CHAPTER I

INTRODUCTION

1.1 Introduction

This thesis has reported the experimental results regarding the interaction of methyl alcohol, acetone, and ethyl acetate with alumina supported Pt and Pt/Sn catalyst surfaces as a function of temperature. These results contribute to the data base needed to better understand the catalytic oxidation of volatile organic compounds (VOCs). Emissions of VOCs occur in many industrial processes including chemical industry, petroleum refineries, pharmaceutical industry, automobile and aircraft manufacturing, food processing, fiber and textile manufacturing, printing facilities, can coating plants, wire enameling plants, electronic component plants, and painting facilities. VOCs emitted into the atmosphere are major contributors to environmental pollution (Cheng, 1996). Many countries have started to enact legislation to control VOC emissions. A number of VOC emission abatement methods are available, for example: liquid adsorption, solid adsorption, scrubbing, precipitation, capture devices (fibers, membranes, condensers, etc.), biodegradation, thermal incineration, and catalytic combustion (Cheng, 1996). Incineration is the most effective way to achieve complete destruction of VOCs. It is typically performed at temperatures in excess of 760°C. To lower the operational temperature and to make the process more economical, the combustion process can be enhanced by adding a catalyst. Catalytic combustion can be carried out at a relatively low temperature in the range of 280-400°C. The catalytic combustion process has been proven to be very effective to eliminate low concentrations of organic emissions i.e., <50000 (Cheng, 1996).

Catalytic combustion has been reviewed by several authors (Cheng, 1996). These reviews cover many different applications, such as gas turbines and aircraft afterburners, systems with heat extraction, small-scale (domestic) heaters, automobile exhaust gas treatment, household, and general abatement of VOC emissions (Spivey, 1989). VOC oxidation catalysts contain noble metals, single oxides, or complex transition metal oxides on thermally stable catalyst supports, such as alumina.

The current state-of-the-art in VOC oxidation catalysis leaves significant room for improvement, both from a macroscopic process perspective and from the fundamental atomic and mechanistic aspects of surface catalysis. There is a dearth of fundamental studies of VOC catalysis, especially with regard to surface interactions of VOC molecules with metal catalyst surfaces. Important insights can be gained from systematically exploring the behavior of VOC catalysts by means of temperature-programmed methods such as temperature-programmed desorption (TPD). A typical TPD experiment involves adsorption of the adsorbate(s) on a clean surface followed by desorption of the adsorbate(s) and possible decomposition products as the temperature of the surface is increased.

Analytical techniques relating some characteristic properties of the sample to its temperature in the course of a temperature-programmed heating process are commonly included in the field of thermal analysis (Delannay, 1984). The characteristic temperature at which a thermal change will occur in a given sample will depend on the nature of the studied system (phase composition of the sample and composition of the surrounding atmosphere) and on any factors affecting the kinetics of the transformation. Some of the kinetic factors relating to the experimental arrangement used for thermal analysis are flow rates of gaseous reactants, the effectiveness of both heat and mass transfers between the solid and its surroundings, temperature program, the properties of the solid sample itself (particle size, pore structure), state of dispersion in an inert material, presence of trace impurities, and the crystallinity form of the solid (Delannay, 1984). The interpretation of a thermogram is, therefore, fairly complex.

As a result of the remarks above, thermal analysis may be useful at two different levels:

1. As a tool for both qualitative and quantitative analysis.
2. As a means of evaluating the influence of various factors on the reactivity of a known substance.

The identification of the constituents in a sample is usually made by comparing its thermogram with that of a reference material, obtained under the same experimental conditions; this procedure has been used satisfactorily in many mineralogical studies (Delannay, 1984). It will be effective for all samples consisting of mixtures of phase exhibiting a small degree of variation in their thermal behaviors, as a function of secondary characteristics such as particle size, crystallinity, presence of trace impurities, and the like.

In the field of heterogeneous catalysis, thermal analysis is often used as a tool for investigating changes of surface and/or bulk reactivity of samples towards the reactive environment, as a result of variations in composition, preparation method, preliminary treatment, and the like (Delannay, 1984).

1.2 Research Objective

The objective of this work was to investigate the temperature programmed desorption of VOC molecules such as methyl alcohol, acetone, and ethyl acetate on Pt-Sn/Al_2O_3 catalysts. These substances are solvents used in many industries, contributing to industrial VOC emissions.

When appropriate conditions were established for achieving significant surface coverage of the catalysts with a given VOC molecule, temperature-programmed desorption (TPD) experiments would be carried out. The catalyst samples would be characterized by TPD in a flow reactor system, passing a stream of nitrogen over a VOC covered catalyst while ramping up the temperature. From these experiments, we would be able to establish the types and relative strength of adsorption sites on the catalyst surfaces. The mechanistic information provided by the TPD studies was primarily based on the transient response of the system to a linear increase in temperature and was contained in the details of the desorption spectra collected during the temperature ramp.

The outcomes of this studied can significantly add to better fundamental understanding of high-temperature-catalytic oxidation and combustion processes. The work proposed will add important background data about adsorption of VOC molecules on Pt catalysts as a first step to understanding the mechanistic aspects of catalysts for VOC emissions control, thereby making a key contribution to environmental issues.