Development of Dyeing Reactive Dyes on Blended Banana Fabrics Treated with Plasma Technology

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Abstract:

Banana pseudo-stem fibres have been used as a greener substitute for synthetic fibres that are harmful to the environment in the textile industry. Banana applications are expanding since different components of the banana are employed in various industries like fruits as food sources, leaves as food wrap, and stems for paper pulp and fibre. this due of rising environmental consciousness and the growing relevance of eco-friendly fabrics. The 4th state of matter is called plasma, Plasma treatment has demonstrated that it can be used as an environmentally friendly method to improve dyeing uptake of textiles with dyes.
The goal of this research is to create a reactive dyeing process suitable for banana fabrics and compare between dyeing behaviours of banana blended fabrics with cotton fabrics. Testing was performed to evaluate the colors properties between pre-treated, dyed banana fabrics, untreated dyed banana fabrics, and cotton fabrics.
In this study, the blended banana/cotton fabrics was pre-treated with Plasma DBD with different gases, and then dyed with synthetic reactive dyes. Finally, the dyed samples were evaluated according to standard testing methods. The findings demonstrated that plasma-pretreated blended banana textiles outperformed untreated fabrics. According to other findings, cotton and bananas also exhibit comparable dyeing behaviors. As a result, fabrics made from bananas may use the cotton dyeing method. Finally, it was possible to dye banana-based fabrics with a reactive dye that had superior washing fastness properties when compared to cotton-based fabrics.

Keywords:

Banana blended fabric, dyeing, Reactive dyes, plasma DBD treatment, Fastness, Colour properties

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1- Introduction:

Banana is a one of the Musaceae family and was one of the earliest domesticated plants. Musa acuminate is the scientific name for banana fibre, a natural fibre derived from the tropical banana plant. All edible parts of this plant, including the fruit, flower buds, leaves, trunk, and pseudo-stem, can be used to make fibre and paper pulp. The leaves can also be wrapped around food and fruits can be eaten. Fig (1) the banana plant's pseudo-stem is used to harvest banana fibre. Banana fibre has been well-liked as an eco-friendly material due to its exceptional attributes and characteristics. [1]

Fig: (1) Banana Tree

A cylinder-shaped clustering of leaf stalk bases is referred to as a "pseudo-stem." The outer layer of the 11 leaf sheaths that make up the sheath layers of the pseudo-13 stem can be used to scrape off the fibres. [2]
Banana fibre is a bast fibre with practically excellent mechanical properties such as high strength, good moisture absorption, and biodegradability. [3] Banana fibre has a typical fineness of 2400 nm. [4]
The banana's fibre chemical composition is as follows: cellulose (50-60%), hemicelluloses (25-30%), lignin (12-18%), pectin (3-5%), fat and wax (3-5%), water-soluble compounds (2-3%), and ash (1-1.5%). [5]
figure (2) shows, the cross section clearly reveals the fiber-cell walls (marked by arrow no. 1) and the lumen (marked by arrow no. 2).

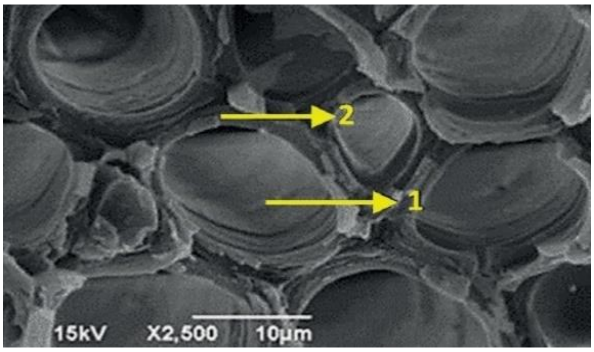

Figure (2) . SEM image of banana pseudo-stem fibre. [6]

The fibres from bananas are highly breathable, have a high tensile strength, and are efficient moisture absorbers with quickly dry. [7] The complex's centre appears to be the substance cellulose, which still has a crystalline fibrous structure. Hemicellulose is found between the micro- and macro-fibrils of cellulose. Lignin serves a structural function for the matrix that contains cellulose and hemicellulose.

