# CHAPTER 1

# INTRODUCTION

Phenol and phenolic compounds are commonly found in effluents from industrial operations such as petroleum refineries, phenol - formaldehyde resin manufacture, plastic and varnish industries, coal conversion, pulp and paper manufacturing, as well as wood preservation and metal casting (Ahmed *et al*., 1995; Bandhyopadhyay *et al*., 2001; Kumar *et al*., 2004). Phenolic compounds are toxic to aquatic life, plants and many other organisms. When phenol-containing water is chlorinated, the forming of toxic polychlorinated phenols may contributed to off flavors in drinking and food processing waters (Jiang *et al*., 2002). WHO has prescribed a concentration of 1 µg as the guideline concentration for drinking water. Thus, elimination of phenol is a necessity to preserve environmental quality and maintain the general well being of the public.



Phenol can be removed by a number of methods such as precipitation/coagulation, osmosis, ion-exchange, ultrafiltration, electrochemical degradation, and floatation, which are costly and inefficient. These methods often produce other toxic end products which required further processing steps (Rengaraj *et al*. 2002). The aerobic biodegradation of the phenolic pollutants, are generally used as

an alternative low cost method which is able to completely mineralize the phenolic compounds (Jiang *et al*., 2004; Stephen *et al*., 2005). Numerous phenol-degrading microorganisms, such as bacteria, yeast and algae had been isolated from environments (Santos *et al*., 2001; Chen *et al*., 2004; Yang and Lee, 2007). Among the yeasts, *Candida tropicalis* has been one of the most studied strain in phenol biodegradation (Stephenson, 1990; Juarez-Ramirez *et al*., 2001; Adav *et al*., 2007).

The overall efficiency of phenol biodegradation may be influenced by physical conditions such as phenol concentration, temperature and pH which directly affect the microbial growth on phenol (Bastos *et al*., 2000; Annadurai *et al*., 2002). The availability of nutrients such as carbon and nitrogen sources helped elevate cells tolerance towards substrate inhibition (Wang and Loh, 2000; Kotresha and Vidyasagar, 2008). In addition, the metal ions which was considered as contaminants in several industrial wastewaters also have strong effect on the phenol degradation (Sandrin *et al*., 2000). Metal ions inhibit general microbial activity but a few reports had specifically investigated the impact of these ions on biodegradation of organic pollutants (Kotresha and Vidyasagar, 2008).



A limited phenol degradation of free cells occurred, due to the toxic effect of high phenol concentration. Immobilized microorganisms were more effective to treat phenol-containing wastewater (Wu *et al.,* 2005). There has been an increasing interests in the immobilization of microorganisms in recent years (Loh *et al.,* 2000; Garcia and Pena, 2001). Immobilized cells are more advantageous than free cells as evident from increased metabolism from high cell density and enhanced permeability

of the cell walls. In addition, the beads of immobilized cells can be reused for an extend period of time (Prieto *et al.*, 2002; Chung *et al.*, 2003). Immobilization matrices increased the chance of cell survival in the environment with high concentration of phenolic compounds by providing the additional protective effect (Juarez-Ramirez *et al.*, 2001; Chen *et al.*, 2002).

**Objectives**

To investigate the phenol degradation at high concentration by free and immobilized cells of *Candida tropicalis* CMU 10.

In order to achieve this goal, the study will be carried out as follows:

1. Investigation of phenol degradation by free cells in various conditions by considering the effect of

   a. Physical factors (temperature, pH and phenol concentration)

   b. Nutritional factors (glucose, organic acids and metal ions)

2. Investigation of phenol degradation by agar- and alginate-immobilized cells.