CHAPTER I
INTRODUCTION

During 2008 and the beginning of 2009 the price of petroleum based fuel was unbelievable high due to the increasing worldwide energy consumption. If the rate of oil consumption does not change, this resource will not be enough to fulfill the worldwide energy demand. This critical problem has boosted the development of alternative fuels from renewable sources in order to substitute the traditional fossil fuels. Alternative fuels have some characteristics such as being economically competitive compared to conventional fossil fuels, environmental friendly, and ready to use, that have increased the interest for their use as alternative fuels. The worldwide demand of petroleum based diesel was 763,623 million liters in 2005 (International Energy Agency (IEA), Statistics Division, 2007). The price of diesel follows the same trend of crude oil prices. So that, as the price of crude oil increases, the price of diesel fuel increases (Energy Information Administration, 2008). For these reasons the cost-effective production of biodiesel could replace significant consumption of petro diesel. In addition, biodiesel has several environmental benefits compared to petro diesel since it is produced from renewable sources such as vegetable oils, animal fats, and waste cooking oils. The fuel properties of biodiesel are similar to the conventional diesel. Biodiesel can be used directly or mixed with fossil based diesel at different ratios in traditional diesel engines (without engine modification), and can also be used as a heating fuel (Ma and Hanna., 1999).

Biodiesel (fatty acid methyl esters or fatty acid ethyl esters depending on the kind of alkyl group present) is the mono-alkyl ester of long chain fatty acids derived from renewable feedstock, such as vegetable oils or animal fats. Biodiesel is synthesized from direct transesterification of vegetable oils and animal fats, where the corresponding triglycerides react with alcohol such as methanol or ethanol in the presence of a suitable catalyst, yielding free glycerol as a byproduct. The presence of a catalyst accelerates the reactions (Srivastava and Prasad., 2000).

There are several catalysts that can be used in the transesterification reaction such as homogeneous and heterogeneous catalysts. Homogeneous catalysts are those that are soluble in the alcohol phase such as the acidic, basic, and enzymatic types. In

the case of heterogeneous catalysts, these are solid compounds that are not or slightly soluble in the methanol phase, such as Calcium oxide (CaO), Magnesium oxide (MgO), and Strontium oxide (SrO). The acidic catalysts take considerable time to complete the conversion of the vegetable oil to biodiesel and the enzymatic catalysts are economically unfavorable. Basic catalysts are more economical and better for fast biodiesel production. Sodium hydroxide (NaOH), potassium hydroxide (KOH), and sodium methoxide ($NaOCH_3$) are the most used base catalysts. The downside of the basic catalysts is that during the transesterification reaction they also produce soaps as undesirable products by neutralizing the free fatty acid contained in the vegetable oil or triglycerides called "saponification reactions". Soap formation is an undesirable side-reaction, because it partially consumes the catalyst decreasing the biodiesel yield and making the separation and purification steps more difficult, which is translated into higher costs of biodiesel production. The main advantages of using heterogeneous catalysts are that there is no or less soap formation, which makes the biodiesel purification easier; there is no waste of catalysts because it can be easily separated by filtration, and catalyst reusability, which potentially leads to a cheaper production cost of biodiesel (Vincente *et al.*,2004).

The main goal of this work is the development of cost-effective heterogeneous catalyst formulations highly active at low reaction temperatures. The optimization of biodiesel production at mild reaction conditions is the ultimate goal of this study. In this work, the transesterification reaction will be carried out using fixed methanol to oil molar ratios to 6:1, various catalyst concentrations, and several reaction temperatures using canola oil (**Can**adian **o**il, **l**ow **a**cid or known as "LEAR" oil for **L**ow **E**rucic **A**cid **R**apeseed). The progress of the reaction will be monitored by ^{1}H-NMR spectroscopy. The organic phase will be separated by decantation, dried with anhydrous sodium sulfate and submitted to the NMR analysis in $CDCl_3$.