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The Investigation of the Effects of Plasma Treatment on the Dyeing Properties of Polyester/Viscose Nonwoven Fabrics

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Abstract

In this study, Polyester/Viscose (PET/CV) nonwoven fabrics were treated with oxygen plasma application. The plasma application was carried out for 1and 10 minutes at low frequency. After then, the samples were dyed with disperse dyes. Where same samples were dyed with carriers, the others were dyed without carriers. Finally, the effects of plasma treatment on dyeing properties of PET/CV nonwoven fabrics were investigated at 3% darkness. The aim of this study is that the effect of hydrophility caused by the plasma application on dyeability properties of samples was investigated.

Keywords: Plasma Treatment, Polyester/Viscose Nonwoven Fabrics, High Temperature Dyeing, Carrier.

1. Introduction

Textile surfaces are classified woven, knitted and nonwoven surfaces, respectively. The woven and knitted surfaces are produced from yarns whereas the nonwoven surfaces are produced with using fibers. Furthermore, the production of nonwoven surfaces is more economical than the other techniques. Nonwoven fabrics are comprehensively produced for single-use and industrial applications (Jinka et al., 2012). Nonwovens are defined as complex three-dimensional (3D) fibrous materials containing fibers oriented in preferential or random directions that are bonded by thermal, chemical, or mechanical techniques (Patel et al., 2013). Nonwovens are used in number

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of applications such as filters, geotextiles, fuel cell membranes or fabrics for ballistic protection because of their advantages (Liu et al., 2014).

Plasma is described as the fourth condition of a substance having the highest energy. Furthermore, plasma is an ionized gas which contains electrons, ions, neutral atoms or molecules (Graham, 2007). In textile industry, cold plasma is used for modification of textile materials (Kut, 2011). In addition, plasma treatment is considered as a dry, environmental and eco-friendly process in textile industry so as not to require water and chemicals (Zille, Oliveira & Souto, 2011). Plasma treatment cause physical and chemical modification in textile materials (Labay, Canal & Canal, 2012). After the plasma treatment, the properties of textile materials which are hydrophility (Wavhal & Fisher, 2002), dyeability (Kamel et al., 2011), air permeability (Karahan et al., 2009), anti-pilling (Ceria &Hauser, 2010), water-oil repellent (Kamel et al., 2011), tear strength (Yuan, Jayaraman & Bhattacharyya, 2002), tensile strength (Shishoo, 2007) and etc. can be improved.

In textile dyeing industry, the use of water, energy and chemical with considerable rate creates problem to the environment. Furthermore, these issues cause an increase on the manufacturing costs (Sathian et al., 2014). Previous researches focused on physical, chemical and biological techniques in order to solve these problems (Sathian et al., 2014). Plasma treatment which is a physical technique causes to improve the dyeability properties of textile materials. After the plasma treatment, hydrophility of textile materials increases due to being the physical and chemical modification.

In this study, PET/CV nonwoven fabrics were treated with oxygen and nitrogen plasma application for 1 and 10 minutes at low frequency. After the plasma treatment, the samples were dyed with disperse dyes with carriers and without carriers. Finally, the effects of plasma treatment on dyeing properties of PET/CV nonwoven fabrics were investigated at 3% darkness. The effect of plasma treatment on dyeability properties of samples was investigated.

2. Materials and Methods

2.1. Fabrics

In this study, nonwovens comprised of polyester and viscose with mixing ratios of 90/10, 80/20, 70/30 and 60/40 were used.

2.2. Plasma Treatment

Plasma treatment was carried out on nonwovens with Diener vacuum plasma. Commercially available oxygen plasma was discharged into the chamber and the nonwoven samples were placed in the discharge chamber. The nonwovens were treated with oxygen plasma for 1 and 10 minutes. The plasma treatment conditions were 40 kHz frequency to LF frequency at the power of 100 W and at the pressure of 0.4 mbar.