The cellulosic fibre known as banana fibre is composed of tiny fibres that are encased in an amorphous matrix of lignin and hemicellulose. The strength and stiffness of the fibres were provided by hydrogen bonds and other linkages.

When compare to cotton's fibre, banana fibre has a higher moisture recovery percentage of 11-15%. Banana fibres absorb and release water better than cotton, jute, and flax. They also have lower crystallinity (19-24%) in the fibre structure. [7.8] The use of banana fibre will encourage long-term community development.

Synthetic dyes are preferred because they provide a wide range of colors, are less expensive, easier to obtain, and have excellent fastness properties.[9] Reactive dyes frequently combine with cellulose fibres to form chemically covalent bonding with the fibres' hydroxyl groups. As a result, reactive dyes have better light and wash fastness qualities. [10]

A plasma treatment is an illustration of an electrical discharge in which the ratio of positive to negative particle densities in the ionised gas in the tube is balanced based on microscopic size and duration. [11]

Dielectric barrier discharge plasma treatment (DBD) has grown in popularity in recent years because it changes the surface properties of polymers without changing their bulk properties. DBD is a low-cost, dry, and environmentally friendly method. [12] Plasma treatment is one method of surface modification. Until the 1950s, the only three states of matter were gas, liquid, and solid. Plasma is considered the 4th state of matter. Plasma is a substance composed of ions and electrons. It is an electrified gas, with electrons freely moving in both the -ve and +ve states.

When the energy of the gas increases, negatively charged electrons are released from the nucleus. Plasma was defined in further detail as a partially ionised gas.

Plasma can be used at either high or low temperatures. Because most textile fibres are heat-sensitive, only low-temperature plasma, also known as cold plasma, is used on textiles. [13] Low-frequency (1-500 kHz), radio-frequency (RF) (commonly 13.56 or 27.12 MHz), and microwave (usually 915 MHz or 2.45 GHz) energy can all be employed to produce direct current (DC) or alternating current (AC) plasma treatment (AC). [14] Plasma can be created using either atmospheric pressure or low pressure in a confined chamber. [15]

The four types of atmospheric-pressure plasmas that are commonly used in the textile industry are corona discharge (CD), dielectric barrier discharge (DBD), atmospheric-pressure glow discharge (APGD), and atmospheric-pressure plasma jet (APPJ), as seen in Fig (3) [16]

The very mild ionization used in the CD method causes a heterogeneous effect on the surface. As a result, CDs are no longer widely used in textiles. DBD is a better method (than CD) for coating an insulating substance with at least one of two electrodes spaced 2 to 5 millimetres apart. The applied voltage for the typical DBD approach is 20 kV. (AC). A well-chosen set of treatment parameters can result in a uniform and homogeneous surface treatment. [16]

The third method, known as APGD, typically employs two bare electrodes (uncoated metal) separated by a few millimetres and operates at a high frequency (2-60 MHz) and low voltage (~ 200 V). The disadvantage of APDG is that it requires the use of pricey Helium gas (He) to prevent arc formation between the electrodes. [17]

The APPJ method, which was recently added, uses two electrodes in a concentric pattern. A nozzle directs the gas toward the surface of the textile substrate after it has been transformed into plasma by electrodes.

