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Performance evaluation of newly developed absorbents for CO_2 capture

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Abstract

Chemical absorption method using amine based absorbents is the most applicable to post-combustion carbon dioxide capture process in thermal power station. The development of absorbent for CO_2 capture is the one of the core technologies in the manner of chemical absorption. To develop post-combustion carbon dioxide absorbents, IEA CCC suggested the requirements for excellent chemical absorbents such as higher carbon dioxide capacity, faster absorption and stripping rates, lower corrosivity and degradation rates, lower volatility, and reduced regeneration energy. In this study, Regeneration energy of KoSol-3 was 2.82 GJ/t-CO_2. This value is lower than the value for the commercially used absorbent (MEA, 3.85 GJ/t-CO_2). These results mean that it is possible to reduce nearly 30% of regeneration energy when we use KoSol-3 as the carbon dioxide absorbent.

Keywords: absorbent, CO_2 capture, regeneration energy

1. Introduction

Chemical absorption method using amine based absorbents is the most applicable to post-combustion carbon dioxide separation process in thermal power station. But, the biggest point at issue of chemical absorption is high regeneration energy. To make this process more practical in the near future it is essential to reduce the regeneration energy. Therefore, many of the research groups have been attempted to develop new types of chemical absorbents for the enhancement of conventional alkanolamine absorbents, especially MEA.

To develop post-combustion carbon dioxide absorbents, IEA CCC suggested the requirements for excellent chemical absorbents such as higher carbon dioxide capacity, faster absorption and stripping rates, lower corrosivity

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and degradation rates, lower volatility, and reduced regeneration energy. Therefore, we focused our efforts on the development of novel amine based carbon dioxide absorbents that have the fast absorption/stripping rates and high absorption capacity for carbon dioxide. In this study, the absorbent candidates have been evaluated their capability for carbon dioxide capture by screening tests, vapor-liquid equilibrium tests and bench scale test.

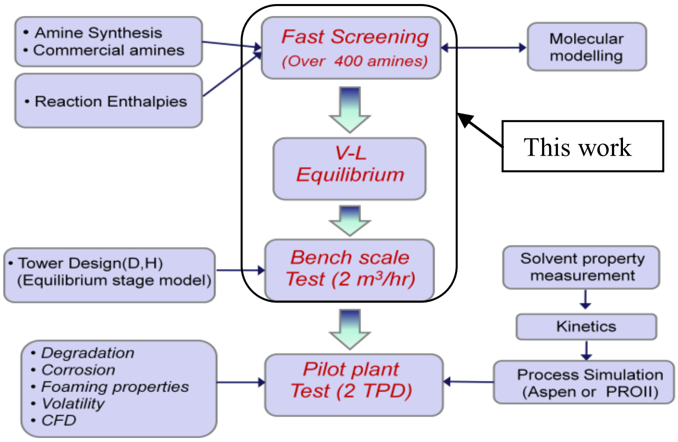

Figure 1. Development scheme of new absorbents.

2. Experimental

(1) Screening test

The purpose of the screening test was to determine the reactivity of the absorbent with carbon dioxide. The screening test was conducted at 40℃ for 90 min (absorption condition) and at 80 ℃ for 30 min (stripping condition). The glass bubbling bottle which was filled with 50ml of absorbent solution was placed in the 40 ℃ water bath. Then, the 15 % CO_2 gas balanced with N_2 was supplied to the glass bubbling bottle for 90 min. After the end of absorption, the glass bubbling bottle moved to the pre-heated water bath (80 ℃). During these tests, the outlet gas emitted from the glass bubbling bottle was analyzed by a carbon dioxide analyzer (VA-3001). From this experiment, newly developed KoSol series absorbents showed the similar absorption performances and excellent stripping performances compared those of 30 wt% MEA solution. These results encouraged us an attempt the experiments of vapor-liquid equilibrium about MEA and KoSol-3A-3, 3A-5.

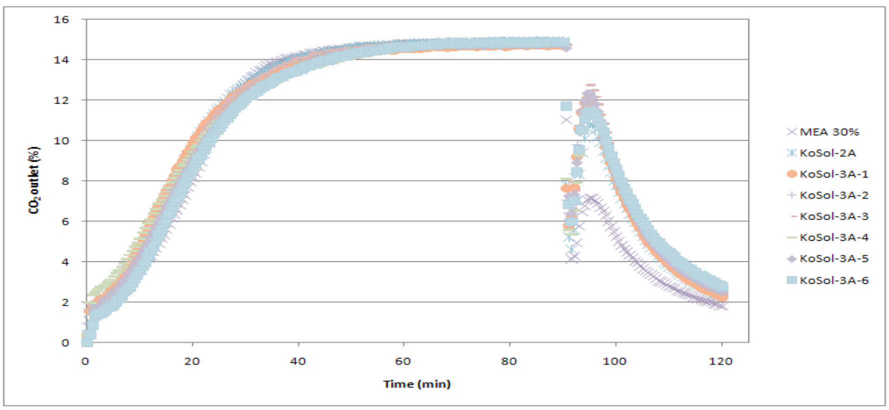

Figure 2. Screening test results of candidate absorbents.

