CHAPTER I
INTRODUCTION

Hydrogen is believed to be an ideal energy carrier in the foreseeable future. It seems to be suitable for replacing conventional energy resources such as coal, natural gas, and fossil fuel because the demand for consumption is growing rapidly. However, raw materials for conventional energy are being diminished, so alternative energy sources for hydrogen must be found (Bak *et al.*, 2002).

From these reasons, hydrogen is appropriated to be an alternative energy owing to the following viewpoints:

- Hydrogen can be produced from water which is abundantly available in the world, so it is a renewable resource that is sufficient all the time.

- Conventional energy resources can significantly produce greenhouse gases (especially carbon dioxide, CO_2), which are thought to be responsible for changes in global climate. In contrast, hydrogen is an environmentally friendly and clean energy resource, not involving CO_2 emission, it therefore dose not affect global warming.

- The combustion of fossil fuels by vehicles and other sources is responsible for the smog and harmful particulates in the air. Fuel cells powered by pure hydrogen emit no harmful pollutants.

- Hydrogen can be used in any applications, in which fossil fuels are being used such as a fuel for furnaces, internal combustion engines, turbines and jet engines, automobiles, buses, and airplanes.

- The heat of combustion is much higher than any other fuels, more than 2.5 times that of hydrocarbon fuels and nearly 5 times that of methanol and ethanol.

Besides, hydrogen and fuel cell technology have the potential to strengthen our national energy security by reducing our dependence on foreign oil.

The water splitting reaction to form hydrogen would be a sustainable source of hydrogen for such the energy/fuel needs. The feedstock, water, is available in virtually inexhaustible supply, and the resulting fuel, hydrogen, is attained without polluting products, the only reaction product being water. The water splitting reaction is endothermic, however, and the energy required to achieve a significant hydrogen production rate is high. Ideally, the energy source must also be available in

abundant supply and be non-polluting. Solar energy, which is another renewable energy source, meets these requirements, and the use of solar energy to drive the water splitting to produce hydrogen is an extremely attractive means to convert solar energy to chemical energy.

There have been extensive investigations of chemical systems that involve the absorption of electromagnetic light radiation by chemical agents, so-called semiconductors, followed by reactions leading to the splitting of water. Photocatalytic hydrogen evolution via the water splitting reaction by oxide semiconductor photocatalysts is among the most promising techniques since the catalyst is a solid material, which is relatively inexpensive, resistant to deactivation, nontoxic, and safe to handle. Titanium dioxide (TiO_2) has been proved to be the most efficient oxide semiconductor photocatalyst. However, the widespread technological use of a TiO_2 photocatalyst has been hampered by its wide band gap (3.2 eV for anatase TiO_2) and the requirement of ultraviolet radiation ($\lambda < 400$ nm) for photocatalytic activation. The sun is an abundant source of photons, however UV light accounts for only a small fraction (~5%) compared to the visible region (45%). An efficient process that shifts the optical response of active TiO_2 from the UV to the visible spectral range can provide a framework to more easily incorporate the photocatalytic and solar efficiency of this material.

Despite numerous studies examining this reaction system, the rate of evolution of hydrogen remains unsatisfactory by using commercial semiconductor photocatalyst powders. Significant limiting factors would appear to be: (1) the difficulty of combining photoaccessibility and reactant accessibility to high surface areas of photocatalysts and (2) the efficiency of the subsequent photocatalytic steps to produce hydrogen. Therefore, the investigation on novel photocatalytic material in nanocrystalline oxide semiconductor category with mesoporous characteristic was focused in this research, attempting to alleviate the limitations cited above.

The purpose of this research is to study hydrogen evolution from water by using modified TiO_2, i.e. N-doped TiO_2, photocatalyst under visible light irradiation in the presence of an electron donor. In this research methanol was used as the electron donor. Nanocrystalline mesoporous TiO_2 synthesized via a surfactant-

assisted templating sol-gel process was used for photocatalytic activity test, compared to commercially available non-mesoporous TiO_2, Degussa P-25. Effects of various preparation conditions for N-doped TiO_2 photocatalysts, as well as Pt cocatalyst loading content, on their physical properties and photocatalytic H_2 evolution activity were investigated.