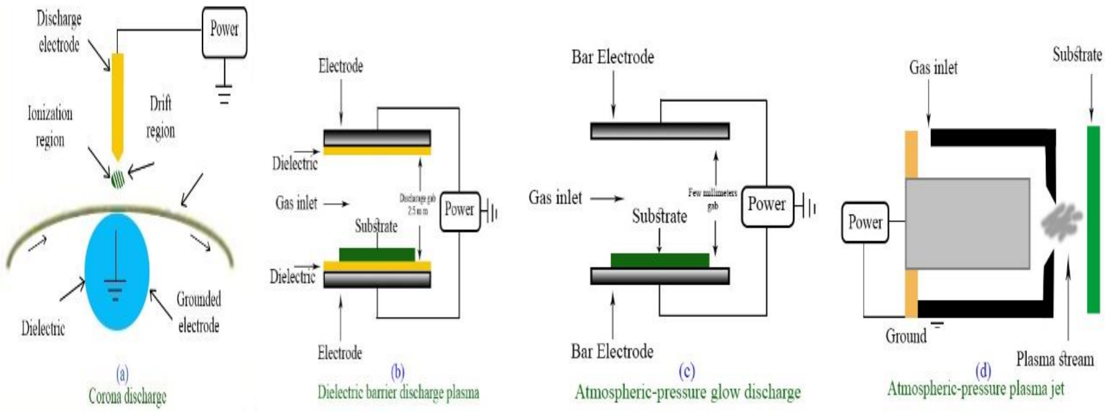

Fig. 3 Schematic illustration of various atmospheric-pressure plasma treatments on textiles: CD (a), DBD (b), APGD (c), and APPJ (d)

In this study, the blended banana/cotton fabrics were pre-treated with plasma DBD using various gases (Argon or oxygen) argon dielectric barrier discharge plasma (DBD Ar. plasma) or oxygen dielectric barrier discharge plasma (DBD O2 plasma), and then dyed with various reactive dyes. Following that, the dyed samples were evaluated according to standard testing methods. Recent researches have shown that the fibres of banana can be dyed. [1,5]

The current work intends to determine the suitable dyeing process for the banana's woven fabrics with reactive dyes, and focused on the comparison between dyeing of banana blended fabrics with cotton fabrics (with or without plasma pre-treatment with different gases). The effect of different fabric's composition and structure on colorimetric values and all fastness properties of banana fabrics and cotton fabrics samples was investigated.

EXPERIMENTAL:

1. Materials

1.1. Substrates: All samples were made with 50/2 nickel thread count, 100% cotton raw warp threads. With a yarn count of 20/1 nickel, the weft was made of either 100% cotton yarn or a blend of cotton and banana yarn (50:50). Banfab Co. Ltd., an Indian company, provided blended yarn that was 50% cotton and 50% banana.

Table (1) The weft and warp yarns' mechanical characteristics.

Substrates	Direction	Count
Cotton 100%	Wrap	50/2 Nickel
Blended fiber Banana: cotton (50 :50)	Weft	20/1 Nickel
Cotton 100%	Weft	20/1 Nickel

Ten samples were prepared using two parameters to investigate how the banana fibre ratio affected the quality of the manufactured fabrics (weave structure and weft ratio). Three distinct weft yarn arrangements were employed to produce research samples, resulting in a difference in banana fibre concentration, with three weave structures (plain 1/1, Twill 2/2, and Satin 4), as shown in Table (2)

Table (2) The specifications of produced samples

Sample no	Weave structure	Weft Ratio	Weft arrangement	Ends /cm	Picks /cm
1	Plain 1/1	75% Cotton : 25% Banana	1 Cotton : 1 Blended	36	21
2		66.6 % Cotton : 33.4 % Banana	1 Cotton : 2 Blended		
3		50 % Cotton :50% Banana	Blended		
4	Twill 2/2	75% Cotton : 25% Banana	1 Cotton : 1 Blended		
5		66.6 % Cotton : 33.4 % Banana	1 Cotton : 2 Blended		
6		50 % Cotton :50% Banana	Blended		
7	Satin 4	75% Cotton : 25% Banana	1 Cotton : 1 Blended		
8		66.6 % Cotton : 33.4 % Banana	1 Cotton : 2 Blended		
9		50 % Cotton :50% Banana	Blended		
10 (control)	Plain 1/1	100% cotton	Cotton		

1.2. Dyestuff: Reactive dyes (blue and red) were used for the banana dyeing process. Structure of red, and blue, reactive dyes is shown in Figures 4 , 5. was supplied by Dystar company.

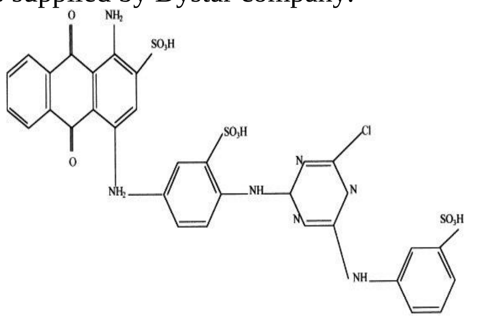

Figure 4. Chemical structure of levafix red.

