CHAPTER I
INTRODUCTION

In recent times, the demand and cost of petroleum based fuel is growing rapidly, and if the present pattern of consumption continues, these resources will be eventually depleted. In addition, general concern about the protection of the environment and the conservation of non-renewable natural resources, has given rise to the development of alternative energy sources as substitutes for traditional fossil fuels. An alternative fuel must be technically feasible, economically competitive, environmentally acceptable, and readily available. In this perspective, biodiesel may be significant in replacing petroleum diesel because of its environmental benefits and the fact that it is produced from renewable sources. Since biodiesel has properties similar to petroleum based diesel fuel, it can be used directly or mixed with conventional fuel for diesel engines with no modification, and as a heating fuel (Ma and Hanna., 1999).

Biodiesel (fatty acid methyl esters) is the monoalkyl esters of long chain fatty acids derived from renewable feed stocks, such as vegetable oil or animal fats, for use in compression ignition engines. Biodiesel is synthesized from direct transesterification (also call alcoholysis) of vegetable oil and animal fats, where the corresponding triglycerides react with alcohol such as methanol in the presence of a suitable catalyst, yielding free glycerol as a byproduct. The presence of a catalyst accelerates the conversion. The catalysts used in transesterification are of the acidic, alkali, and enzymatic type. The acidic catalysts take considerable time for complete conversion and the enzymes are economically unfavorable. Base catalysts are more economical and better for fast production of biodiesel fuel. The commonly used base catalysts are NaOH, KOH, and sodium methoxide. Nonetheless, the alkali catalyst in vegetable oil transesterification produces soaps by neutralizing the free fatty acid in the oil or triglyceride saponification. Both soap formations are undesirable side-reactions, because they partially consume the catalyst, decrease the biodiesel yield, and make the separation and purification steps more difficult. These problems could be eliminated by using heterogeneous catalysts because these do not pose the problem of soap formation. Therefore, separation processes are simplified because separation of heterogeneous catalysts is easier, there is no waste of catalyst from the washing step, and potentially it leads to a cheaper production cost (Vicente *et al.*, 2004).

The research problem address in this work is the evaluation of the catalytic activity of an organic base with potential for heterogenization and an alkaline earth metal oxide. The performance of these catalysts will be compared against the behavior of a typical industrial catalyst such as sodium methoxide. The catalyst efficiency was examined based on the conversion of canola oil to methyl esters. The quality of the biodiesel produced was also evaluated trough the determination of soap content. The goal is to establish the optimum reaction conditions for the production of high biodiesel yield as a function of catalyst type and concentration, excess reagent, temperature, and biodiesel quality. This overall research problem can be broken down into three sub problems as follows.

1. To compare the catalytic activity of heterogeneous catalysts with sodium methoxide ($NaOCH_3$), which is a typical industrial catalyst.
2. To develop heterogeneous catalysts based on organic bases and/or oxide metal complexes that would allow the production of biodiesel at practical reaction conditions for commercial application.
3. To study the synergistic effect of heterogeneous catalyst combinations (generation of multiple basic catalytic sites) by using animal shells on the transesterification reaction yield, conditions, and reaction time. The heterogeneous catalyst that will be evaluated in this study are Strontium Oxide (SrO), and 1,5,7-triazabicyclo[4.4.0]dec-5-ene (TBD), which is an organic base with potential for heterogenization.

The transesterification reaction was carried out using various heterogeneous catalyst concentrations, different methanol to oil molar ratios, and several reaction conditions for the transesterification of raw canola oil. The progress of the reaction was monitored by ^1H NMR spectroscopy. The conversion of the canola oil to a mixture of methyl esters were determined by the ratio of the signals at 3.70 ppm (methoxy groups of methyl esters) and 2.30 ppm (carbon CH_2 groups of all fatty acid derivatives) (Gelbard G. *et al.*, 1995).

The working hypotheses of this work are:

1. The stronger the basicity of the catalyst used the higher the biodiesel yield. The use of the catalysts such as Sodium methoxide ($NaOCH_3$), 1,5,7-triazabicyclo[4.4.0]dec-5-ene (TBD) and Srontium Oxide (SrO) in that order of basicity strength from lower to higher will allow high catalytic activity for biodiesel production.
2. The synergistic effect of using heterogeneous catalyst combinations and animal shells such as shellfish and eggshell will improve the transesterification reaction yield at practical reaction conditions.

The main objectives of this project are twofold. The first objective is the establishment of the effect of the catalyst type, catalyst amount, excess reagent, and temperature on the yield and quality of biodiesel. The second objective is to study the synergistic effect of heterogeneous catalyst combinations on the transesterification yield, conditions, reaction time, and product quality.