CHAPTER I

INTRODUCTION

1.1 Statement of Problem

With the rapidly expanding uses of nuclear energy , the problems of control of radioactive waste products become more acute. These include a variety of low-and intermediate-level radioactive wastes. The major areas where these wastes arise are from nuclear medicine, therapy, agriculture and research efforts. Waste materials resulting from these activities contain quantities of radionuclides sufficient to present potential health risks to people and the environment if they are not adequately managed.

Although, the quantities and varieties of radioactive liquid wastes have generally been increasing in Thailand, they are presently under adequate control. The liquid wastes are mainly from the nuclear reactor of the Office of Atomic Energy for Peace (OAEP). The technetium-99 and cesium-137 liquid wastes generated from the nuclear reactor have gained interest because of their solubility and mobility in aqueous systems, and their long physical halflife, 2.15×10^5 years for technetium-99 and 30 years for cesium-137.

Under the pressure of limited time, the major effort in addressing the problem has been directed toward the adaption of known techniques in chemical processing and waste water treatment. One of the most attractive techniques, particularly from considerations of efficiency and volume reduction, is the use of ion-exchange processes.

In some cases, radionuclides are sorbed from waste by natural or artificial media at decontamination factors exceeding 10^3. Large varieties of ion-exchange materials are available in different physical forms with a wide range of capacities.

Many nuclear facilities throughout the world have included ion-exchange techniques in their radioactive waste control programmes. Advantages of selected materials and methods have often determined ion-exchange as the most economically feasible waste control tool.

Adequate management of radioactive wastes involves a series of steps from the arising of the wastes to their safe disposal, including collection, segregation, treatment, conditioning, transport, interim storage and disposal. Each step is defined by the need to accommodate to the preceeding one and to facilitate the ones that follow.

One key step is that of conditioning the wastes to transform them into stable and solid forms suitable for storage, transportation and disposal. Ideally, it would be desirable that the waste forms remain essentially stable throughout the hazardous life-times of the radionuclides. However, depending on the half-life of the radionuclides, this is not always technically or economically feasible and the selection of processes for waste immobilization is frequently a balance of economic and reliability factors versus a combination of short and long term ojectives.

The conditions for disposal of low and intermediate level radioactive wastes are particularly important considerations to ensure the health and safety of the environment. Cementation has been the most extensively used conditioning media throughout the world for the past 45 years. Some of the main reasons for using cement are availability, low cost, the ability to incorporate aqueous wastes, and process simplicity.

The development of waste form performance criteria and testing methods are also necessary to ensure the long-term durability of the waste forms in storage and disposal.

1.2 Objective

1.2.1 To develop processes for the treatment of radioactive cesium-137 and technetium-99 in liquid wastes, by inorganic ion-exchange techniques.

1.2.2 To study the immobilization process for conditioning of radioactive wastes by cementation.

1.2.3 To decrease the economic cost of liquid waste treatment.

1.3 Scope

1.3.1 A study of suitable inorganic ion-exchangers such as titanium dioxide, kaolinite, zeolite, hydrated antimony pentoxide (HAP), antimony pentoxide, bentonite, sand and sandy soil for the treatment of low-level radioactive cesium-137 and technetium-99 in aqueous wastes.

1.3.2 An investigation of the effect of time, pH, temperature and optimum ratio of ion-exchangers to waste solutions.

1.3.3 Basic study of immobilizing process by cementation

1.3.4 Basic study of the pertinent properties of waste forms.

1.3.4.1 Physical Stability

1.3.4.2 Compressive Strength

1.3.4.3 Leachability

1.4 Literature Search of Previous Work

The study of inorganic ion-exchangers has in the past been over shadowed by a much greater interest in organic ion-exchange resin. However, records indicate that the phenomenon of inorganic ion-exchange, though not recognized as such, served the earlier civilizations as far back as Aristotle(Miller,1965) for purification of sea and polluted waters using sand filters. Little is heard then until the writing of Sir Francis Bacon who described purification by passage of salt water.

The clay of the pots apparently deionized the water. Natural exchange was investigated in the early nineteenth century by Sir Humphrey Davy, Lambuschini, Huxtable (Way, 1850), Liebig(1855), Thompson(1850), Graham, Esprit and Fuchs (Liebig,1855). Most authorities agree, however, that the English agriculturist Thompson (1850) was the first to actually recognize the"base exchange" phenomenon and to publish descriptions. The study, in which calcium and ammonium ion were exchanged,was thoroughly investigated (Kunin, 1958). This great contribution was investigated by many others, but it was not until later that the understanding of ion-exchange was materially increased. Lemberg (1870) reported on experiments which demonstrated the stoichiometry and reversibility of this phenomenon. Lemberg and Wiegner(1912) identified natural ion exchangers and early efforts were made to utilize these materials in plant operations and to synthesize similar substances.

Harm and Rumpler(1903) prepared the first synthetic industrial ion-exchanger. Gans is credited with the first successful large scale industrial application. His synthetic inorganic material, of the $Na_2\,Al_2\,Si_3\,O_{10}$-Na^+ type, was applied to water softening and sugar treatment.

The volume of literature regarding ion-exchange studies appearing annually since the late 1940s' has increased tremendously.

Pratipasen M. and Mongkolphantha S.(1976) did "Study of The Utilization of Clays and Minerals for Radioactive Waste Treatment"

In June 1984, E.W Hooper presented a paper at the IAEA Technical Committee Meeting on Inorganic Ion Exchangers and Adsorbents for Chemical Processing in the Nuclear Fuel Cycle entitled "The Application of Inorganic Ion-Exchangers to The Treatment of Alpha-bearing Waste Streams".

Hooper, Phillips and Dagnall (1984) reported their experimental work on absorber preparation and performance, in a paper entitled "The Study of The Behaviour of Inorganic Ion Exchangers in the Treatment of Medium Active Effluents".

Ion-exchange is now firmly established as a unit chemical process, a chemical engineering tool on an even par with such processes as evaporation, distillation and precipitation. This process has been universally adopted for treatment of radioactive wastes generated at nuclear power plants and other facilities.

It is anticipated that the work accomplished in this study will further contribute to the understanding and applications of ion-exchange processes in the field of nuclear waste.