Plasma-fabric interaction for surface activation and functionalization: A review

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Abstract. The applications and effects of plasma on textile fabrics are the main focus in this paper. We surveyed available literature on the plasma-fabric interaction and found that there are variation of parameters affected the plasma application. The parameters can be classified as weight loss, tensile strength, contact angle, aging effect and addition of contents of different chemical functional groups. The increase or decrease in weight of fabrics after oxygen, nitrogen, and atmospheric plasma treatment was obtained in this study. The weight loss increased with the exposure time of plasma but decreased with the pressure. The tensile strength decreases with plasma duration and increases with plasma power. The type of plasma also affects the wettability of fabric. Wettability of a fabric increases with plasma treatment time. The plasma treatment of fabric adds different elements such as oxygen, carbon and nitrogen on the surface. The amount of oxygen increases but carbon and sulphur decreases. The increase or decrease in contact angle depends on the conditions of plasma treatment. The aging time of plasma depends on different parameters of plasma treatment. The hydrophilicity character also affected by plasma treatment. The hydrophilicity decreased with treatment time.

1. Introduction

Plasma is a quasi-neutral gas of charged and neutral particles, which exhibit collective behaviour Nakasugi et al [1]. The photons, ions, electrons, atoms, free radicles, and excited molecules are present in the plasma [2]. A gas is an electrical insulator but when the electric potential is applied to the gas, it breaks down the gas and produces a conducting state of matter. The breakdown depends on several factors, such as gas species, gas pressure, gas flowrate, geometry of the setup and separation of the surfaces across which the voltage is sustained. When electric potential is applied, immediately a cloud of ions surrounds the negative ball and a cloud of electrons surrounds the positive ball. This phenomenon is called Debye shielding. If the thickness of charge particle layer is much smaller ($\lambda_D<<L$) than the length of plasma dimensions, it becomes ionized gas known as a plasma and the number of charged particles in the Debye sphere must be greater than one ($N_D^{>}>1$). Electrons in the plasmas are displaced from a uniform background of ions due to perturbation. Because of their inertia, the electron will overshoot and oscillate around their equilibrium position with their characteristic frequency known as plasma frequency. For an ionized gas to behave like a plasma, the condition $\omega_P>\nu_C$ should be fulfilled. Plasma is used in textile processing, where electrically charged particles interact with each other and surface of fabric to introduce unique physical and chemical properties at the surface.

The collective behaviour of plasma has the ability to screen out the local density perturbations and to produce a sheath between of external surface and plasma. In low-pressure discharge plasmas, the
equilibrium is not reached between the electrons and heavy particles. The plasma has two types, one is low temperature plasma or weakly ionized plasma or gas discharge and other is high temperature plasma or fusion plasma. The low temperature plasma can be thermal or non-thermal. The temperature of all species in thermal plasma are same at thermal equilibrium, such as in stars and fusion plasma. In non-thermal plasma, all species do not have the same temperature. The electrons have temperature greater than the other species in plasma. There are many sources of creation of plasma, such as direct current, capacitively coupled plasma (CCP), inductively coupled plasma (ICP), microwave plasma, electron cyclotron resonance plasma, etc.

2. Characteristics of textile fabrics
A fibre is a unit of fabric, which is either natural or artificial. It is the basic element of fabrics and textile products. A fiber has a length at least 100 times of its diameter or width. This unit can be spun to made yarn or a fabric by methods including knitting, weaving, felting, braiding and twisting. The requirements for fibres to be spun include a length of at least 5 mm, cohesiveness, flexibility, elasticity, fineness, uniformity, durability, lustre and sufficient strength.

