CHAPTER I
INTRODUCTION

The acceleration of global climate change and the energy crisis caused by the wide use of fossil fuels have encouraged the development of hydrogen as a clean secondary energy source. Hydrogen, a renewable, high burning heat, energy source and low environmental pollution can be used as an alternative fuel for vehicles. One of the challenges in the development of the hydrogen economy is the storage of hydrogen with reliability and safety along with high density, low cost, and a fast releasing rate. As a target given by the U.S. Department of Energy (DOE), the storage criteria for vehicular applications are 6 wt% storage capacity at a temperature below 200°C with low cost and low toxicity (Ye *et al.*, 2011).

Currently, four methods are available for hydrogen storage: high-pressure gas cylinders, liquid hydrogen in cryogenic tanks, absorption by metal hydride or adsorption on materials with a large surface area, and chemical hydrogen storage (including off-board regeneration). However, some storage methods cannot match the requirement for hydrogen as a fuel in car engines or aircraft turbines because of the low hydrogen uptake and ungovernable hydrogen desorption rate. For example, a high pressure storage needs high strength containers and has a limited volume capacity including safety problems (Dong *et al.*, 2007). Therefore, chemical or physically combined storage of hydrogen in other materials has potential advantages over other storage methods because this process may provide high volumetric and gravimetric storage capacities. However, due to the strong interaction between the adsorbate and surface, reversibility can only be observed at high temperatures (Hu *et al.*, 2011).

Hydrogen forms metal hydrides with some metals and alloys leading to solid-state storage under a moderate temperature and pressure that gives the important safety advantage over the gas and liquid storage methods. Metal hydrides have higher hydrogen-storage density (6.5 H atoms/cm^3 for MgH_2) than hydrogen gas (0.99 H atoms/cm^3) or liquid hydrogen (4.2 H atoms/cm^3). Hence, metal hydride storage is a safe, volume-efficient storage method for on-board vehicle applications. A group of Mg-based hydrides stands as a promising candidate for competitive hydrogen storage with reversible hydrogen capacity up to 7.6 wt% for on-board applications (Sakintuna *et al.*, 2007). Furthermore, borohydrides have been considered interesting candidates for hydrogen storage applications due to their high gravimetric hydrogen content (Pistidda *et al.*, 2010).

Among all possible complex hydride candidates, magnesium borohydride [$Mg(BH_4)_2$] seems to have the potential to satisfy the performance targets proposed by the U.S. Department of Energy because it contains not only high gravimetric (14.8 wt %) and volumetric (112 g/l) hydrogen densities, but also a low hydrogen binding enthalpy. Moreover, research results concerning the correlation between the thermodynamic stability of $M(BH_4)_n$ (M = Li, Na, K, Ca, Mg, Zn Sc, Zr and Hf, n = 1-4) and the electronegativity of M suggest that $Mg(BH_4)_2$ is one of the most attractive borohydrides for hydrogen storage owing to its favorable desorption hydrogen enthalpy. However, the high decomposition temperature of about 300 °C makes it unfavorable for practical fuel cell applications (Zhang *et al.*, 2011).

To enhance the hydrogen storage capacity, the kinetics and life cycle including desorption temperature, modified $Mg(BH_4)_2$ has been investigated. The kinetics has been improved by adding an appropriate catalyst into the system and by ball-milling that introduces defects with improved surface properties (Sakintuna *et al.*, 2007).

From the previous studies, attempts have been made to improve metal hydride properties including hydrogen-storage capacity, kinetics, cyclic behavior, toxicity, pressure and thermal response (Sakintuna *et al.*, 2007). In this research, $Mg(BH_4)_2$ was synthesized by a dry process. The hydride was then investigated for its hydrogen storage properties. Effects of catalyst, ball-milling, temperature, and pressure on the hydrogen storage capacity, were reported.