CHAPTER V

CONCLUSION

The hydrogen desorption/absorption of $HfCl_4$-$NaAlH_4$ with the chelating compound (H_2TPP and $HfCl_2$TPP) as a co-catalyst were carried out over a temperature range of 25-280 °C. The hydrogen desorption took place at the temperature range of 170-220 °C, the pressure of 11 MPa, with 4.5 wt% and 3 wt% hydrogen released with the addition of H_2TPP and $HfCl_2$TPP into doped $NaAlH_4$, respectively. The sequent addition of the chelating compounds affected the desorption kinetics and reversibility of hydrogen desorption on $NaAlH_4$. With the simultaneous addition of the chelating compound with $HfCl_4$ and $NaAlH_4$, hydrogen desorption was low. The more organic compound was added, the less hydrogen was released. However, when 4mol% $HfCl_4$ and $NaAlH_4$ were mixed before adding H_2TPP, hydrogen released was about 5.5 wt%. Moreover, adding H_2TPP significantly lowered the temperature of the first hydrogen desorption from 90 °C to 75 °C. The subsequent dehydrogenation cycles occurred at higher temperature (90-150 °C) and the amount of hydrogen reieased was about 0.7-1.0 wt%. The Hf-Al alloy formation could be prevented as intended by adding the chelating compounds. The HfH_x, where $0<x<2$, was found in the desorbed sample of $HfCl_4$-$NaAlH_4$ doped the chelating compound.

When using $CuCrO_4$ as another co-catalyst, the hydrogen desorption took place at the temperature range of 62-270 °C. The temperature of the first hydrogen desorption decreased much further to 62 °C and the hydrogen released was 5.9 wt%, which was higher than the theoretical value of 5.6 wt%. The equivalent mole of H_2 released per one equivalent mole of $NaAlH_4$ was increased to 1.65, compared to 1.5 of $NaAlH_4$ doped with $HfCl_4$ alone, as can be seen from the following equations.

$$10NaAlH_4 + HfCl_4 + 2CuCrO_4 \rightleftharpoons 3NaH + 10Al + 3NaOH + 4NaCl + HfH + CuO.CuCr_2O_4 + \frac{33}{2}H_2$$

$$NaAlH_4 + xHfCl_4 \rightleftharpoons (1-4x)NaH + 4xNaCl + Al + xHfH + \frac{3}{2}(1+x)H_2$$