3. Effect of plasma on fabric properties

3.1. Weight loss
Trejbal et al. [3] determined the weight loss of plasma exposed fibre at different treatment times. The weight loss more familiar and frequently used for plasma treatment time over 60 seconds. After 480 seconds of treatment, the coated and uncoated fabrics lost their weight up to 2.4% and 4.7%, respectively. The loss in weight was proportional to the duration of plasma treatment. The loss in weight reduces the mechanical strength of fibres. Ling et al. [4] treated the grey cotton fabric with plasma. The pressure of inlet gas for plasma was in the range of 20 Pa to 100 Pa by keeping an interval of 20 Pa. The input discharge power was changed from 50 W to 350 W at interval of 50 W, and the exposure time was also changed from 3 min to 20 min. Lee et al. [5] treated the polyethylene terephthalate fibers with atmospheric pressure plasma. The weight loss increased by increasing the plasma treatment time but after the exposure time of 50 s, the increase in weight loss slowed down. It was due to the fact that the plasma etching rate was more rapid but after removing some etchable amorphous materials, the removal of crystalline materials was more difficult. The other reasons of slowing down the etching rate were of some molecular fragments in plasma re-deposited on the surface. Wang et al. [6] investigated the plasma treated grey cotton fabric by low pressure DC air plasma. The top layer of fabric consisted of oil, cotton wax and dirt particles. The low molecular weight layer introduced the hydrophobic properties at the surface. The high energy beams of electron collide with fabric and removed the contaminated layer from the fabric. The ablation of polymer chain started after plasma cleaning, which caused the weight loss. The weight loss was calculated using the following equation (1):

\[
\text{Weight loss} \% = \left( \frac{W_f - W_i}{W_i} \right) \times 100 \tag{1}
\]

Here \( W_i \) and \( W_f \) are the final and initial weight of the plasma treated fabric. Zhang et al. [7] treated the cotton fabrics with the atmospheric pressure plasma for different intervals of time. The loss in weight after plasma treatment is given table 1. The loss in weight increased with prolonged treatment time. It reveals that cleaning and etching affects were strong enough to degrade the sample surface.

3.2. Tensile strength
Trejbal et al. [3] studied the effect of plasma treatment time on surface properties of fabric. After 120 s of treatment time, 40% reduction in tensile strength was observed. The load bearing capacity of fiber was not affected during plasma treatment. The plasma only effected the fiber coating and did not affect the load bearing core. Similar results were reported by Ling et al. [4] who studied the effect of low-pressure nitrogen plasma on grey cotton fabric. The tensile strength reduced with nitrogen plasma pressure from 20 Pa to 100 Pa. The tensile strength was measured by strip method ASTM D5035. The
dimensions of cotton fabric were 5×35 cm$^2$ in warp direction. The tensile strength loss can be obtained using equation (2).

\[
\text{Tensile strength loss} = \frac{T_0 - T_1}{T_0} \times 100
\]

where $T_0$ and $T_1$ represent the fabric tensile strength before and after plasma treatment. Stefano et al. [8] performed the atmospheric pressure plasma treatment of wool/cashmere (15/85%) by using dielectric barrier discharge plasma setup. Four samples (60×30 mm$^2$) were treated using Instron 5942 instrument. The traverse rate was maintained at 50 mm/min and the load was kept 200 N. The recording was performed at 800 point/min. Both extensibility and tensile energy of fabric increased but linearity and resilience decreased slightly.

Table 1. Comparison of different plasma treated fabrics by changing plasma parameters.

| Plasma type                          | Processing parameters                        | Fabric property             | Reference               |
|--------------------------------------|----------------------------------------------|-----------------------------|-------------------------|
| Oxygen plasma on hydrophobic fiber   | After 480 s, coated and uncoated fibers lost weight up to 2.4% and 4.7%, respectively | Weight loss increased with treated time | Trejbal et al. [3]     |
| Nitrogen plasma on grey cotton fabric| Plasma pressure range was (20.0 to 1000.0) Pa, power 200 W. Exposure time 5 min | Weight loss decreased with gas pressure | Ling et al. [4]        |
| Atmospheric plasma on PET fabric    | ---                                          | Weight loss increased with time | Lee et al. [5]          |
| Atmospheric pressure plasma on cotton fabric | Pressure 20 Pa, treatment time 1 to 20 min | Weight loss increased with time | Zhang et al. [7]       |

Gaminian et al. [20] treated the fabrics with madder/TiO$_2$ and TiO$_2$ nanomaterial. The Alkaline hydrolysis of polyester fabric generated pits on the fabric surface that probably act as weak points when fiber is extended under the action of stress. The introduction of TiO$_2$ nanoparticles onto the surface of polyester fiber increased the tensile strength by filling the pits and interaction with hydroxyl and carboxyl groups of polyester chains. Chongqi et al. [9] investigated the effect of low temperature plasma on polyester fabrics. The tensile strength decreased significantly after plasma treatment, especially at voltages above 55 V. The large voltage induced rigorous etching on polyester surface and reduced the tensile strength. Sudhir et al. [10] studied the properties of carbon fiber after treating it with cold remote nitrogen oxygen plasma. The presence of oxygen in plasma induced some functional groups on the surface. The mixture of 1% O$_2$ in N$_2$ proved more effective than 0.5% O$_2$ in N$_2$ plasma. The effect of plasma treatment on tensile strength is summarized in table 2.