2.3.Dyeing Process

In this study, the samples were dyed with disperse dyes which were big and small particle via conventional dyeing method at the liquor ratio of 1:50. Firstly, the samples were classified in eight different groups and all the groups of samples were dyed in different bath. The dyeing solution was prepared 10 g/l and the depth of colour was prepared %3. The dispersing agent was used for the all dyeing solution in the amount of 1 g/l. The dyeing process was carried out with carrier and without carrier. The amount of carrier was 2 g/l. In conventional method, the samples were dyed at the boiling temperature for an hour. After all dyeing process, the samples were washed with 5 g/l sodium carbonate, 3 g/l hydrosulfite and 1 g/l wetting agent at 80ºC for 20 min at the liquor ratio of 1:50. The properties of dyeing process, samples code and type of fabric are given in the Table 1. In addition, the dyeing process is given in the Figure 1.

Table 1. The properties of samples.

Sample Code	Type Of Fabric	Dyeing Properties
K1	60 (PET)/40 (VIS)	Dyeing with big particle disperse dyes and carrier.
K2	60 (PET)/40 (VIS)	Dyeing with big particle disperse dyes and carrier before plasma treatment for 1 minutes.
K3	70 (PET)/30 (VIS)	Dyeing with big particle disperse dyes and carrier.
K4	70 (PET)/30 (VIS)	Dyeing with big particle disperse dyes and carrier before plasma treatment for 1 minutes.
K5	80 (PET)/30 (VIS)	Dyeing with big particle disperse dyes and carrier.
K6	80 (PET)/30 (VIS)	Dyeing with big particle disperse dyes and carrier before plasma treatment for 1 minutes.
K7	90 (PET)/10 (VIS)	Dyeing with big particle disperse dyes and carrier.
K8	90 (PET)/10 (VIS)	Dyeing with big particle disperse dyes and carrier before plasma treatment for 1 minutes.
K9	60 (PET)/40 (VIS)	Dyeing with big particle disperse dyes and carrier.
K10	60 (PET)/40 (VIS)	Dyeing with big particle disperse dyes and carrier before plasma treatment for 10 minutes.
K11	70 (PET)/30 (VIS)	Dyeing with big particle disperse dyes and carrier.
K12	70 (PET)/30 (VIS)	Dyeing with big particle disperse dyes and carrier before plasma treatment for 10 minutes.
K13	80 (PET)/30 (VIS)	Dyeing with big particle disperse dyes and carrier.
K14	80 (PET)/30 (VIS)	Dyeing with big particle disperse dyes and carrier before plasma treatment for 10 minutes.
K15	90 (PET)/10 (VIS)	Dyeing with big particle disperse dyes and carrier.
K16	90 (PET)/10 (VIS)	Dyeing with big particle disperse dyes and carrier before plasma treatment for 10 minutes.
K17	60 (PET)/40 (VIS)	Dyeing with big particle disperse dyes.
K18	60 (PET)/40 (VIS)	Dyeing with big particle disperse dyes before plasma treatment for 1 minutes.
K19	70 (PET)/30 (VIS)	Dyeing with big particle disperse dyes.
K20	70 (PET)/30 (VIS)	Dyeing with big particle disperse dyes before plasma treatment for 1 minutes.
K21	80 (PET)/20 (VIS)	Dyeing with big particle disperse dyes.
K22	80 (PET)/20 (VIS)	Dyeing with big particle disperse dyes before plasma treatment for 1 minutes.
K23	90 (PET)/10 (VIS)	Dyeing with big particle disperse dyes.
K24	90 (PET)/10 (VIS)	Dyeing with big particle disperse dyes before plasma treatment for 1 minutes.
K25	60 (PET)/40 (VIS)	Dyeing with big particle disperse dyes.

