CHAPTER I
INTRODUCTION

Hydrogen is a promising alternative fuel since it can be used completely pollution-free and can readily be produced from renewable energy resources. It is efficient energy because of containing more chemical energy per weight than other hydrocarbon fuels. Uses of hydrogen can be found in many applications such as a fuel in fuel cell, in gas run diesel engines, and in microturbines. Moreover, hydrogen is an important raw material for the aerospace, chemical, semiconductor and other sectors (Hotovy *et al.,* 2004). Although hydrogen is very useful but it is lighter than air so it can easily build up explosive proportions with air. In order to warn of gas leaks and to indicate the efficiency of combustion, H_2 sensor is a necessary safety device.

The demands for accurate and dedicated sensors to provide precise process control and automation in manufactoring process, and also to monitor and control environmental pollution, have accelerated the development of new sensing materials and sensor technology over last decade (Wang *et al.*, 2002).

Recently, there have been interests in using conductive polymers in gas sensing materials, as an alternatives to metal or metal oxide sensing films. Conductive polymers can offer a variety of advantages for sensor applications over the metallic or ceramics counterparts: conductive polymers are relatively low cost materials and lighter; their fabrication techniques are relatively simple and straightforward since there are no needs for clean room and high temperature processes; they can be deposited on various types of substrates and can be operated at lower applied voltage in many conditions, these materials exhibit moderately fast reversible electrical conductivity changes when exposed to gases or vapors at room temperature; they have flexibility in molecular architectures such as side chain attachments, and modifications by charged or neutral particles either in the bulk or on the surface (Prissanaroon *et al*., 2000).

Many conductive polymers have been used as gas sensing materials (Prissanaroon *et al.,* 2000). Polypyrrole (PPy) is the one of the most interesting amongst many conductive polymers known due to its relatively high environmental stability and the eases in synthesizing and doping with various dopants (Ruangchuay *et al.*, 2004). Polyaniline (PANI) has several interesting features such as inexpensiveness, ease to process, high yield, and excellent chemical stability (Kiattibutr *et al.*, 2002). Another conductive polymer, polythiophene, is also a candidate gas sensor material. It has good mechanical properties, high electrical conductivity, and environmental stability in both doped and pristine form (Bantaculo *et al.*, 2001). This polymer is potentially useful components in field-effect transistors, optical and electronic sensors, light-emitting devices, nonlinear optical materials, and etc (Ribeiro *et al.*, 2004). The modified polythiophene by introducing various constituent groups as the side chains with electron donating and accepting nature can improve such as solvent solubility, fusibility, environmental stability, electrical conductivity and optical properties. In the case gas sensing application, polythiophene film and poly(3-n-dodecylthiophene) film coated over polythiophene film with the electrochemical polymerization were investigated and they responded to various gases such as ammonia, chloroform, methane and ethanol gases (Sakurai *et al.*, 2002). Soluble polythiophenes deposited by spray coating on an adapted substrate is an interesting material to consider for building gas sensors (Schottland *et al.*, 1999). In this work, they investigated in poly(3-thiopheneacetic acid) in order to investigate gas sensor properties. Poly(3-thiopheneacetic acid) has attracted much attention due to its bioelectrochemical and photochemical properties in homogeneous competitive immunoassays. Although the PTAA salt form shows high water-solubility, the PTAA acid form is not soluble in water due to the strong hydrogen bonds between the carboxyl groups. Moreover, the carboxyl group of PTAA can react with a desirable compound or can interact with an antigen, a desirable feature for biological devices (De Souza *et al.*, 2001).

Not only conductive polymers can be used for gas sensor but also zeolite is another candidate material. Zeolite, a class of microporous aluminosilicate crystals based on an extensive three-dimensional network of oxygen ions. Situated within the tetrahedral sites form by the oxygen can be either Si^{+4} or an Al^{+3} ion. The AlO_2^-

tetrahedral in the structure determines the framework charge that is balanced by cations (Szostak, 1989). Zeolite framework contains molecular-sized void spaces within their crystal structures. Because of their unique structure, zeolites and related microporous materials possess molecular-sieving property, which has widely been utilized as catalysts, ion-exchanges and adsorbents. As a sensing layer, zeolites are very favorable due to its additional high thermal stability and chemical resistance. These properties are desirable in fabricating robust sensors for NO and SO_2. Moreover, the characteristic molecular sieving has been applied in the gas sensors to detect H_2O and large organic molecules which can discriminate each other (Sasaki *et al.,* 2002). Adsorption of CO_2, N_2 and O_2 on natural zeolite has been investigated (Siriwardane *et al*., 2003).

Combining the advantages of the two materials, we propose to mix a conductive polymer that is poly(3-thiophene acetic acid) with a variety of zeolites to be used as selective gas sensors. The effects of zeolite type, zeolite concentration, cation type, and cation concentration on elcetrical conductivity response of composite were investigated in this work. We will use zeolites L, Mordenite, and Beta since they have nearly the same pore sizes but different structures and Si/Al ratios.