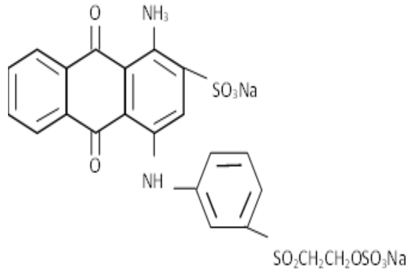

Figure 5. Remazol Brilliant Blue R

Other chemicals: Acetic acid, wetting agent, non-anionic detergent, sodium hydroxide and sodium carbonate were of laboratory grade chemicals.

2. METHODS:

2.1. Dielectric barrier discharge setup:

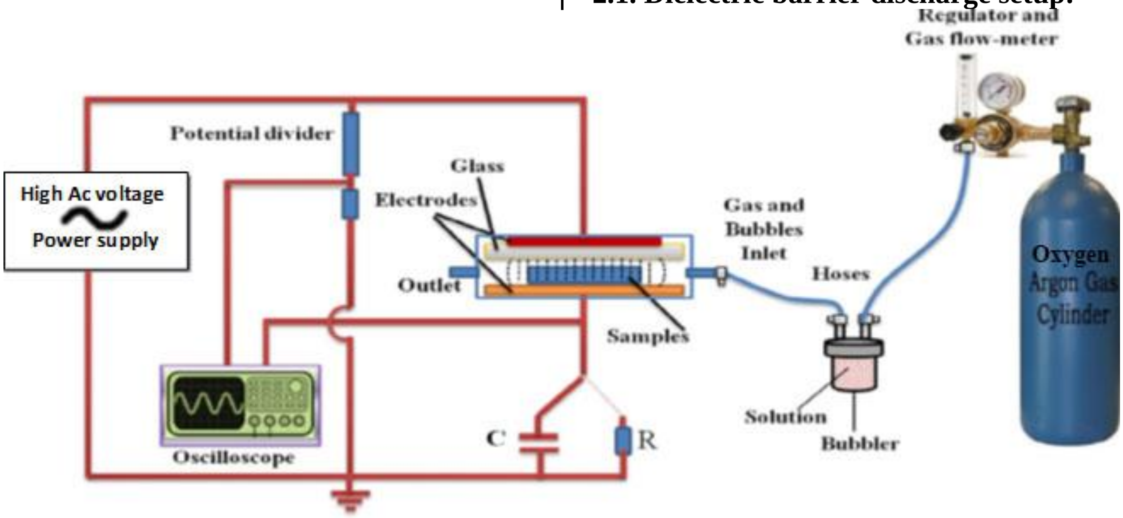

Figure 6 shows a schematic diagram of the DBD reactor used to treat samples.

DBD reactor had two parallel electrodes. A circular rubber ring (O-ring) with dimensions of 8.5 cm in diameter and 3 mm in thickness connected the upper electrode, which had a stainless-steel disc with diameter and thickness of 4 cm and 1 cm, to a glass disc with diameter and thickness of 10 cm. As the lower electrode, a 25x25 cm2 stainless steel plate was used.

The gap between the glass disc and the lower electrode measured 3mm. As a gas inlet and outlet, two ports were used. The plasma discharge was produced by a 25 kV/30mA AC power supply source at a frequency of 50Hz was connected to the upper electrode, while the lower electrode was connected to ground via a resistor R = 100 Ω or a capacitor C of 3.35 μF capacitance. The ideal treatment duration for plasma is chosen to be 10 minutes. [18]

In the space separating the two electrodes, samples were inserted. The electrical discharge was produced in this area where the gas freely flowed through the gas flow meter to the bubbler, and then into the space between the two electrodes.