K26	60 (PET)/40 (VIS)	Dyeing with big particle disperse dyes before plasma treatment for 10 minutes.
K27	70 (PET)/30 (VIS)	Dyeing with big particle disperse dyes.
K28	70 (PET)/30 (VIS)	Dyeing with big particle disperse dyes before plasma treatment for 10 minutes.
K29	80 (PET)/30 (VIS)	Dyeing with big particle disperse dyes.
K30	80 (PET)/30 (VIS)	Dyeing with big particle disperse dyes before plasma treatment for 10 minutes.
K31	90 (PET)/10 (VIS)	Dyeing with big particle disperse dyes.
K32	90 (PET)/10 (VIS)	Dyeing with big particle disperse dyes before plasma treatment for 10 minutes.
M1	60 (PET)/40 (VIS)	Dyeing with small particle disperse dyes and carrier.
M2	60 (PET)/40 (VIS)	Dyeing with small particle disperse dyes and carrier before plasma treatment for 1 minutes.
M3	70 (PET)/30 (VIS)	Dyeing with small particle disperse dyes and carrier.
M4	70 (PET)/30 (VIS)	Dyeing with small particle disperse dyes and carrier before plasma treatment for 1 minutes.
M5	80 (PET)/20 (VIS)	Dyeing with small particle disperse dyes and carrier.
M6	80 (PET)/20 (VIS)	Dyeing with small particle disperse dyes and carrier before plasma treatment for 1 minutes.
M7	90 (PET)/10 (VIS)	Dyeing with small particle disperse dyes and carrier.
M8	90 (PET)/10 (VIS)	Dyeing with small particle disperse dyes and carrier before plasma treatment for 1 minutes.
M9	60 (PET)/40 (VIS)	Dyeing with small particle disperse dyes and carrier.
M10	60 (PET)/40 (VIS)	Dyeing with small particle disperse dyes and carrier before plasma treatment for 10 minutes.
M11	70 (PET)/30 (VIS)	Dyeing with small particle disperse dyes and carrier.
M12	70 (PET)/30 (VIS)	Dyeing with small particle disperse dyes and carrier before plasma treatment for 10 minutes.
M13	80 (PET)/20 (VIS)	Dyeing with small particle disperse dyes and carrier.
M14	80 (PET)/20 (VIS)	Dyeing with small particle disperse dyes and carrier before plasma treatment for 10 minutes.
M15	90 (PET)/10 (VIS)	Dyeing with small particle disperse dyes and carrier.
M16	90 (PET)/10 (VIS)	Dyeing with small particle disperse dyes and carrier before plasma treatment for 10 minutes.
M17	60 (PET)/40 (VIS)	Dyeing with small particle disperse dyes.
M18	60 (PET)/40 (VIS)	Dyeing with small particle disperse dyes before plasma treatment for 1 minutes.
M19	70 (PET)/30 (VIS)	Dyeing with small particle disperse dyes.
M20	70 (PET)/30	Dyeing with small particle disperse dyes before plasma treatment for 1 minutes.

	(VIS)	
M21	80 (PET)/20 (VIS)	Dyeing with small particle disperse dyes.
M22	80 (PET)/20 (VIS)	Dyeing with small particle disperse dyes before plasma treatment for 1 minutes.
M23	90 (PET)/10 (VIS)	Dyeing with small particle disperse dyes.
M24	90 (PET)/10 (VIS)	Dyeing with small particle disperse dyes before plasma treatment for 1 minutes.
M25	60 (PET)/40 (VIS)	Dyeing with small particle disperse dyes.
M26	60 (PET)/40 (VIS)	Dyeing with small particle disperse dyes before plasma treatment for 10 minutes.
M27	70 (PET)/30 (VIS)	Dyeing with small particle disperse dyes.
M28	70 (PET)/30 (VIS)	Dyeing with small particle disperse dyes before plasma treatment for 10 minutes.
M29	80 (PET)/20 (VIS)	Dyeing with small particle disperse dyes.
M30	80 (PET)/20 (VIS)	Dyeing with small particle disperse dyes before plasma treatment for 10 minutes.
M31	90 (PET)/10 (VIS)	Dyeing with small particle disperse dyes.
M32	90 (PET)/10 (VIS)	Dyeing with small particle disperse dyes before plasma treatment for 10 minutes.

