CHAPTER I

INTRODUCTION

1.1 Statement of Purposes

Hospitals use toxic chemicals and hazardous materials for many diagnostic and treatment purposes. Some of those materials become parts of their waste streams such as chemotherapy and antineoplastic chemicals, formaldehyde, radiographic chemicals, radionuclide, solvents, mercury, waste anesthetic gases, and other toxic and corrosive chemicals (U.S.EPA, 1990).

Radiographic waste is associated with image processing at hospital radiology departments that contains processed radiographic films, photographic solutions, and spilled chemicals. These wastes are classified as "hazardous" due to their heavy metal contents. Similar to other countries, Thailand has recognized that certain wastes from the production, formulation, and the processing of photographic chemicals e.g., water-based developers and activator solutions, water-based offset plate developer solutions, solvent-based developer solutions, fixer solutions, bleach solutions and bleach fixer solutions, wastes containing silver from on-site treatment of photographic wastes, and aqueous liquid waste from on-site reclamation of silver, are defined as hazardous wastes by the Ministerial Notification of the Ministry of Industry [B.E. 2548 (2005)] issued pursuant to the Factory Act B.E. 2535 (1992) in Appendix 1 Waste Code No. 09 (Department of Industrial works, 2005).

Radiographic film is a polyester sheet coated on both sides by radioactive material, which is sensitive to light. It is generally used for industrial purposes and medical and dental services. Approximately 2 billion radiographs (sheets) are taken around the world each year, including chest X-rays, mammograms, CT scans, etc. Traditionally, 94-98% of X-ray films are used in medical services (Gambhir, 2004). During the image developing process, a part of the silver compounds is removed from the film. Several waste streams are generated in hospital radiology departments, such

as wastewater containing photographic chemicals, scrap films, spent developer solution, spent fixer solutions, and spilled/spoiled chemicals.

Up to date, only a few researchers have reported on silver cycles (Johnson, 2005; Lanzano, 2006). They have, however, discussed the presence of silver cycles in commodities of the industrial sectors rather than those from medical applications. Due to the fact that silver is toxic when presents in the environment, emissions of silver through spills and solid wastes is, therefore, of great concern. To reduce contamination of silver in the environment, the best way of environmental management practice, when a reuse technique is no longer applicable, is recycling or recovery of this precious material. Various available technologies can be applied to recover silver from the valuable waste streams and/or to treat certain radiographic wastes prior to disposal. There is adequate evidence about silver recovery from used films and spent fixer/developer solutions.

In Thailand the photographic wastes are managed by a market drive rather than by an environmental concern. Although silver has extensively been recovered from used film sheets and spent fixer solutions; other waste streams, especially a second generation waste from recovery processes, are poorly managed. In a view of an integrated management, there are many related laws and regulations from several authorities, which are overlapped or leave an empty space for state (legal) monitoring of the movement of the wastes. Apparently, setting-up an appropriate management system of radiographic waste from cradle to grave is necessary to avoid adverse effects on environment, public health, and public welfare.

The aims of this study are to investigate the current situation and a material flow analysis of silver in radiographic film, and to propose silver recovery process in order to technically support the development of the radiographic waste management system in Thailand.

1.2 Research Objectives

The major objective of this research is to develop the strategic development of the radiographic medical film management system. This research is divided into two sections; the technological part and the management part. The sub-objectives are as followed:

1.2.1 Technological Part

1) To study and to investigate 5 major operating parameters that effect on efficiency of acid leaching technique of silver from radiographic medical film i.e., film size, temperature, retention (leaching) time, acid type, and acid concentration.

2) To explain reaction/mechanism of silver leaching from silver sludge at optimal condition by analyzing of sludge morphology using XRD and SEM-EDX techniques.

3) To conduct a comparative evaluation of CO_2 emission between the proposed leaching technique and the existing technology used in Thailand.

1.2.2 Management Part

1) To formulate a material flow analysis of radiographic medical film.

2) To investigate the current roles and responsibilities of key stakeholders, viz. waste generators, waste dealers, waste processors, and waste regulators, in the radiographic medical waste cycle in Thailand.

3) To evaluate deficiencies in the radiographic medical waste cycle.

4) To establish a fact sheet to assist the development of radiographic medical film management system.

1.3 Scopes and Limitations of the Study

The following research work was carried out.

1.3.1 Development of a green technology for recovery of silver, in particular, from radiographic film.

1.3.2 Survey and investigation of radiographic waste flow focusing on hospitals (waste generators), waste dealers (or transporters), waste processor, and waste regulators.

1.3.3 Estimation of CO_2 emission as a decision tool to determine and classify a green (environmental-friendly) silver recovery technology from used radiographic medical film.

1.4 Hypotheses

1.4.1 Problem identification of all stakeholders can be used as an initiative of the development of systematic radiographic medical film management.

1.4.2 Chemical leaching recovery process based on the concept of "Green chemistry" should be able to demonstrate a more efficient and feasible recycling option for used radiographic films.

1.5 Expected Outcomes

1.5.1 Hazardous waste management: a conceptualized policy to be applied for radiographic waste management system.

1.5.2 Clean technology: the introduction of an alternative recovery method of used radiographic films by means of a green chemistry leaching technique.

This dissertation includes 5 chapters as the followings.

Chapter 1 introduces the objectives, hypotheses, scopes, limitations, and expected outcomes of this research.

Chapter 2 is an overall review which explains the background of the radiographic wastes (i.e., films and spent fixer/developer solutions) from their origins to final destinations (i.e., import, uses, recovery, treatment and disposal) from a number of references.

Chapter 3 focuses on the experiment to develop a green chemical (less polluted) leaching process for recovery of silver from radiographic medical wastes focusing on used X-ray film, when compared with other available techniques and, particularly, with the existing combustion technology in terms of CO_2 emission.

Chapter 4 reports about present situation radiographic waste in Thailand focusing on a material flow analysis and the overlapped jurisdictions of related government authorities. This chapter also proposes a structured fact sheet and, in particular, a future system for radiographic medical waste management.

Chapter 5 gives concluding results of this research. The technology aspect discloses how the green chemical leaching process could be introduced as a cleaner technology for recovery of silver from radiographic film. While the management aspect reveals the necessity to consider and the possibility to implement the radiographic medical waste management system in Thailand. The recommendations how to manage the downstream wastewater from the green process are cited and the future work to scale up the experimental research to a pilot unit for commercial purpose is suggested.