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Atmospheric pressure plasma treatment of wool fabric structures

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ABSTRACT

Polyaniline-wool (PAN-WF), poly(3,4-ethylenedioxythiophene)-wool (PEDOT-WF), polypyrrole-wool (PPy-WF) fabrics were successfully prepared via atmospheric pressure plasma process. Scanning electron microscopy-energy dispersive X-ray spectroscopy (SEM-EDS), Fourier Transform Infrared Spectroscopy (FTIR) and four-probe resistance measurements were used to study the properties of the plasma polymer coated wool fabrics. The effects of the addition of iodine doping on the morphology and electrical properties of the fabrics were examined. The lowest electrical resistance was measured to be 7.7×10^3 Ω cm for PEDOT-I_2-WF sample after washing with water two times.

1. Introduction

Many great investigations and new techniques have been focused on the study of textile to improve surface properties such as wetting, antistatic, electrical conduction, penetration, and so on [1–3]. Both low-pressure and atmospheric pressure plasma systems were used for novel antistatic acquisition; processing fibers, yarns, fabric [4–6]. Plasmas generate a high density of free radicals via disassociating molecules through electro collisions and photochemical processes that allow it to disrupt the chemical bonds in the fiber polymer. As a result, new chemical species form on fiber and polymer surfaces [7,8]. Aside from plasma activation or plasma modification process, plasma is used to deposit chemical materials onto wide variety of substrate by plasma polymerization or plasma grafting techniques [8]. Since the depth of plasma modification has from tens to hundreds nanometers, plasma can be used to materials surface modification without changing their bulk properties [9]. The plasma polymerization has advantageous including the environmental friendliness of the solvent-free process, the deposition of ultra-thin films with thickness directly proportional to deposition time, the deposition of pinhole free films without dimensional changes associated with solvent evaporation [10,11].

The plasma polymerization process starts with gas ionization. Plasma is generated via supplying energy to an ordinary neutral gas and converting from the gas atoms to charged and excited species such as electrons, radicals and excited atoms. The collisions among these particles cause various kinds of reactions including plasma-phase and radical initiated polymerization in plasma [12]. The mechanism of plasma polymerization is difficult to explain exactly due to a great number of elementary processes [12,13]. Early study indicates that the number of adsorbed molecules on electrode have effect onto rate of polymerization. Moreover, they found that there was no polymer on the anode in a dc discharge and their results showed that the positive ions occurred in the negative glow via electron bombardment of the monomer molecules played an important role in polymer formation [13,14]. However, recently articles have been put emphasis on the role of free radicals in plasma polymerization and the rather random nature of plasma-phase reactions such as ionization via collisions [13]. It is well known that the interaction between radical and molecule for plasma polymerization brings about a higher concentration of free radicals in a non equilibrium plasma and faster rates of radical–molecule reaction when compared to ion–molecule reaction [12,15].

Wool is good substrate for plasma modification due to outermost part of fiber that is consisted of lipid layers and ionizable functional groups. Moreover, the fiber surface is divided into four coaxial layers of different chemical compound including epicuticle, exocuticle that is highly cross-linked by cystine bridges, the less cross-linked endocuticle, the cell membrane complex (CMC) [5,8,16]. According to several investigations including the effect of

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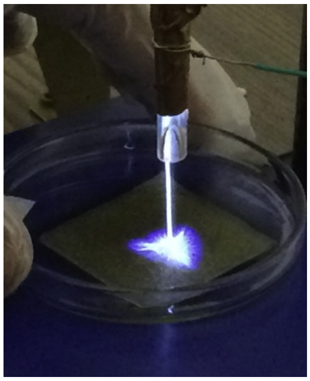

Fig. 1. Plasma treatment process on wool fabric.

plasma treatment on wool, the changing performance of wool are related to surface-specific changes of the protein fiber via the plasma treatment [16].

Compared to high and low pressure plasmas, atmospheric pressure plasma systems have an exciting alternative due to in-line process capabilities, low production costs. The shape and size of the plasma systems are simply altered in atmospheric pressure systems [10,11,17,18]. Atmospheric pressure discharges have made it available to treat polymers surfaces rapidly, continuously, uniformly without using expensive equipment like vacuum [19]. Atmospheric pressure non-thermal plasmas are generally excited via a dielectric barrier discharge, plasma jet or diffuse discharge [20,21]. This work aims to investigate antistatic and surface properties of atmospheric pressured plasma-induced graft polymerized (APPGP) conducting polymer coated wool fabrics. As conducting polymers, polyaniline

Table 1
The abbreviations and resistance of all samples.