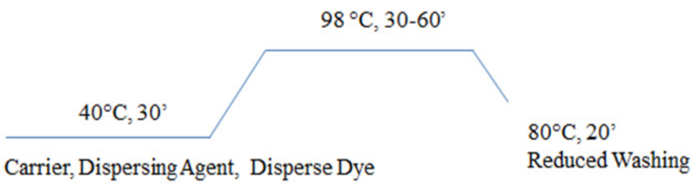


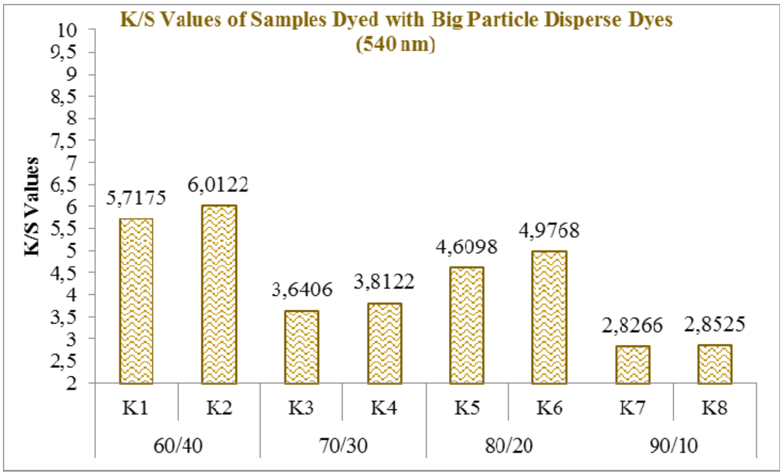
Fig. 1.The properties of dyeing process.

