CHAPTER 1

INTRODUCTION

1.1 Thesis Motivation

At present, the finishing of textile to improve various properties of fibers and fabrics is one of the major challenge in textile industry. Wettability, fire retardancy, dyeability, easy of printing, shrink resistance, and water or oil repellence are some of the example [1, 2]. One of the most attractive properties of fabric is hydrophobicity or water repellence. Example for hydrophobicity is best demonstrated with lotus leaf. The obvious effect is that when the water droplet drops on the surface, it can stay as droplet and is not absorbed into the surface. The benefit of this effect is that when a water droplet rolls off the inclined surface, surface impurities such as dirt get loosen by the water droplet, resulting in a self-cleaning effect.

In the past, chemical treatment was the major method for finishing of textile [3, 4, 5]. However, some chemical method damage the fabric surface and also release high level of chemical substance during finishing process. Because of the increasing of ecological regulations on the textile industry, the industries are required to be more environmentally friendly during finishing of textile. Recently, the cold plasma method have advantageously replaced some of the chemical application. This is due to the minimal contamination and the high acquiring speed during plasma. Moreover, most plasma methods only produce minimal gas exhaust, hence, more environmentally friendly. In addition, the important benefit of plasma method is in the fact that plasma treatment can be controlled to avoid harmful action of plasma onto the fabric.

Many researchers have used plasma process to improve properties of fabrics. For example, Work by Kan et al. [6] used glow discharge generator model SPP-001 with nitrogen plasma to enhance the hydrophilicity, surface electrostatic properties of wool fabrics and improved the dyeing rate. Work by Yip et al. [7] used the same reactor to study the low-stress mechanical properties, air permeability and thermal properties of nylon fabrics using oxygen, argon and tetrafluoromethane plasma. Yip et al. showed that different gases and exposure time of plasma treatment can change both surface morphology and properties of fabrics. Work by Errifai et al. [8] showed that the polyamide-6 (PA6) has efficient fire retardant properties after treated by fluorinated acrylate (AC8) using microwave plasma reactor. Höcker [9] presented that the shrink-resistant properties of wool fabric can be obtained after treated by both of glow discharge under reduced pressure and barrier discharge under atmospheric pressure. Work by McCord et al. [10] studied on the hydrophobicity properties of cotton fabric using radio frequency capacitively couple plasma system with either CF_4 or C_3F_6 gas. They found that the florocarbon gas enhances the hydrophobicity of cotton fabrics. They also found that C_3F_6 plasma can increase the hydrophobicity better than CF_4 plasma. This is due to C_3F_6 plasma can generate polymers on the fabric through both plasma polymerization and plasma-induced polymerization mechanisms, while CF_4 plasma can generate only plasma polymerization mechanism.

As mentioned earlier, the finishing of textile to improve properties of fabrics by plasma process can be achieved employing various reactor. Nevertheless, as for our knowledge, there was no prior study used radio frequency inductively coupled plasma (RF-ICP) system to improve hydrophobicity of fabric. It has been reported that the fluorine-based gas such as CF_4, C_3F_6, C_6F_{14}, and SF_6 can be used to improve the hydrophobicity [10, 11, 12, 13, 14]. However, the groups of fluorocarbon gases (CF_4, C_3F_6, C_6F_{14} etc) are difficult to obtain into our laboratory due to the state regulation. Fortunately, the SF_6 gas can be acquired easier than fluorocarbon gases. The SF_6 gas in our study was offered by Bangkrauy power plant. It is well known that the SF_6 is extensively used in microelectronics

industrials. Particularly, it is used as etching gas in the plasma cleaning process [15, 16, 17]. However, not only etching process, but also the SF_6 plasma can produce depositing process of residue on sample surface. In order to investigate the main reason for the improvement in hydrophobicity property of fabrics whether it is due to the increasing of surface roughness or the participating of fluorine-containing groups on fabric surface after plasma treatment, we propose to use sulphur hexafluorine (SF_6) which is nontoxic fluorine-based gas as plasma media to improve hydrophobicity of fabrics in RF-ICP system.

1.2 Aims of Thesis

1) To investigate the optimum operating condition of plasma for hydrophobicity improvement of fabric (polyethylene terepthalate (PET), mixed cotton-Thai silk, Thai silk, and cotton) using radio frequency inductively coupled plasma (RF-ICP) system with SF_6 plasma.

2) To characterize the treated fabric by contact angle and absorption time measurement, scanning electron microscopy, atomic force microscopy, X-ray photoelectron spectroscopy as well as to analysis atomic species in SF_6 plasma using optical emission spectroscopy.

1.3 Overview of Thesis

After mention the introduction in the first section, this thesis is divided into 6 chapters, chapter 2 describes the essential theory in this thesis. It begins with the definition of plasma, type of plasma, radio frequency inductively plasma, fundamental process in plasma and finally, the reactions between plasmas and textile surfaces. Chapter 3 describes the detail of techniques used to characterize the fabric surface which include contact angle and surface tension/energy, optical emission spectroscopy, X-ray photoelectron spectroscopy, scanning electron microscopy, and

atomic force microscopy. The experimental setup including inductively coupled plasma reactor, fabric samples, contact angle and absorption time measurement are given in chapter 4. Chapter 5 is dedicated to result and discussion, for example, effect of the RF power and SF_6 pressure on hydrophobicity properties of the fabrics, fiber surface morphology and the surface roughness, chemical composition on fabric surface and atomic species in SF_6 plasma is discussed. Chapter 6 is the conclusion of the thesis.