CHAPTER 1

Introduction

After the Industrial Revolution, the amount of CO_2 being released from many sources such as the combustion process in power plants, deforestation and transportation has been increasing. There are several different types of greenhouse gases but CO_2 is the most influential and potentially harmful gas that leads to the global warming and climate change (Pires *et al*., 2012). The Intergovernmental Panel on Climate Change (IPCC) reported that total greenhouse gas emissions increased by 78% from 1970 to 2010. It has been determined that this has been caused by rising CO_2 levels that are directly related to fossil fuel combustion and industrial processes (IPPC, 2014a).

Rising CO_2 concentrations in the atmosphere is an extremely big problem. Therefore, the initiation of strategies aimed at capturing CO_2 from various industries is both a very significant and challenging proposition. Presently, many countries are trying to find ways to reduce CO_2 emissions. The potential for low cost and effective CO_2 reduction methods that are now being investigated could be used to mitigate CO_2 emissions from fossil fuel combustion in both the industrial and transportation sectors. Among various methods being proposed to reduce CO_2 emission, the biological CO_2 sequestration method using phototropic microalgae has received widespread attention in recent years because the CO_2 fixation ability of microalgae is significantly higher than many other plants and the microalgae can use the CO_2 in the atmosphere as a carbon source under the photosynthesis system to produce biomolecules in their cells (e.g. carbohydrates, proteins and lipids) (Yoo *et al*., 2010; Goswami *et al*., 2012).

Moreover, the lipids produced by microalgae can be substituted as a raw material for biodiesel production. For example, *Botryococcus braunii* could produce hydrocarbon up to 25-75% of its dry weight. Moreover, green microalgae *Scenedesmus* sp. and *Chlorella* sp. display lipid content in their cells at up to 12-40% and 28-58% of their dry weight, respectively (Miao and Wu, 2004; Metzger and Largeau, 2005; Chisti, 2007; Parker, 2010). The findings regarding other benefits of using microalgae to produce biodiesel are also note-worthy, such as the fact that microalgae do not require a large area for cultivation, are easily cultured, are capable of growing quickly, and can be grown in any type of water body in which sunlight can be reached and by adding a few simple nutrients and aeration (Rahamana *et al*., 2011; Goswami *et al*., 2012).

Additionally, the selection of the tolerant microalgal species is very important in order to be able to use the species as bio-fixation materials and for biofuel production. Hence, several species have been tested under high CO_2-level conditions (over 15% CO_2). Ono and Cuello (2003) reported that some species of microalgae could grow under up to 40% CO_2 levels. Additionally, it was determined that *Chlorococcum littorale*, *Scenedesmus* sp., *Chlorella* sp., and *Cyanidium caldarium* could grow under 60%, 80%, 40% and 100% of CO_2 concentrations, respectively.

Most of the microalgae related to CO_2 reduction are monocultures because the specific strains have high biofixation efficiency and can be grown for the production of high value products such as lipids and pigments (Tang *et al*., 2011; Johnson and Admassu, 2013). However, cultivation of the monocultures has certain note-worthy disadvantages such as the significant amount of time needed for the purposes of screening and isolation. Also, while they are easily contaminated, they are hard culture on a large scale. Using mixed microalgae cultures can mitigate these problems because they have displayed greater levels of efficiency and have proven to be more flexible than monocultures. By applying methods of mixed populations (consortia), the following advantages can be achieved: (i) they are tolerant of harsh environmental conditions; (ii) they display marked levels of stability; (iii) they possess an ability to share metabolites; and they are able to endure attacks by other species (Haruta *et al*., 2002; Subashchandrabose *et al*., 2011). Nevertheless, there have only been a few studies focused on the utilization of mixed microalgae for CO_2 fixation and biofuel production in Thailand. In this study, a laboratory scale cultivation of the microalgal consortium (MC) has been investigated. The cultures were cultivated with high levels of CO_2 concentrations and different aeration rates for enhanced biomass production and CO_2 fixation efficiency. The growth, lipid content, carbon content and CO_2 fixation of the microalgae were also evaluated.

Typical industrial exhaust gases contain CO_2 levels ranging from 15–20% (v/v). Many researchers have suggested the use of exhaust gas as a carbon source for microalgal cultivation, which could combine biofuel production and CO_2 mitigation strategies (Brown, 1996; Yoo *et al*., 2010; Chiu *et al*., 2011; Cuellar-Bermudez *et al*., 2015). Thus, the MC was cultivated with exhaust gas contained 19% v/v of CO_2 concentration. This gas derived from a power generator supplied by biogas from chicken manure was used to evaluate the possibility of CO_2 reduction from industrial exhaust gas and for the purposes of bio-oil production derived from microalgae. Finally, the potential of microalgae cultivation with CO_2 supplementation was confirmed on the pilot industrial scale.

1.1 Objectives

1.1.1 To study the effects of CO_2 concentrations on growth, lipid production and CO_2 fixation of the microalgal consortium (MC).

1.1.2 To study the effects of different CO_2 aeration rates on CO_2 fixation efficiency of MC.

1.1.3 To study the cultivation of MC using exhaust gas acquired from a power generator supplied by biogas from chicken manure for CO_2 mitigation and lipid production.

1.1.4 To study the effects of season and CO_2 supplementation on the cultivation of the MC in an outdoor open system for lipid production and CO_2 mitigation.