CHAPTER I
INTRODUCTION

Hydrogen is considered as an efficient and environmentally friendly energy source. One of the major applications of hydrogen is in fuel cell. This usage has been reported to play an important role in transportation in the near future (Sandrock *et al.*, 2002). However, storage for hydrogen is a crucial step because hydrogen has low energy density at ambient condition that leads to incompatibility with the vehicle need. Consequently, many innovations have attempted to overcome this problem and achieve high-capacity hydrogen storage systems.

There are several approaches for hydrogen storage: compression, liquefaction, and metal hydrides. The first two techniques are not practical in transportation nowadays because they either require high pressure or cryogenic conditions. Some metal hydrides, MgH_2 and LiH, alleviate the difficulties in the storage and reach the standard value specified by the Department of Energy (DOE) in the USA for transportation (6.5 wt% H_2) (Sandrock *et al.*, 2002). Moreover, it can absorb, hold, and release hydrogen many times without deterioration.

Many metals and alloys are capable for reversibly absorbing at the same pressure and high selectivity for hydrogen. In metal hydrides, the intermetallic compounds are usually in one of these five different forms: AB_5 ($LaNi_5$), AB (FeTi), A_2B (Mg_2Ni), AB_2 (ZrV_2), and BCC (TiV_2) (Cuevas *et al.*, 1996). In hydrogen absorption, hydrogen is located on interstitial sites of a host metal lattice. Based on their excellent properties, metal hydrides such as Ni-MH used as a negative electrode in batteries for portable electronic devices and for hydrogen storage in vessels.

According to Slattery and Hampton (2002), there are about seventy complex metal hydrides, which are known as the other type of metal hydrides. Certain transition metals form a hydride with some elements from the periodic table groups IA and IIA when hydrogen is present (Hottinen, 2001). The kinetics of complex metal hydrides tend to be slower than the case of intermetallic hydrides since the formation and decomposition of the hydride complex requires some metal atom diffusion. Hydrogen desorption usually needs quite high temperatures (over 150

°C). Despite of these disadvantages, the high hydrogen capacity makes these materials potential for hydrogen storage. Some procedures such as, metal powder preparation by ball milling (Zaluska *et al.*, 2000) and surface doping with a catalyst (Bogdanović *et al.*, 2000) help metal hydrides to undergo cycles at higher rate, lower temperature, and enhance stability during cycles or increase H/M (hydrogen content per metal atom).

In this study, Ti, Zr, and Hf-halides were added to $NaAlH_4$, the complex hydride which seems to be a candidate for on-board hydrogen storage. In order to investigate the metal effect on the hydrogen storage capacity, absorption/desorption rate, and ability to recycle, both desorption and absorption behavior was observed. Amount of hydrogen desorption was measured as a function of temperature (25-250 °C) under the TPD-like operation whereas the isothermal constant volumetric method was used for the hydrogen absorption (125 °C).