CHAPTER I

INTRODUCTION

1.1 Synthesis of silver nanoparticles

Synthesis of silver nanoparticles is an interesting topic because of the special size-dependent properties of silver nanoparticles such as physical properties, optical properties, and thermal properties [1]. Silver nanoparticles have been used in many applications in different areas of science such as catalysis [2], optical sensors [3-4], electronic devices [5], and antibacterial agents [6-7]. This study will focus on synthesis of silver nanoparticles in mass-scale production because there are many industries that using silver nanoparticles as an antibacterial agent in their commercial products such as textiles, fibers, medical devices and food packaging [8-10]. The antibacterial activity of silver nanoparticles is depending on the amount, size, shape, and surface properties of particles [11-12]. The smaller particles with weakly-bound stabilizer show the greater antibacterial activity [13]. Therefore, it is important to develop a method for synthesizing silver nanoparticles that can control their size, shape, and size distribution without any stabilizer. This specific method should also easily to scale-up to a mass scale production. Furthermore, this method should be a clean and environmental friendly due to an increasing interest on the topic of green chemistry in chemical processes [14].

There are many methods for synthesizing silver nanoparticles. Generally, the synthesis methods were divided into two approaches i.e. top-down and bottom-up or largely define as chemical method and physical method, respectively. The most common one is the chemical reduction method. This method involves the reduction of silver salt by a reducing agent with the present of stabilizer or capping agent. The common reducing agents are sodium borohydride, sodium citrate, alcohol, ethylene glycol, and aldehyde (i.e., formaldehyde and reducing sugar) [15-19]. A strong reducing agent such as sodium borohydride yields small size nanoparticles with a narrow size distribution. A weak reducing agent leads to a slower reduction rate. As a result large size particles with a broad size distribution are yielded. Syntheses of silver nanoparticles by chemical methods were largely developed in liquid phase contain stabilizer for controlling particle to particle interaction. However, these methods have many impurities such as the reducing agent, stabilizer, and by-product which require a process of purification. On the other hand, the physical method such as spray pyrolysis [20] and inert gas condensation [21] are generally cleaner. Moreover, these methods are continuous process which is more favorable in industrial scale production [22].

In this work, silver nanoparticles were synthesized by thermal reduction of sprayed silver salt. This method is based on the reduction of silver salt by a reducing agent in spray pyrolysis condition. The use of reducing agent will decrease the reaction temperature from around 600-900 ^{o}C to 100-150 ^{o}C. In this method the reaction occurs inside a micro-reactor droplet, hence one particle per drop was generated. As a result, the particle size can be controlled using no stabilizer. The composition was varied in order to produce small silver nanoparticles with a narrow size distribution. This procedure is a continuous process that can be easily verified for mass scale production.

1.2 The objectives

The objectives of this research are to develop a new method for synthesis of silver nanoparticles which can control particles size and size distribution, easily scale-up to mass scale production, and obtain the stable silver nanoparticles without stabilizer. The synthesis route should be environmental friendly. Factors that affect on size, size distribution and morphology of particles were the concentration of silver nitrate, reducing agent, temperature, aerosol droplets size which generate from nebulizer, and carrier gas type. Size, size distribution, and morphology of synthesized silver nanoparticles were investigated by UV-Visible spectroscopy (UV-Vis) and Transmission electron microscopy (TEM).

1.3 Scopes of research

1. Design and invent an apparatus for synthesis of silver nanoparticles by means of thermal reduction of sprayed silver salt and find an optimal condition.
2. Study the effects of concentration of silver nitrate, reducing agent, temperature in tubular reactor, aerosol droplets size, and carrier gas type on size, size distribution and morphology of synthesized silver nanoparticles by thermal reduction of sprayed silver salt method.
3. Characterize size, size distribution and morphology of synthesized silver nanoparticles using UV-Visible spectroscopy and Transmission electron microscopy.
4. Study the stability of synthesized silver nanoparticles.