Trejbal et al. [12] investigated the effect of corona discharge and enzymatic treatment on the tensile strength of fabric. Wool fabrics were pre-treated with corona discharge at power of 100 W. These samples were then treated with enzyme by keeping humidity and temperature constant. Ming et al. [2] studied the effect of low temperature oxygen plasma on the ramie fabric. A decrease in tensile strength was observed with plasma treatment times due to etching and oxidation effects.
3.3. Wettability
Stefano et al. [11] studied the effect of atmospheric pressure plasma on wool/cashmere (15/85%) textiles with dielectric barrier discharge in humid air (air water mixture). The adsorption time of de-ionized water droplets was decreased with plasma treatment. The untreated fiber did not adsorb the water droplets and droplets remained on the surface until evaporation. It was observed that wettability increases for both cashmere and wool/cashmere with energy dose and wheel speed. The cashmere fiber was influenced more than the wool/cashmere. In other experiments, power and energy dose were kept at 270 W and 4500 Wmin/m² and speed of mobile station was varied from 0.3 to 4.8 m/min and number of passes from 1 to 16. The wettability increased at higher number of passes. The wettability also revealed an increase with increasing the energy dose. The better results were obtained by providing energy in multiple steps. The multiple steps of energy caused more uniform surface modification.

### Table 2. Effect of plasma treatment on tensile strength of fabric.

| Plasma type                        | Processing parameters                                                                                                                                                                                                 | Property affected                                      | Reference         |
|------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|-------------------|
| Oxygen plasma on polymer macro fiber | Loading frame Web Tiv Ravestein FP100, loading rate 0.8 mm/min until load of 60 N and 0.6mm/min until ultimate strength                                                                                                         | Tensile strength decreased with plasma duration       | Trejbal et al. [3] |
| Nitrogen plasma on grey cotton fabric | Dimensions were 5.0 cm × 35.0 cm in warp direction, pressure 20.0 Pa to 100.0 Pa, power 200.0 W, time 5.0 min                                                                                                         | Tensile strength loss reduced with pressure and enhanced with power and time | Ling et al. [4]   |
| Atmospheric pressure plasma        | Power 180 W, 270 W, energy dose 1200, 3600 adsorption time 13 min, 1 min                                                                                                                                               | Extensibility and tensile energy increased but linearity and resilience decreased | Stefano et al. [8] |
| Low temperature plasma on polyester fabric | Voltage from 40 to 60 V                                                                                                                                                                                                 | Tensile strength decreased after plasma treatment     | Chongqi et al. [9] |
| Cold remote nitrogen oxygen plasma on carbon fiber reinforced polymer composites | Pressure 10 Pa, time 5 min, nitrogen flow rate 2.5slm, working pressure 4hPa                                                                                                                                               | Tensile strength increased by enhanced adhesion due to the presence of oxygen in nitrogen | Sudhir et al. [10] |
| Low temperature oxygen plasma on the ramie fabric | Gas pressure 20 to 100 Pa, power 150 W for time 3.0 min                                                                                                                                                                    | Tensile strength decreased with time and discharge but increased with pressure | Ming et al. [2]   |
| Corona discharge and enzymatic treatment with protease and cellulose on wool fabrics | Power 100 W, speed 0.5 cm/s, 5wt% enzyme at constant temperature and humidity                                                                                                                                          | Strength decreased with plasma treatment time         | Gaminian et al. [20] |
Deterioration was observed at high dosage and low speed with the presence of burnt fibers, while there was no variation in organoleptic properties.

Shahidi et al. [21] carried out the drop test to investigate the hydrophobic and hydrophilic properties of the plasma treated samples. The drop absorption time of the untreated sample was larger than the plasma-treated sample. Moreover, with an increase in plasma treatment time, the roughness on the surface also increased. Stefano et al. [8] studied the effect of atmospheric pressure plasma on wool/cashmere (15%/85%) textiles with dielectric barrier discharge arrangement. The energy was supplied in multiple steps. The treated samples lost their weight due to some dehydration during plasma treatment. The wettability of treated fibers increased with an increase of energy dose. The nitrogen plasma introduced some functional groups of cysteic acid (SO₃ groups), cystine monoxide (-SO-S- groups) and cystine dioxide (-SO₂-S-groups) on the treated surface. These groups provided polar characteristics and improved wettability to fabric. The effect of plasma treatment on wettability of fabrics is summarized in Table 3.