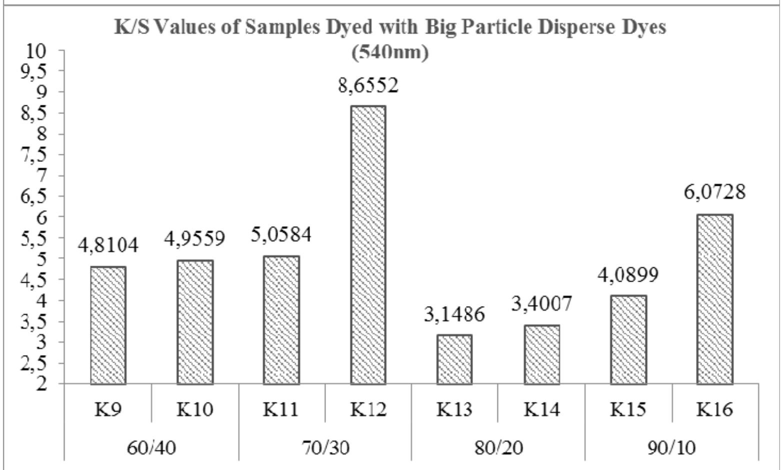
2.4. Colour Measurement

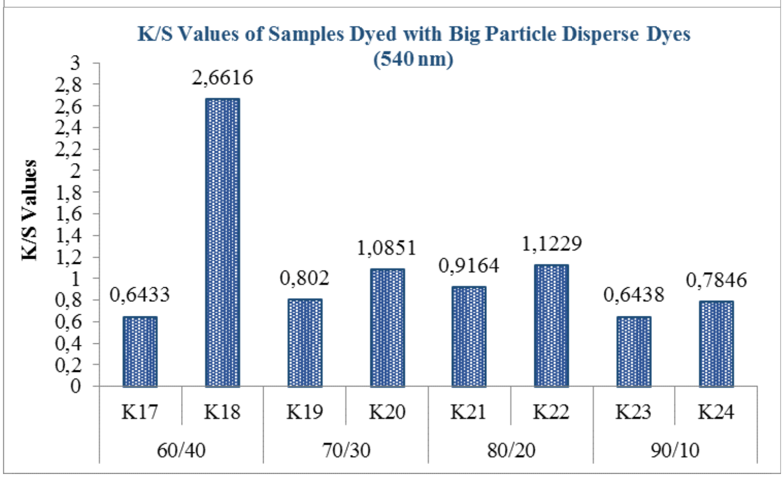
The reflectance values of the dyed fabrics were measured by using Gretaq Macbeth – Colour Eye 2180UV spectrophotometer and the CIELab values were calculated using illuminant D65 and 10° standard observer values. The colour strength (K/S) values of samples were calculated with Kubelka-Munk equation and the reflectance values (R) at the maximum absorption wavelength (λmax).

