A Study of Calcium - Cobalt based particles as Oxygen Carrier for Chemical Looping Combustion

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Highlights

- The Ca-Co-based oxygen carrier was made using the glycine GNP method.
- 15% H_2 / N_2 was used as reducing gas and air was used as oxidizing gas.
- The Ca-Co based oxygen carrier had stable reaction rate and high oxygen transfer capacity.

1. Introduction

Recently, efforts are being made around the world to reduce CO_2 emissions from the use of fossil fuels. Chemical Looping Combustion(CLC) technology is one of the representative technology of CO_2 capture technology [1]. The CLC process is divided into an air reactor and a fuel reactor. The metal oxide will circulate through these two reactors. This metal oxide is called an oxygen carrier. In chemical looping combustors, oxygen carriers play an important role in transferring oxygen and heat through a redox reaction [2]. The study was conducted to test the possibility of Ca-Co-based particles as oxygen carrier.

2. Methods

TGA and TPR analysis were performed to see the redox reactivity of the oxygen carrier. In order to see the reactivity according to the cycle, the experiment was carried out at 900 ℃ similar to the actual operating conditions. In addition, we alternately injected reduction gas and oxidation gas to repeat the oxidation and reduction. 15% H_2/N_2 was used as reduction gas, and air was used as oxidation gas. We also added nitrogen gas 3 minutes between the oxidation and reduction to avoid mixing the reduction gas and oxidation gas. TPR was used to see the redox properties depending on the temperature. At this time, 5% H_2/Ar was used as reduction gas and 5% O_2/H_2 was used as oxidation gas. We used XRD for crystal structure analysis and FE-SEM to observe the morphology of the particles.

3. Results and discussion

From Fig.1, it can be seen that the reaction proceeded slowly until about 4 minutes at the time of reduction and then proceeded rapidly after 4 minutes. Also, even when the cycle was increased, there was no significant change of oxygen transfer performance. During the oxidation, the reaction proceeded slowly until about 1 minute, and then the reaction speed became faster. The oxygen transfer capacity was measured at 15.1% in the first cycle, and subsequently increased to 15.6% in the 10th cycle. Fig.2 shows that the reduction rate is the fastest among the conversion between 0.5 and 0.7. The oxidation rate was the fastest among the conversion between 0.2 and 0.4. The maximum reduction rate was 0.027mmol O_2/g/sec in the first cycle when reducing through fig.3. Thereafter, the reaction rate gradually increased to 0.030mmol

O_2/g/sec in the tenth cycle. On the contrary, during oxidation, the maximum oxidation rate was 0.047 in the first cycle, but the reaction rate gradually decreased to 0.043 in the tenth cycle.

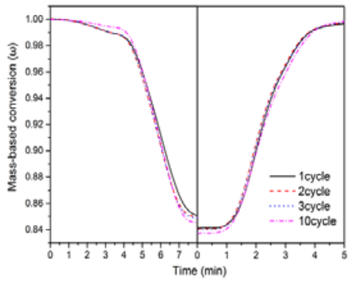

Figure 1. Time to mass-based conversion of $CaCoO_3$ measured using 15%H_2/N_2 reducing gas and air oxidizing gas.

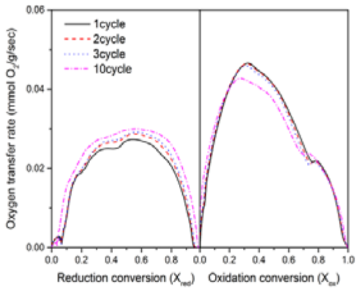

Figure 2. Reduction and oxidation conversion to Oxygen transfer rate of $CaCoO_3$ measured using 15%H_2/N_2 reducing gas and air oxidizing gas.

	maximum reduction transfer rate (mmol O_2/g/sec)	maximum oxidation transfer rate (mmol O_2/g/sec)	oxygen transfer capacity (R_o)
1cycle	0.027	0.047	15.1%
2cycle	0.029	0.047	15.2%
3cycle	0.029	0.046	15.3%
4cycle	0.029	0.045	15.3%
5cycle	0.029	0.045	15.4%
6cycle	0.030	0.044	15.4%
7cycle	0.030	0.044	15.5%
8cycle	0.030	0.043	15.5%
9cycle	0.030	0.043	15.5%
10cycle	0.030	0.043	15.6%

Figure 3. Maximum reaction rate and Oxygen transfer capacity of $CaCoO_3$ with cycle.

4. Conclusions

The Ca-Co based oxygen carrier showed a stable reduction rate and oxidation rate when 15% H_2 / N_2 was used as the reducing gas. Also, the oxygen transfer capacity was about 15%, which is good. Therefore, Ca-Co-based particles are likely to be used as oxygen carrier.

References

The reference format is provided below [1 – 3]. [Times New Roman 10].

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Keywords: Chemical Looping Combustion, $CaCoO_3$, Oxygen carrier, Oxygen transfer capacity, Oxygen transfer rate.