| Plasma type | Processing parameters | Property affected | References |
|-------------|-----------------------|-------------------|-----------|
| Atmospheric pressure DBD of nitrogen, wool/cashmere textile | Weight of drop 12 μL, 8 passes of mobile station, ATR spectra in 800-1800 cm⁻¹ | Wettability increased by supplying energy dose | Stefano et al [11] |
| Low pressure nitrogen plasma on grey cotton fabric | Capillary rise height method, in warp direction, power 200 W, time 5.0 min, K₂Cr₂O₇ (1wt.%) for 1 cm | Capillary rise height decreased due to decrease of impurity removal efficiency | Ling et al [4] |
| Atmospheric pressure plasma with DBD in humid air on wool/cashmere textile | Experiment 1 (power 270 W, speed 2.5 m/min), Experiment 2 (power 270 W, energy dose 4500 W min/m²) | Wettability increased with supplying energy dose and number of passes | Stefano et al [8] |
| Diode plasma discharge device using DC Ar plasma on non-woven poly-hydroxy-butyrate (PHB) | Air flow rate 3 L/s, density of fiber= 1.25 g/cm³, power 8W, time 240 s. Ar pressure 10 Pa, electrode area 48 cm², distance between electrode 5 cm | Plasma treatment decreased the contact angle and metallic sputtering increased the contact angle | Slepicka et al [18] |
| Dielectric barrier discharge on antimicrobial viscose fabric | Optimal treatment time was 120 s, energy density=14.4 J/cm² | Plasma treatment increased the surface energy, wettability and capillary height | Kramar et al [21] |

Ling et al. [4] investigated the effect of nitrogen plasma on grey cotton fabric. The fabric capillary rise height decreased as nitrogen pressure increased from 20 Pa to 100 Pa. The Capillary rise height decreased due to decrease of impurity removal efficiency during plasma treatment. Slepicka et al. [18] investigated the wettability and contact angle of non-woven poly-hydroxy-butyrate after treating with DC Argon plasma. The untreated sample was hydrophobic with surface contact angle of 120°. The plasma treated fiber exhibited a decrease in contact angle. The surface also became completely hydrophilic after treatment. The plasma treated samples were metalized through direct metal sputtering.
and immersing into Au/Ag nanoparticles’ solution. The contact angle was increased after sputtering of gold and silver coated fabric due to formation of discontinuous metal clusters on the polymer. Kramar et al. [22] applied dielectric barrier discharge on antimicrobial viscose fabric to study the wettability and sorption properties. The capillary rise of sample, treated with air DBD, was increased appreciably. The plasma introduced the new polar groups on the surface through oxidation, such as hydroxyl functional groups and carboxylic groups. The increased number of polar groups improve the surface energy, wettability and capillary height. For longer plasma treatment times, some of the fibers get damaged. The optimal treatment time and energy density were revealed as 120 s and 14.4 J/cm², respectively.

3.4. Addition of functional groups
Trejbal et al. [3] studied the addition of oxygen groups on the surface of polymer fiber after the oxygen plasma treatment. The ion beam of plasma increased the surface roughness and activated the functional groups on the surface by reducing the surface energy. The X-ray photo electron spectroscopic analysis was carried out after one day of oxygen plasma treatment. XPS analysis showed that the prolonged plasma treatment leads to a bonding of 48 at% of O2 on coated fiber and 21 at% on uncoated fiber. Both the coated and uncoated fibers were treated with oxygen plasma for 5 s, 30 s and 480 s. The plasma treatment significant enhanced the oxygen content in the fiber, consequently the hydrophilicity. These results were also supported by the contact angle measurements. After XPS analysis of deconvoluted high resolution C 1s XPS peaks, it was found that oxygen containing groups (C=O, C=O, and O-C=O) on the surface were increased by 17%, 21% and 34% after treated time of 5 s, 30 s and 480 s, respectively. Stefano et al. [11] studied the effect of atmospheric pressure plasma on wool/cashmere (15/85%) textiles using a dielectric barrier discharge arrangement. Nitrogen was used as a source gas for discharge plasma. Plasma treatment decreased the carbon content and increased the oxygen content of the fabric. The ratio of O to C increased due to etching of external layer of lipids and insertion of oxygenated species on surface after plasma treatment. The nitrogen plasma treated samples showed a better oxidation of lipid layer. Plasma treatment also reduces the amount of sulphur on the fiber.

