CHAPTER I
INTRODUCTION

Removal of heavy metal ions from waste management due to their severe toxicity to all living organisms together with human. The accumulation of heavy metals in the environment still remains an unsolved problem in several developed and developing countries (Harmens *et al.*, 2004) including Thailand (Patungtod *et al.*, 2006).

Many treatment techniques are now available for removing heavy metal ions from aqueous solutions. They include chemical precipitation, solvent extraction, ion exchange, membrane processes, and electrowinning. However, these techniques are not considered to be economically possible for treating large volumes of wastewaters containing heavy metals at low levels due to the high operational cost, which results from large volumes of chemicals and/or high energy consumption (Gupta *et al.*, 2000; Kurniawan *et al.*, 2006). Lime precipitation has been found to be one of the most effective heavy metal removal techniques, if the heavy metal concentration is higher than 1000 mg/L; however, it still requires a large amount of lime and produces a large quantity of residue (Kurniawan *et al.*, 2006). Solvent extraction treated a large volume of dilute wastewater, which this leads to the loss of the solvent and the high cost of the energy (Fillipi *et al.*, 1998). In ion exchange, the resins used are sensitive to fouling by high suspended solids and an initial metal concentration greater than 100 mg/L is required to achieve complete removal (Kurniawan *et al.*, 2006). Although electrolytic processes have a great advantage of the possibility of the metal recovery in a pure solid form, most of them are ineffective at low heavy metal concentrations due to the low mass-transfer rate, leading to high energy consumption (Elsherief, 2003). Although membrane processes are technically appropiate for treating dilute waste solutions, their permeability decreases over the time due to the membrane fouling. As environmental regulations tighten, new techniques are needed for removing metal ions from a dilute wastewater as a polishing step after the conventional separation process (Qu *et al.*, 2009; Doyle, 2003; Fang and Yang, 2010).

In removing trace heavy metal ions from a dilute wastewater with large volume, ion flotation or ion foam fractionation appears to be particularly promising (Wang *et al.*, 2008; Doyle, 2003; Perry and Green, 2007). The foam fractionation of ions called "ion foam fractionation" is similar to ion flotation but uses an excess of surfactant or a proper bubbles to produce stable foam (Rubio *et al.*, 2002). Ion foam fractionation was found to offer high metal removal (≈100 %) at a low feed metal concentration (50 mg/L) with both low chemical and energy costs (Kurniawan *et al.*, 2006). Foam fractionation is based on the selective adsorption or attachment of materials onto the surfaces of foam or froth generated by gas bubbles rising through a solution (Prudich, 2007). This process offers many advantages for the treatment of industrial wastewaters compared to other treatment processes, including low space and energy requirements, simple plant design, operation, and scale-up, and low capital and operating costs (Wong *et al.*, 2001).

The main problem of ion foam fractionation is that nearly complete removal (>99 %) always yields a large volume of foamate with a low heavy metal enrichment ratio while dry foam always comes with low heavy metal removal efficiency (Qu *et al.*, 2008; Scorzelli *et al.*, 1999; Polat and Erdogan, 2007). Only one study focused on process design to reduce the interstitial liquid or liquid hold-up in the foam (Kinoshita *et al.*, 2007). The separation efficiency of multistage foam fractionation for the recovery of cetylpyridinium chloride (CPC), a cationic surfactant, from water was found to be much higher than that in a single-stage system, especially in terms of the enrichment ratio and % recovery of the CPC (Boonyasuwat *et al.*, 2005). Further development of ion foam fractionation equipment and processes is still needed to improve the separation efficiency by reducing liquid hold-up in the foam without causing foam collapse. Removal of Cadmium ions (Cd^{2+}) from simulated wastewater by multistage ion foam fractionation was found to be a promising technique for high heavy metal removal (more than 99%) for a feed having a low heavy metal concentration in the ppm (mg/L) level. In this study, a continuous multistage foam fractionation with bubble-cap trays was competitive removed mixed heavy metals from water. Moreover, the removal of heavy metals by ion flotation were studied about selectivity of separation including copper (Cu) an lead (Pb). They indicated that the lager ions are preferentially adsorbed because their outer secondary hydration water molecules are more easily to be lost when interacting with the anionic surfactant adsorbed at the interface (Zhendong Liu *et al.*, 2000).