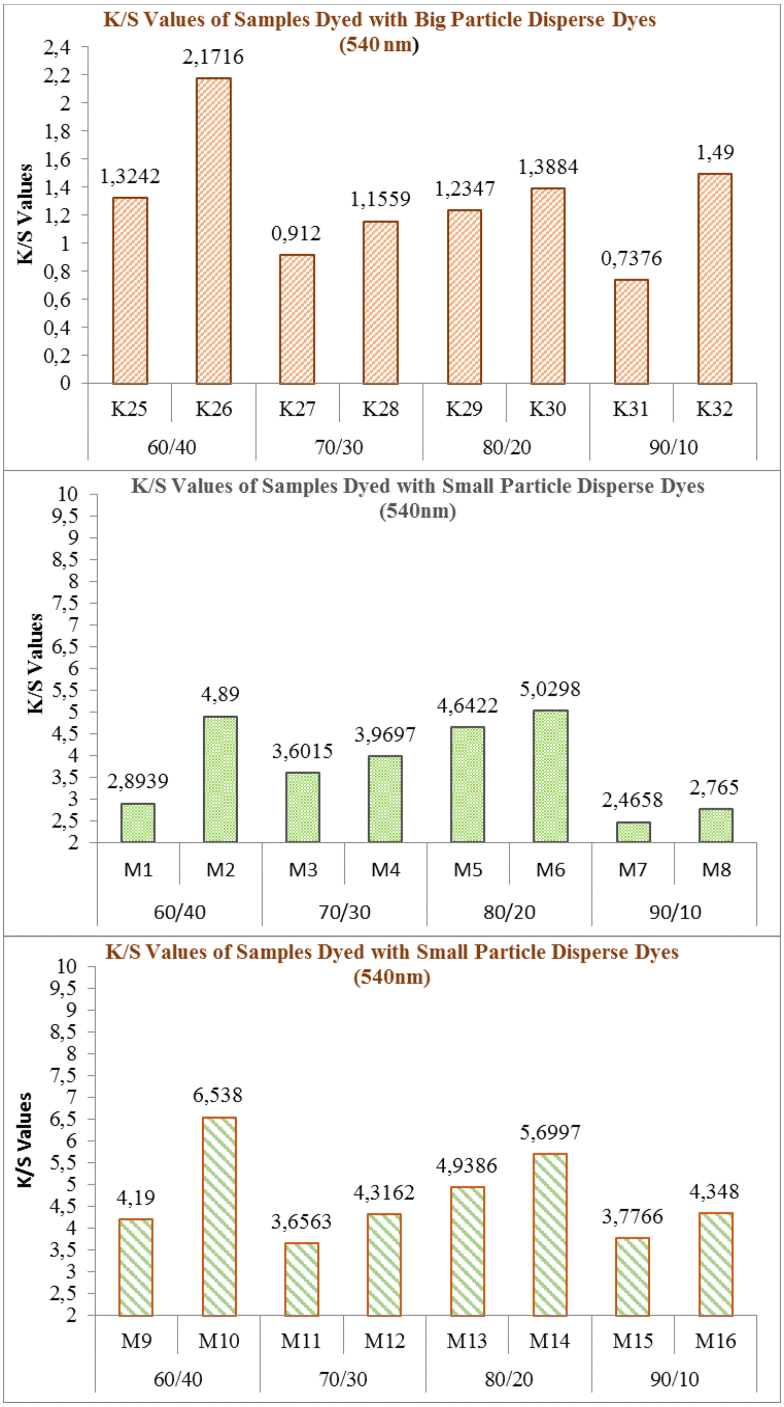
3. Results and Discussion

The samples were categorized into sixty four groups. While some samples were dyed with big particle disperse dyes, the others were dyed with small particle disperse dyes. In addition, some samples were treated with oxygen plasma for 1 and 10 minutes before the dyeing process. Furthermore, whereas some samples were dyed with carrier, the other samples were dyed without carrier. Thus, it was investigated whether the plasma treatment could be used instead of carrier in disperse dyeing or not. The results of colour strength (K/S) values of the samples dyed via different conditions are given in Figure 2.


K/S Values of Samples Dyed with Big Particle Disperse Dyes
(540 nm)
K/S Values
10
9,5
9
8,5
8
7,5
7
6,5
6
5,5
5
4,5
4
3,5
3
2,5
2
5,7175
6,0122
3,6406
3,8122
4,6098
4,9768
2,8266
2,8525
K1
K2
K3
K4
K5
K6
K7
K8
60/40
70/30
80/20
90/10


K/S Values of Samples Dyed with Big Particle Disperse Dyes
(540nm)
10
9,5
9
8,5
8
7,5
7
6,5
6
5,5
5
4,5
4
3,5
3
2,5
2
4,8104
4,9559
5,0584
8,6552
3,1486
3,4007
4,0899
6,0728
K9
K10
K11
K12
K13
K14
K15
K16
60/40
70/30
80/20
90/10


K/S Values of Samples Dyed with Big Particle Disperse Dyes
(540 nm)
K/S Values
3
2,8
2,6
2,4
2,2
2
1,8
1,6
1,4
1,2
1
0,8
0,6
0,4
0,2
0
0,6433
2,6616
0,802
1,0851
0,9164
1,1229
0,6438
0,7846
K17
K18
K19
K20
K21
K22
K23
K24
60/40
70/30
80/20
90/10


K/S Values of Samples Dyed with Big Particle Disperse Dyes (540 nm)
K/S Values
2,4
2,2
2
1,8
1,6
1,4
1,2
1
0,8
0,6
0,4
0,2
0
1,3242
2,1716
0,912
1,1559
1,2347
1,3884
0,7376
1,49
K25
K26
K27
K28
K29
K30
K31
K32
60/40
70/30
80/20
90/10
K/S Values of Samples Dyed with Small Particle Disperse Dyes (540nm)
K/S Values
10
9,5
9
8,5
8
7,5
7
6,5
6
5,5
5
4,5
4
3,5
3
2,5
2
2,8939
4,89
3,6015
3,9697
4,6422
5,0298
2,4658
2,765
M1
M2
M3
M4
M5
M6
M7
M8
60/40
70/30
80/20
90/10
K/S Values of Samples Dyed with Small Particle Disperse Dyes (540nm)
K/S Values
10
9,5
9
8,5
8
7,5
7
6,5
6
5,5
5
4,5
4
3,5
3
2,5
2
4,19
6,538
3,6563
4,3162
4,9386
5,6997
3,7766
4,348
M9
M10
M11
M12
M13
M14
M15
M16
60/40
70/30
80/20
90/10