Marija et al. [19] treated the cotton and rayon with low pressure water vapour plasma and an extract of japonica rhizome. The plasma treatment increased the adsorption capacity of cotton and rayon. Jian et al. [12] studied the effect of oxygen plasma on pure wool, chitosan deposited wool and polyaniline deposited wool. After plasma treatment, the carbon peak in XPS spectra became much lower and peaks of nitrogen and oxygen became stronger. The amount of nitrogen increased due to loss of carbon content. A decrease in C/N ratio and increase in O/N ratio was observed due to plasma etching of the surface and destruction of C-C bonds. The hydrophilic character of wool was increased due to attachment of groups, such as hydroxyl and carboxyl groups. The polyaniline/wool fabric was doped in acetic acid and hydrochloric acid. The doping enhanced C1s peak and decreased O1s peak. The C/N ratio was increased, and O/N ratio was decreased after plasma treatment. The effect of plasma treatment on surface chemistry of different fabrics is summarized in table 4.

Stefano et al. [8] investigated the effect of atmospheric plasma on pure cashmere and wool cashmere textiles. The XPS analysis showed a decrease in carbon content and increase in oxygen content in fiber with plasma treatment. Yongqing et al. [13] revealed a decrease in C-C/C-H component of C 1s peak and an enhancement of C= O, C= O and O- C= O components. Stefano et al. [8] and increased in C/O ratio due to etching of lipids and the insertion of oxygenated species. The insertion of oxygen by atomic oxygen was much higher than the nitrification induced by atomic nitrogen. The amount of nitrogen increased slightly due to removal of external hydrocarbon chains. Lee et al. [14] investigated the effect of diffused plasma on polyamide 66 (PA66). After the plasma treatment, the carbon content of PA66 fabric decreased and oxygen content increased. Nitrogen content also changed with treatment time. The plasma treatment added some polar functional groups to the surface of polyamide material. C1s and O1s spectra split into four peaks, which represent four carbon groups: C-C (285.0 eV), C-N (285.3 eV), C-O/C-OH (286.5 eV) and CONH (288.0 eV).
Table 4. Effect of different plasma treatments on surface chemistry of fabrics.

| Plasma detail                                      | Processing parameters                                                                 | Property affected                                                                                       | References                  |
|----------------------------------------------------|----------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|-----------------------------|
| Oxygen plasma on polymer fiber                     | Diameter of fiber 0.1mm, length 10 mm, treated time (5, 30, 480) s, power 100 W, pressure 56 Pa | Oxygen bonds increased on the coated and uncoated fiber                                                | Trejbal et al. [3]          |
| Nitrogen and humid air plasma on wool/cashmere (15/85%) textiles | Gas flow (20 L/min), power 180 W and 270 W, energy dose 1200 J and 3600 J              | Percentage of oxygen increased but carbon and sulphur decreased                                         | Stefano et al. [11]         |
| Oxygen plasma on pure wool, low temperature plasma wool chitosan (CTS) deposited wool, polyaniline deposited wool, | Air pressure 20 Pa, radio frequency plasma for 1-6 min, power between 50 W and 400 W       | Percentage of oxygen increased and of carbon decreased in LTP wool and vice versa in PANI wool, PANI/CTS wool | Jian et al. [12]            |
| Atmospheric pressure plasma on wool/cashmere textiles in humid air | Treatment A (gas flow10 L/min, water vapour flow rate 3 g/h, station speed 2.5 m/min, power 450 W min/m³) Treatment B with water flow rate 6 g/h. | Treatment A increased the percentage of O, N and S but treatment B increased O, N contents and decreased S | Stefano et al. [8]          |
| Diffused plasma at atmospheric air pressure on polyamide 66 (PA66) | Treated for 10 s, 60 s. frequency (100 Hz,3 00 Hz, 500 Hz)                               | Amount of oxygen increased but carbon decreased                                                        | Lee et al. [14]             |

3.5. Contact angle

Trejbal et al. [3] investigated the effect of oxygen plasma on fiber reinforced composites material. The hydrophilicity was quantified by the contact angle measurements using an optical method. The fabrics were submerged in the demineralized water to evaluate the contact angles by using software CAMTIA. The angles were measured automatically at the outlines of menisci, formed due to adhering of water. Measurements were taken after 1, 7, and 30 days after plasma treatment. The uncoated fabric retained its hydrophilicity. The average contact angle of coated fabric was equal to 55.2°±2.3° and for uncoated fabric, the contact angle was 82.1°±2.8°. The plasma treatment reduced the contact angle by 24° to 29°.

