CHAPTER I

INTRODUCTION

1.1 General introduction

Nanotechnology relates to a wide range of technologies that incorporate materials feature with a range of dimensions between approximately 1 and 100 nm. Nanoparticles, particles in nano scale, are a part of nanotechnologies claimed to substance, such as silver, iron, gold, and nanotubes (nano-scale carbon) (Kaiser et al., 2008; Savage and Diallo, 2005). The nanoparticles have been incorporated in numerous consumer products. Silver nanoparticles (AgNPs) are one of the most well-liked nanoparticles utilized in the world. It is known as the antimicrobial agent. In industrial sector, AgNPs were broadly utilized in products, such as bicycles frames, plastic containers, drug delivery, and textiles (Nanohorizon, 2007; Yang et al., 2005; Hong et al., 2006; Benn and Westerhoff, 2008). Although there has not been the published document of AgNPs contamination levels in the environment, the trend of AgNPs utilization significantly increases. Nearly one-third of AgNPs products on the market in 2007 had the potential to disperse into the environment. A few information of the adverse effect of AgNPs were presented. Consequently, in the near future, the contamination of nanomaterials especially AgNPs would be a problematic issue in surface water, soil, groundwater, or wastewater treatment systems.

It has been known that silver nanopaticles affected on microorganisms. Antimicrobial achievement of silver nanoparticles has been assumed to its surface oxide layer release of silver ion species which is highly toxic to organisms (McGeer, 2000; Fan and Bard, 2002). It is also known that silver is toxic to cell because it can destroy or attach to cell membrane resulting in inhibition in growth or effect on viability (Lok et al., 2006; Choi et al., 2008). Nonetheless, most of previous studies were focus on effect of silver particles in micro scale. There were only a few reports on effect of AgNPs (Lok et al., 2006; Choi et al., 2008). Silver nanoparticles could penetrate though cell membrane and cause more 100-time severe effect to the cells (Lok et al., 2006).

As mentioned earlier, biological wastewater treatment system would be critically affected by AgNP contamination. Nitrification is known as the most sensitive process among wastewater treatment processes. The nitrification process is an important process for removing nitrogen from wastewater treatment plants (WWTPs). It is a biological transformation of reduced forms of nitrogen to nitrate by nitrifying activated sludge (NAS). In prior study, it was found failure in nitrification process (Choi et al., 2008). The nitrification decreased up to 86±3%. Although there are a few studies on fate and toxicity mechanism of AgNPs in wastewater treatment systems, there was no such the problem abatement of AgNPs in the systems.

Cell entrapment technique, microorganism immobilization in a porous polymeric matrix, is a potential method to alleviate the problem. The technique was used in pollutant removal such as, nitrogen, carbon, herbicide and other hazardous substance in wastewater and contaminated sites (Chen et al., 1998; Siripattanakul et al., 2008). The polymeric materials widely used as cell entrapment matrices were calcium alginate (CA), polyvinyl alcohol (PVA), carrageenan (CN), and cellulose triacetate (CTA) (Siripattanakul and Khan, 2010). The entrapment matrices can increase biological activities and protect the cells from toxic substances (Chen et al., 1998; Siripattanakul et al., 2008). Based on the advantages, the technique is promising to lessen the problem.

This study aims to investigate effect of AgNPs on the nitrification process and to protect toxic substance from microorganisms using cell entrapment technique. Effects of initial AgNP concentrations, entrapment material types (CA and PVA), and bead sizes (small and large beads) of the entrapped NAS on the nitrification kinetics were conducted. The free NAS was tested for comparative purpose. The nitrification kinetics in the present study was used respirometric approach followed the previous studies (Surmacz-Gorska et al., 1996; Ginestet et al., 1998; Schramm et al., 1998; Chandran and Smets, 2001; Moussa et al, 2003; Ciudad et al., 2006; Chandran and Love, 2008).

1.2 Objectives

Main objective of this study is to investigate effect of AgNPs on the nitrification process using entrapped cells compared to free cells. The specific objectives are:

1. to examine effects of AgNP and initial ammonia at different concentrations on nitrification performance,
2. to examine effect of cell entrapment matrices (different sizes and types) on nitrification performance of the entrapped NAS that was exposed by AgNPs, and
3. to observe interaction of AgNPs on the free and entrapped NAS microstructure.

1.3 Scopes

This study has been held at the environmental laboratory, National Center of Excellence for Environmental and Hazardous Waste Management (NCE-EHWM), Chulalongkorn University since September 2008. It is expected to complete all tasks in September 2010. The experiment was in a bench-scale experiment. The following details are the specific informations on the scope of study.

1. Returned activated sludge used in the study was taken from returned activated sludge at Siphraya municipal wastewater treatment plant, Bangkok, Thailand.
2. The NAS was enriched from the returned activated sludge at 28 and 70 mg/L of ammonia concentration.
3. Respirometer was used for studying nitrification.
4. Silver nanoparticles were varied at 0.5, 1, and 5 mg/L.
5. The NAS was entrapped using CA and PVA entrapment techniques.
6. The entrapped cell sizes of 3 and 6 mm were tested.
7. Microstructure of cells was observed using Scanning Electron Microscope (SEM) and Transmission Electron Microscope (TEM).

1.4 Hypotheses

1. Entrapped cells perform better than free cells on nitrification with AgNP contamination.
2. Both CA- and PVA-entrapped cells were protected from AgNPs. The PVA-entrapped cells are more effective because the matrix structure is more suitable for the cell protection from AgNPs.
3. The large entrapped cells perform better than the small entrapped cells. Thicker matrix provides lower contact of AgNPs to the microbial cell leading to lower cell damage.