3A4) Gaseous CO_2 Decomposition to Carbons by Oxygen-deficient Metal-ferrites

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1. Introduction

Due to the stable chemical properties, CO_2 chemical fixation, transformation and application have greatly been limited. There was no major breakthrough in CO_2 decomposition efficiency until Tamaura and Tabata [1] who reported that CO_2 could be reduced to C nearly 100% at 290°C on the oxygen-deficient magnetite in the early of 1990s. Subsequently, some researchers found that the oxygen-deficient spinel structure, $MFe_2O_{4-\delta}$ (M = transition metals), could also decompose CO_2 to C. The present study will cover the preparation of metal composite catalysts for CO_2 decomposition and the decomposition of CO_2 at elevating temperatures.

2. Material and Experimental

Preparation methods impact greatly on the decomposition activity due to the catalyst size. Chemical co-precipitation is a method which uses metal salts, ammonia or sodium hydroxide as initial materials; $Fe(OH)_3$, MFe_2O_4, Fe_3O_4 etc. Precipitates could be obtained under a certain temperature and pH. The flow diagram for preparation procedure of M-ferrites (M=Co, Ni, Cu, Zn) is shown in Figure 1.

Fig. 1. Block diagram for procedure of ferrites.

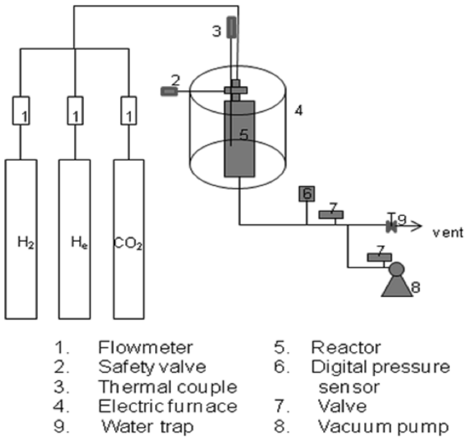
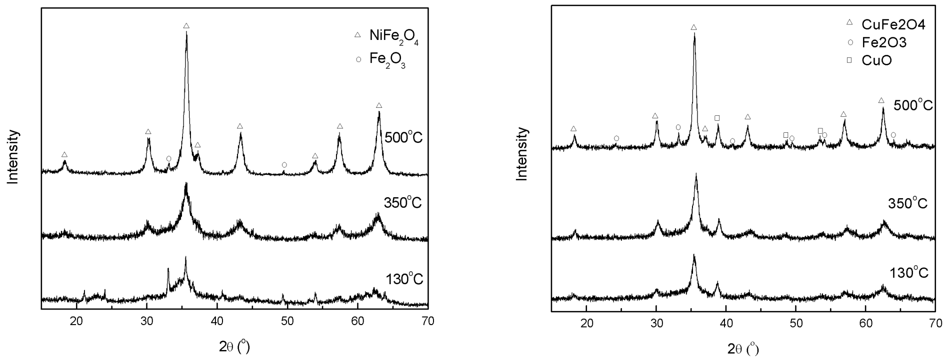


Fig. 2. Schematic set-up for CO_2 decomposition test.

The CO_2 decomposition to C on M-ferrites was conducted in a reaction system shown in Figure 2. The catalyst sample of 2 grams was placed in a stainless tube reactor which is heated with an electric furnace. After the catalyst was activated by H_2 and the reactor was evacuated, the pure CO_2 gas was fed into the reactor. The inner pressure is measured by the digital pressure sensor which may indicate the decomposition of CO_2

3. Results and Discussion



NiFe$_2$O$_4$ CuFe$_2$O$_4$

Fig. 3. XRD profiles of M-ferrites (M = Ni, Cu).

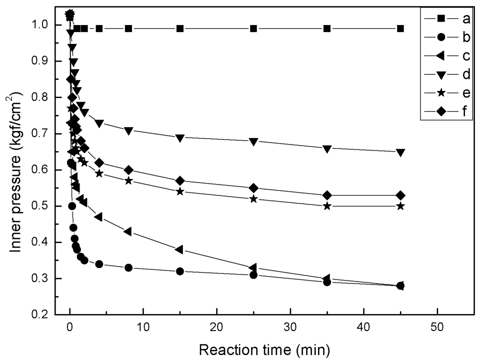


Fig. 4. CO_2 decomposition reactivity by oxygen-deficient M-ferrite at different temperatures(a, b, c is $CuFe_2O_4$ reacting at 200℃, 250℃ and 300℃ respectively; d, e, f is $NiFe_2O_4$ reacting at 200℃, 250℃ and 300℃ respectively).

The X-ray diffraction(XRD) patterns of Ni-ferrite and Cu-ferrite powder are shown in Figure 3. Spinel peaks were detected from the XRD results, and higher calcination temperature makes more crystallites. However the crystals will be lager while the BET surface area becomes smaller with the increase of calcination temperature. $CuFe_2O_4$ shows better CO_2 decomposition reactivity than $NiFe_2O_4$ under most condition. $CoFe_2O_4$ and $ZnFe_2O_4$ catalysts did not have any reactivity at lower than 350 °C.

Acknowledgements

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References

Tamaura, Y. and M. Tahata (1990) Complete reduction of carbon dioxide to carbon using cation-excess magnetite. Nature 346(6281), 255-256.