Mehmet et al. [15] presented an atmospheric pressure plasma method to improve the pigment-based ink-jet printing performance on silk fabric. The contact angle was measured with DSA-100 drop shape analyzer (KRÜSS GmbH, Hamburg and Germany) to know the wettability of the silk fabrics. The probe liquid was distilled water and ethylene glycol. It was observed that the contact angle decreases by 20° and 15° for distilled water and ethylene glycol, respectively. Lee et al. [16] studied the effect of atmospheric-pressure air/He plasma on the surface of polyester fabrics. A mixture of air and 10% helium was used to generate plasma. The fabric was treated for 90 seconds. The effect of plasma treatment on hydrophilicity was investigated by measuring the dynamic contact angle. The probe liquids were the distilled water and ethylene glycol. It was observed that the contact angle of control fabric was about 85° and 72° for distilled water and ethylene glycol, respectively, which was decreased to 28° and 18°.
after plasma treatment. The effect of different plasma treatments on contact angle is summarized in Table 5. Yongqiang et al. [13] studied the effect of helium plasma on cotton fabric. This work showed that coating a film of polymer on cotton fiber with plasma would result in high hydrophobicity. Park et al. [17] measured the water contact angle of the fabrics at ambient temperature by utilizing the sessile drop technique. The argon gas was used to produce plasma. The argon plasma caused sputtering of copper electrode. The copper was deposited on the surface of polyester/silk blended fabrics. 5 mL of distilled water was placed at five different points on the surface of fabric. The sputtering power was 100 W and distance between target and sample was 5.5 cm. The sputtering times were set as 4, 10, 20, 30 and 40 minutes. The contact angle of the copper coated fabric was increased many folds depending on the treatment time.

### Table 5. Comparison of effect on fabric of different plasma treatment for contact angle.

| Plasma detail | Processing parameters | Property affected | References |
|---------------|-----------------------|-------------------|------------|
| Oxygen plasma on fabrics reinforced composite materials | Measuring time 0, 1, 7 and 30 days after plasma treatment time of 0-480 s | Contact angle decreased after plasma treatment | Trejbal et al. [3] |
| Atmospheric pressure plasma on silk fabrics | Power 300 W, treatment time 90 s, dielectric space 3 mm, temperature 20 ± 2 °C and relative humidity 65 ± 5% | Contact angle decreased from 82° to 55° for distilled water and ethylene glycol | Mehmet et al. [15] |
| Atmospheric-pressure air/He plasma on surface of polyester plain weave fabric | Power 0 to 500 W, frequency 1kHz, pressure 100 kPa, air and 10% helium, dielectric space of 3 mm | Contact angle decreased to 28° and 18° for distilled water and ethylene glycol from 85° and 72°, respectively | Lee et al. [16] |
| Glow discharge of Helium low temperature plasma on the cotton fabrics | Frequency 13.56 MHz, power 0 to 500 W, process time 0-300 s | Contact angle increases with an increase in mass concentration of polymer | Yongqiang et al. [13] |
| Plasma sputtering process of copper on polyester/silk blended fabrics | Argon gas flowrate 14 mL/min, working pressure 6x10⁶ mbar, power 100 W, sputtering time 4, 10, 20, 30 and 40 minutes | Contact angle increased from 0° to 146° after coating the fabric with copper | Park et al. [17] |

4. Conclusion

In this paper, plasma-fabric interaction was reviewed pertaining to the effect of plasma treatment on physico-chemical properties of different fabrics. The post-plasma treatment weight loss, tensile strength, contact angle, aging and functional groups of the fabrics were reviewed. An increase or decrease in weight of fabrics generally happens after treatment depending on the type and conditions of plasma treatment. The weight loss increases with plasma exposure time and decreases with plasma pressure. The tensile strength decreases with exposure time but increases with plasma power. Plasma treatment also tailors the fabric wettability. Wettability of a fabric increases with plasma treatment time. The plasma treatment of fabric adds different functional groups to the fabric surface. The groups may contain oxygen, carbon and nitrogen, depending on the type of plasma.

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