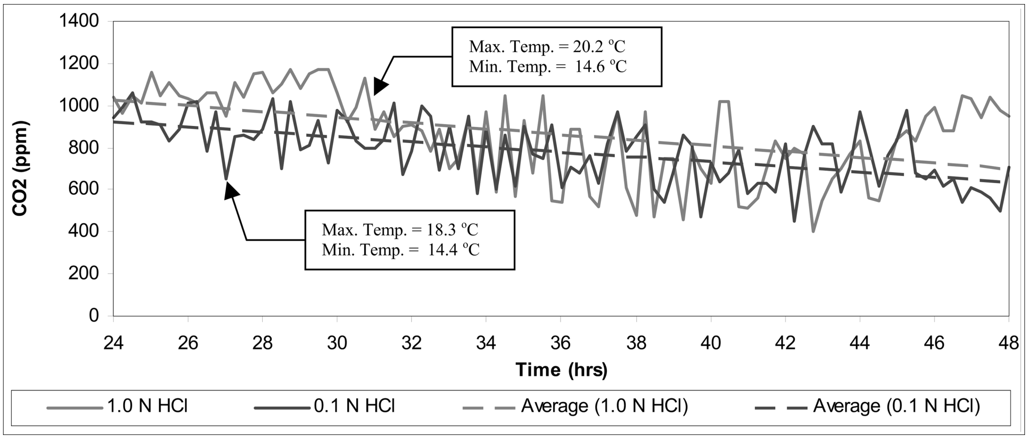

Fig. 5. Effect of acid treatment by HCl on CO_2 removal by CSFs.

efficiency of CO_2 on adsorbent (CSFs) was directly depending on ambient temperature. Highest CO_2 adsorbed on CSFs was occurred on the day time while lowest adsorption capacity was recorded in the night time (low temperature resulting on increasing of desorption rate of CO_2 from CSFs). However, the result obtained from CSFs treating with 0.1 N HCl shown that derivation of CO_2 between influent and effluent was sharply increased after 48 hours of operation and reduced after 72 hours of operation. The reason is that the saturated of CO_2 was occurred after the time of 72 hours and continuous feeding of CO_2 after 72 hours resulted on desorption of CO_2.

Fig. 5 shows the distinction between CSFs by acid treatment of 0.1 N HCl and 1.0 N HCl at average temperature about 16-17°C. The graph show that increasing concentration of HCl during acid treatment resulted on increasing of adsorption capacity of CSFs.

and removal of CO_2 from CSFs with the different concentration of HCl during acid trae comparison between.

4. Conclusion

The removal of CO_2 by using CSFs as an adsorbent in pipe-line transportation reactor is greatly varied with the temperature of environment. The results had shown that approximately 10-17% of initial CO_2 of 9,500-11,000 ppm can be removed by replacing about 35% of CSFs by total volume of pipe-line during transportation process. In addition, increasing concentration of HCl during acid treatment of CSFs resulted on increasing of adsorption capacity on CSFs.

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