CHAPTER I

INTRODUCTION

1.1 Statement of problem

The oil crisis nowadays does not only directly affect the energy industry but it also shows the strong influence to petrochemical industry due to high cost and shortage of raw materials supplied for polymer production. Therefore, there are many attempts to develop the technology to produce polymer from other routes besides those from petrochemical routes. Polylactide (PLA) is one of the polymers, which can be derived from agricultural resources such as corn, cassava, and potato by mean of fermentation to produce lactic acid. The basic building block of PLA is lactic acid, which is a chiral molecule and exists as the two isomers, L-lactic acid, and D-lactic acid. Depending on the monomers, poly(L-lactic acid), poly(D-lactic acid), poly(D,L-lactic acid) and their copolymers can be formed but until now poly(D-lactic acid) and its copolymers have found no commercial interest due to their low molecular weight. The structure of PLA is shown in Figure 1.1

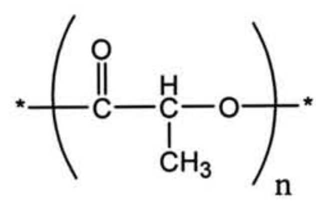

Figure 1.1 Structure of polylactide or poly(lactic acid).

PLA is a well-known biodegradable polymer, which has wide range applications in the biomedical, textile, and packaging fields. In medical area, PLA can be used for suture, prothesis, controlled release, and tissue scaffold [1-4]. PLA textile can be found in shirts, tags, pillows, mattresses, and duvets. In addition, PLA can be used to produce biodegradable containers such as retailed bags, disposable caps, and agricultural mulch film; thus, helps saving the environment.

Bulk polymerization is a one phase reaction which provides pure PLA. Bulk polymerization can be classified into polycondensation [5] and ring-opening polymerization (ROP) [2, 6-10]. In polycondensation method, heat is used to polymerize lactic acid to PLA. However, this process produces low molecular weight PLA. On the other hand, ROP always use catalyst to open L-lactide ring and polymerize to high molecular weight PLA.

Table 1.1 Advantages and disadvantages of two methods.

Polycondensation	Ring-opening polymerization (ROP)
Less expensive	Expensive
No need to use catalyst	Using catalyst to open ring
Low molecular weight	High molecular weight
Impure polylactic acid	Pure polylactic acid
Unable to control stereospecific	Able to control stereospecific

ROP process can be classified into three mechanisms, cationic polymerization, anionic polymerization, and coordination insertion polymerization [10]. Among the 3 methods, coordination insertion polymerization produces the highest molecular weight of PLA using heavy metal as a catalyst. It is expected that the molecular weight of final PLA product should be approximately 100,000-300,000.

According to the applications, high molecular weight PLA is widely used for packaging, thermoplastic, textile, fiber forming material, and tissue scaffold. Whereas low molecular weight PLA can be used in biomedical area such as for controlling drug release [2].

According to the wide range applications of PLA, each product made from PLA requires a specific PLA property. For example, food packaging industry requires water and heat resistant PLA. PLA required in phamaceutical and medical applications needs to be non-toxic [2, 4]. Therefore, specific reaction condition needs to be determined to produce various types of PLA for various applications.

1.2 Objective of study

To synthesize L-lactide and to use coordination insertion polymerization method for ROP of L-lactide to produce high molecular weight PLLA. Chain extenders were used to further increase molecular weight of PLLA. In this research, relevant process parameters including type of catalysts, temperature, synthesis time and the ratio of PLLA to chain extender were studied.

1.3 Scope of the investigation

1. To synthesize L-lactide using toluene-4-sulfonic acid monohydrate or stannous (II) 2-ethylhexanoate as an initiator.

2. To produce polylactide by ring-opening polymerization of L-lactide.

   Parameters studied:

   - Type of initiators (stannous(II) 2-ethylhexanoate or creatine hydrate)
   - Reaction time
   - Reaction temperature

3. To further increase molecular weight of poly(L-lactic acid) using chain extender, those are:

   - 1,6-Hexamethylene diisocyanate (HMDI), M.W. = 168.2
   - Tolylene 2,4-diisocyanate terminated poly 1,4-butanediol prepolymer, M.W. = 900

   A parameter studied:

   - Ratio of PLLA to chain extender