Chapter 1

Introduction

1.1 Atmospheric Pressure Discharge and Its Applications

The use of atmospheric pressure discharge has been of great interest in industrial applications. With the absence of expensive vacuum system and vacuum compatibility issue, the cost of operation can be reduced to minimal. However, discharges employed at atmospheric pressure are usually associated with gas heating, electrode erosion and transformation to thermal arc discharge (Benocci *et al.*, 2004), and these disadvantages limit the development and wider usage of this technology.

The introduction of non-thermal atmospheric pressure discharge is breaching the aforementioned limitations. The thermal compatibility issue of atmospheric pressure discharge is solved by limiting the current development in the discharge to form thermal arc discharge. Many configurations and geometries of non-thermal plasma system have been studied, among which are the Dielectric Barrier Discharge (DBD), corona discharge, plasma jet (Li and Lim, 2008), and One Atmosphere Uniform Glow Discharge Plasma (OAUGDP) (Roth *et al.*, 2007).

The non-thermal DBD is employed in many industrial applications such as ozone generation (Garamoon *et al.,* 2002), surface modification of polymers, plasma-chemical vapor deposition, pollution control, excitation of CO_2 lasers, excimer lamps, and, large-area flat plasma display panels (Kogelschatz *et al.*, 1999). All of these applications utilize the active species, metastable, ions and free radicals generated within the plasma as energetic components (Wagner *et al.*, 2003). It is expected the utilization of DBD plasma for medical and biological application could make the best use of the influences of active species on biological cells.

Conventional methods of sterilization of tissue wound, cuts and medical instrument were mostly done by application of alcohol, chemicals, UV, or steam heating (for instrument and hardware). In the case of plasma involvement in medical field which has a long history, it has been limited to thermal plasma for surgical cauterization and dissection, and as coagulation media in severe surgery (Brand *et al.,* 1998). The availability of non-thermal plasma bridges the two practices and opens up the possibility for application of non-thermal plasma as sterilization agent for medical purposes. This is especially suitable for sterilizing subjects that are heat sensitive such as living tissue, and biomaterials (Ayan *et al.,* 2009).

The ability of non-thermal plasmas for biological sterilization has been demonstrated by many researchers over the past years (Laroussi, 2005a; Sun *et al*., 2007). Advantageous over convention chemical and thermal sterilization techniques, non-thermal plasma avoid unnecessary thermal heat and chemical transferred to the subject while retaining its sterilization function (Birmingham and Hammerstrom, 2000). Some of the recent research activities on these rapidly growing applications of non-thermal plasmas include rapid blood coagulator, disinfection of bacteria on living tissue, wound healing (Fridman *et al.*, 2005b), and plague treatment (Sladek *et al.*, 2004) and etc.

Hence, the interest in the study of the atmospheric DBD is driven by its numerous useful applications, especially in the medical field. This project aims to study the efficiency of the sterilization effect of an atmospheric DBD on three types of bacteria and the required operating conditions of the DBD.

1.2 Objectives of the Project

The main purpose of this research project is to assess the ability of atmospheric pressure non-thermal plasma for bacteria inactivation, including its effectivity and efficiency, effectivity measures the level of inactivation while efficiency measures the time rate of inactivation. The DBD is chosen as the non-thermal plasma source to be studied because it can be constructed with ease at low power consumption. The DBD is characterized by its electrical discharge behaviour as well as the optical emission spectrum of the plasma.

The sequence of the project carried out is as follows:

(i) Design and construction of a dielectric barrier discharge (DBD) system

The DBD is designed to work with two types of dielectric materials, namely glass and alumina. The DBD system includes a pair of circular parallel plate electrodes, one of which is movable to adjust the air gap, and a self-built high voltage supply comprising a car-coil transformer to drive the DBD.

(ii) Characterization and optimization of the plasma produced in the DBD system

The DBD is characterized by the voltage and current of the discharge. Its emission spectrum is obtained and the active species generated in the plasma are identified. The operating parameters are optimized with reference to these characteristics to produce a suitable condition for sterilization.

(iii) Investigation of the effectiveness of the plasma for sterilization and disinfection purposes

Bacteria of gram positive type and gram negative type was treated with plasma by exposing them to the discharge; the study includes the survivability of the bacteria and efficiency of the plasma for sterilizing with gradually increasing treatment time.

1.3 Outline of Dissertation

The dissertation is divided into 6 chapters. Chapter 2 explains the basics of DBD including breakdown and formation of the discharge, electrical characteristics and discharge mode. Chapter 3 presents the details of the DBD system set up, power supply circuit and monitoring tools. This chapter also includes the introduction of the target bacteria to be inactivated. Chapter 4 describes the electrical properties of the discharge as well as the optical emission from the plasma. Sterilization effects of the DBD plasma and comparison of sterilizing efficiency between different bacteria types are presented in Chapter 5. The last chapter summarizes the results and outcomes and some suggestion for future works are put forward here.