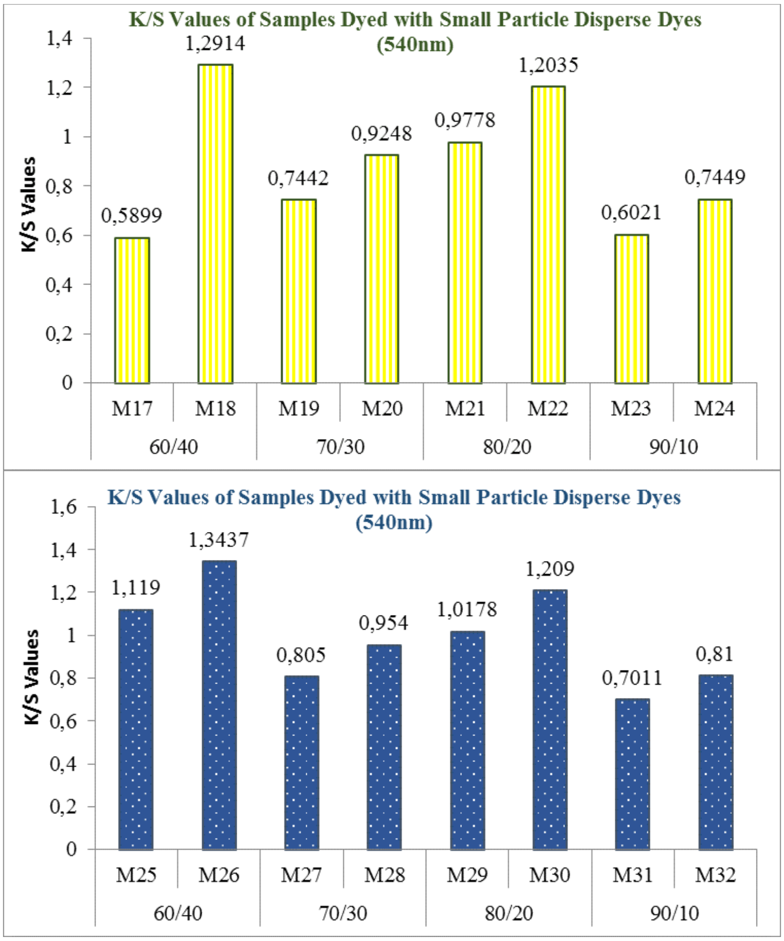


Fig 2. The colour strength values of samples.

According to the colour strength results, the colour strength of samples increased with plasma treatment and using carrier. The plasma treatment caused to increase in the dyeing absorption of samples. The reason of this result considered that the plasma application caused to increase the capillarity and functional groups of samples. Furthermore, the use of carrier caused an increase on the dyeing absorption of samples. Carriers caused to increase the amount of amorphous regions of polyester fibers and the diffusion of dyeing molecules to polyester fibers. The results showed that the increase of the amount of viscose caused to decrease in the dyeing absorption of samples. Moreover, the decrease in particle size caused to increase the colour strength of samples. The reason of this result was deemed that the decrease in particle size of dyes caused to increase the absorption of dyes to the fibers.

4. Conclusion

In this experiment, plasma and carrier effects were investigated on the colour strengths of four different polyester/viscose blends fabrics which were 90/10, 80/20, 70/30 and 60/40. The plasma treatment was performed on to the fabrics with Diener vacuum plasma for 1 and 10 minutes. After the plasma treatment, fabrics were dyed with and without carriers. Disperse dyes in two different particle size were used to understand the particle size effect on the colour strength. As a result of this experiment, the plasma treatment could not be used instead of carrier in disperse dyeing. Because, the plasma treated samples has less colour strength then the dyed samples with carrier. However plasma treatment can be used to improve the dyeability by comparison with the normal dyed samples. In addition to this, small particle disperse dye have better colour strength then the big particle disperse dye. When the results were analysed in terms of the fibre blend, the results demonstrated that the dyeing absorption is generally optimum in 60/40 PET/VIS samples.

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