Sample	Description	R_{es} (Ω cm)
WF	Wool fabric	7.7×10^4
PAN-WF	Plasma-induced graft polymerized aniline coated wool fabric	1.0×10^4
PAN-I_2-WF	Iodine doping on plasma-induced graft polymerized aniline coated wool fabric	6.7×10^4
PEDOT-WF	Plasma-induced graft polymerized edot coated wool fabric	3.3×10^4
PEDOT-I_2-WF	Iodine doping on plasma-induced graft polymerized edot coated wool fabric	9.1×10^5
PPy-WF	Plasma-induced graft polymerized pyrrole coated wool fabric	3.3×10^4
PPy-I_2-WF	Iodine doping on plasma-induced graft polymerized pyrrole coated wool fabric	1.3×10^5

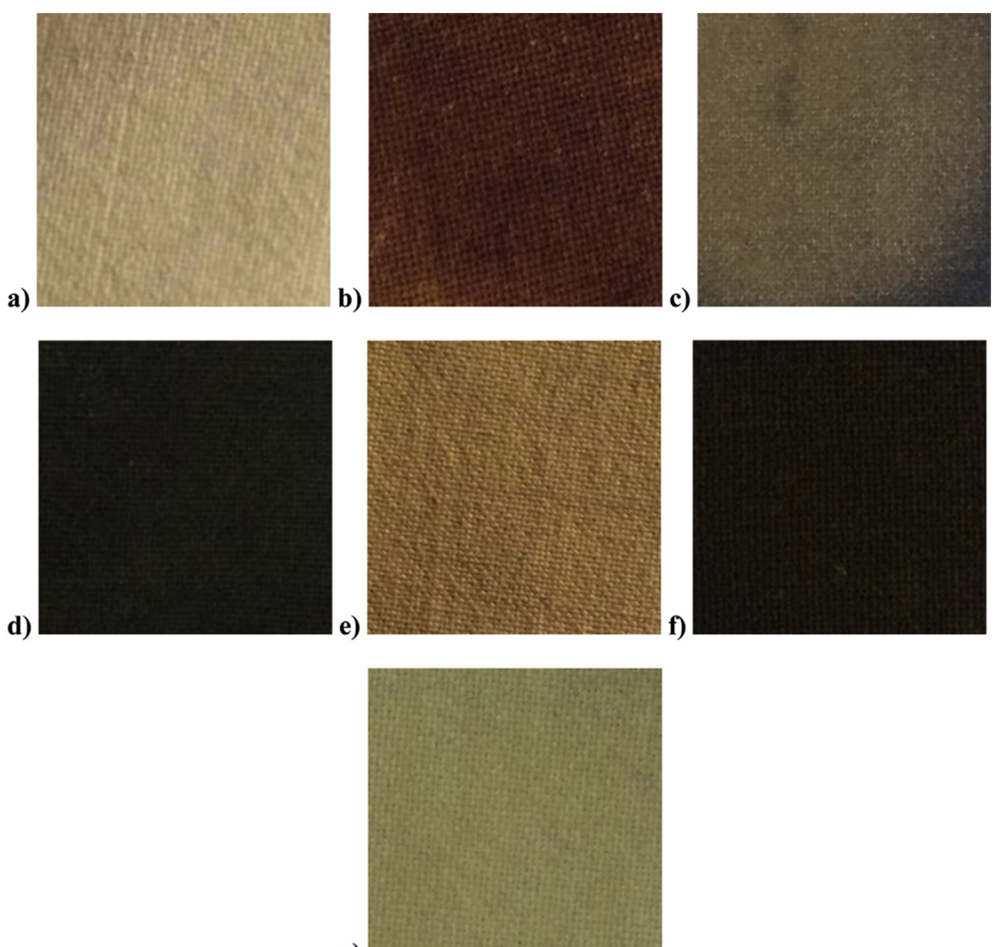

Fig. 2. Photo images (a) PAN-WF (b) PAN-I_2-WF (c) PEDOT-WF (d) PEDOT-I_2-WF (e) PPy-WF (f) PPy-I_2-WF (g) WF.