EFFECT OF OXYGEN AND NITROGEN PLASMA TREATMENTS ON NATURAL DYEING AND TENSILE PROPERTIES OF SILK YARN

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Abstract

Silk has become a very popular protein fiber, owing to its special characteristics of durability, softness, luster and surface smoothness [1]. It can be dyed with various synthetic and natural dyes. Natural dyes are known for their beautiful, soft and multi-hued shades. Recently, the interest in the dyeing of textile fibers with natural dyes has been increased due to their compatibility with the environment, lower toxicity and allergic reaction compared with the man-made dyes [2]. Most natural dyes have low affinity for textiles fibers which necessitates the use of potentially toxic metal mordants to improve their absorption [3]. Different methods have been studied to enhance the dyeing properties of natural dyes on textiles fibers. Plasma treatment is an environmentally friendly technique for modifying the fibers’ surface without interfering with their bulk properties to improve different properties such as wettability, shrink resistance, interfacial adhesion, hydrophilicity, hydrophobicity, and dyeing properties [2].

In this study, oxygen and nitrogen have been used as the processing gas to modify the surface of silk fibers using a low-pressure microwave plasma equipment. The samples treated with oxygen and nitrogen plasmas at different durations were dyed with the aqueous extract of Salvadora persica stem bark. The effect of both types of plasma treatment on the color strength and tensile properties of silk yarn was studied and compared with untreated samples.

Results

Figure 1 shows the effect of oxygen and nitrogen plasma treatments on the tenacity and elongation of silk yarns before dyeing. It can be seen that plasma treatment for 10 seconds has no significant influence on the tensile strength of silk yarn. When using plasma treatment times greater than 30 seconds, the tenacity of the samples reduced to some extent. The reduction in tenacity is higher in case of oxygen plasma treatment. It may be due to the oxidation effect of oxygen plasma on silk fibers which can cause the reduction of the tensile strength. However the maximum loss in tenacity was 11.1% and 19.4% for samples treated with nitrogen and oxygen plasmas (300 sec) respectively. This maximum reduction in strength is still in the acceptable
range. Maximum loss of 20% in tenacity is usually acceptable in chemical treatment of textiles.

The elongation at break has remained unaffected for both oxygen and nitrogen plasma treated samples compared to the raw silk yarns. The results of physical properties measurements confirms that both types of plasma treatments can be used on silk yarn without significant adverse effect on the physical properties of the fibers, especially when applied at durations lower than 30 seconds.

Figure 1. The effect of oxygen and nitrogen plasma treatments on the tenacity and elongation of silk yarns

Figure 2 shows the effect of oxygen and nitrogen plasma treatments on the color strength of the samples dyed with the 25 %owf of the plant extract. Color strength (K/S) was considered as the sum of K/S values at wavelengths ranging from 360 to 740 nm. It can be seen that both types of plasma treatments increased the K/S of the samples, indicating that the concentration of dye in the plasma-treated silk samples is higher, i.e. the dyeability of the fibers has been improved by the plasma treatment. The reason for this is probably the formation of polar groups on the fabric surface. The surface roughness caused by etching also increases the surface area and aids wetting of the surface and penetration of the dye molecules [4]. This increase is higher in case of oxygen plasma treatment. The reason may be due to the higher ability of oxygen plasma in hydrophilization and surface etching of silk fibers causing more sorption of the dye molecules.

Considering the SEM image shown in figure 3, it can be concluded that plasma treatment can help to remove sericin remained after the degumming process from the silk fiber surface so that water can penetrate easily into the fiber. On the other
hand, the creation of surface roughness on the surface of silk fiber as a result of plasma treatment would also increase its water absorption property and enhance the dyeability [4].

Conclusion

The results of this study showed that both oxygen and nitrogen plasma treatments can improve the natural dyeing of silk fibers without significant adverse effect on the tensile properties of the yarns. This environmentally friendly process can be a candidate for eliminating or reduction of the amount of potentially toxic metal mordants usually used in natural dyeing recipes.

Figure 2. The effect of oxygen and nitrogen plasma treatments on the color strength of the dyed samples

Figure 3. SEM images of raw (A) and oxygen (120 sec) plasma treated (B) silk fibers
References