(2) Vapor-liquid equilibrium test

Excellent absorbent candidates in the screening test were further investigated by vapor-liquid equilibrium (VLE) tests. VLE test was conducted at 40 ℃ and 120 ℃, respectively. These temperatures are regarded as typical absorption/stripping conditions for the chemical absorption process. To analyze the equilibrium data, the carbon dioxide partial pressure was measured in both the gas and liquid phases. As shown in Figure , KoSol series absorbents gave the higher absorption capacity for carbon dioxide than that of MEA at 40 ℃ (absorption condition) and the lower absorption capacity than that of MEA at 120 ℃ (stripping condition), simultaneously. This phenomenon means that the loading capacity of KoSol series absorbents is higher than that of MEA.

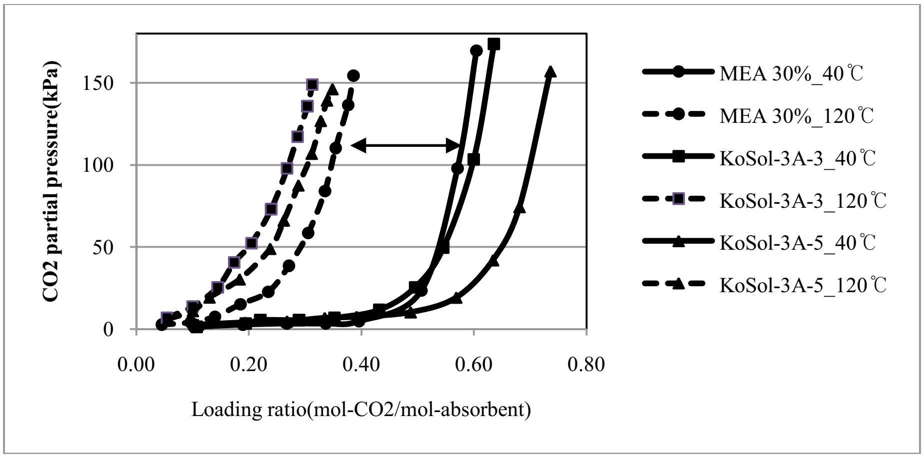

Figure 3. VLE test results of KoSol

(3) Bench scale test(2 Nm^3/hr)

Bench scale test was conducted by KoSol-3 and 30 wt% MEA solution, respectively. The newly developed absorbent (KoSol-3) gave the value of 2.82 GJ/t-CO_2 as its regeneration energy. In the case of MEA (30 wt%), the regeneration energy was 3.85 GJ/t- CO_2. These results mean that it is possible to reduce nearly 30% of regeneration energy when we use KoSol-3 as the carbon dioxide absorbent (Figure 4).

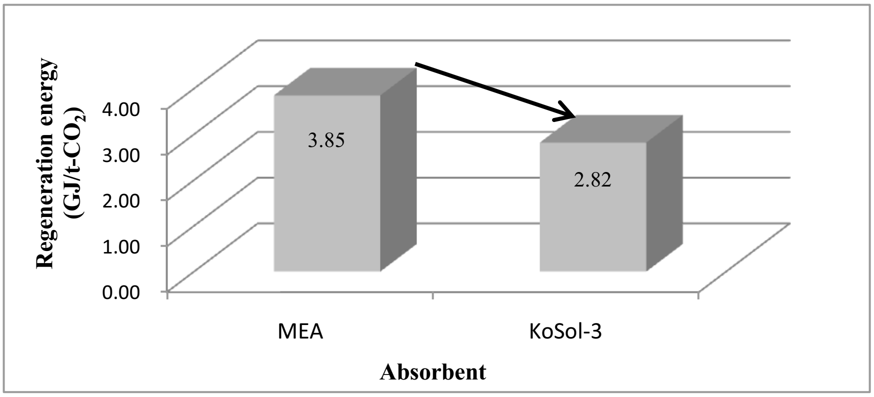

Figure 4. Regeneration energy of MEA and KoSol-3

3. Conclusions

We developed new absorbent, KoSol-3, with superior absorption/desorption rates and regeneration energy compared with MEA, a conventional absorbent. In the bench scale test, Regeneration energy of KoSol-3 was 2.82 GJ/t-CO_2. This value is lower than the value for the commercially used absorbent (MEA, 3.85 GJ/t-CO_2). We will evaluate KoSol-3 using the pilot plant (2 ton-CO_2/day) which will start in 2010 using the actual flue gas from a coal fired power station in boryung, Korea.

4. Acknowledgement

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