2.2. Scouring Process:

In a 3% sodium hydroxide solution (based on the weight of the fabrics: o.w.f) at the boil for one hour, the 5 gramme banana samples were subjected to the scouring process. After being neutralized with acetic acid, the samples were then dried.

2.3. Dyeing methods:

The dyeing treatment liquor ratio is 1:50. Banana and cotton fabrics (plain 1/1, Twill 2/2, and Satin 4) were oven-dry weights of 20 g each were dyed with different colors (red, and blue). Reactive red and reactive blue were utilized, and the salt concentration was set at 18 g/L, the soda ash concentration at 3.6 g/L, and the wetting agent concentration at 2 g/L. The dyeing temperature was maintained at 45°C and increased gradually to 60°C for 90 minutes.

2.4. Washing procedure:

After the dyeing procedure was completed, the samples were cooled down in the liquor before being rinsed in cold water and hot soaped for 15 minutes at 90° C with 2 g/L non-ionic detergent. The samples were then rinsed in hot water at 95°C for 10 minutes before and being rinsed again in cold water and air dried. Finally, the color properties of the samples were evaluated.

3. Testing, Analysis and Measurements:

3.1. Color strength and fastness:

By employing the light reflectance technique and a

Shimadzu UV/Visible spectrophotometer, the colour strength (K/S) of the samples was assessed [19].
Applying the Kubelka equation, the colour strength given as K/S value was evaluated as follows:

$$K/S = \frac{(1-R)^2}{2R} - \frac{(1-R_o)^2}{2R_o}$$

Where:
R= Decimal fraction of the dyed fabric's reflectance.
R = Decimal fraction of the un-dyed fabric's reflectance.
K= Absorption coefficient
S= Scattering coefficient.
In addition, the color overall fastness properties: i.e. to rubbing, washing, or perspiration fastness were evaluated according to standard methods [20].

3.2. Color fastness to rubbing:
The AATCC test method 8-1996, International Organization for Standardization (ISO) 105X12, was used to determine the color fastness to rubbing. Include both a dry and a wet rubbing test. [21]

3.3. Color fastness to washing:
Color fastness to wash is evaluated using the International Organization for Standardization (ISO) 105-C06 A2S: 1994 standards (AATCC test method 36-1972). [22]

3.4. Color fastness to perspiration:
The colour fastness to perspiration was determined using ISO 105 E04:2013 and AATCC 15: 2009. [23]
Include both acidic and alkaline solution test. the effect on the color change of the test samples were expressed and defined using the gray scale for color change.

4. RESULTS AND DISCUSSION:
4.1. Effect of pretreated DBD Plasma gas on K/S of dyed samples with Reactive Remazol Blue:
To study different pre-treatment plasma gases and their effects on dyeing Reactive Blue dye on banana/cotton blended or cotton samples, and compared with non-mordanted samples, The K/S values were remarked as shown in Table (3).

Table (3) represents the data of K/S values of using different pre-treatment plasma gases and their effects on dyeing Reactive Blue (λ 625), on plain 1/1, twill 2/2 or satin 4 samples, and compared with non-pretreated samples.

Weave structure	Weft Ratio	Weight undyed (g/m2)	K/S of dyed samples without Plasma	K/S of dyed samples pretreated with Plasma gas	
				O2	Ar.
Plain1/1	75% Cotton 25% Banana	145	16.18	22.09	21.34
	66.6% Cotton 34.4% Banana	143.8	16.29	22.97	22.77
	50 % Cotton 50 % Banana	141.7	19.94	21.82	21.62
	100 “control” **%**Cotton	147.1	17.38	18.74	18.23
Twill 2/2	75% Cotton 25% Banana	143.7	16.89	22.61	16.92
	66.6% Cotton 34.4% Banana	142.7	18.34	23.14	22.35
	50 % Cotton 50 % Banana	138.9	19.21	22.71	17.86
Satin 4	75% Cotton 25% Banana	142.2	17.56	19.90	19.56
	66.6% Cotton 34.4% Banana	141.3	20.20	20.29	19.80
	50 % Cotton 50 % Banana	137.5	20.22	20.27	18.71

4.1.1. Effect on Plain 1/1 fabrics:

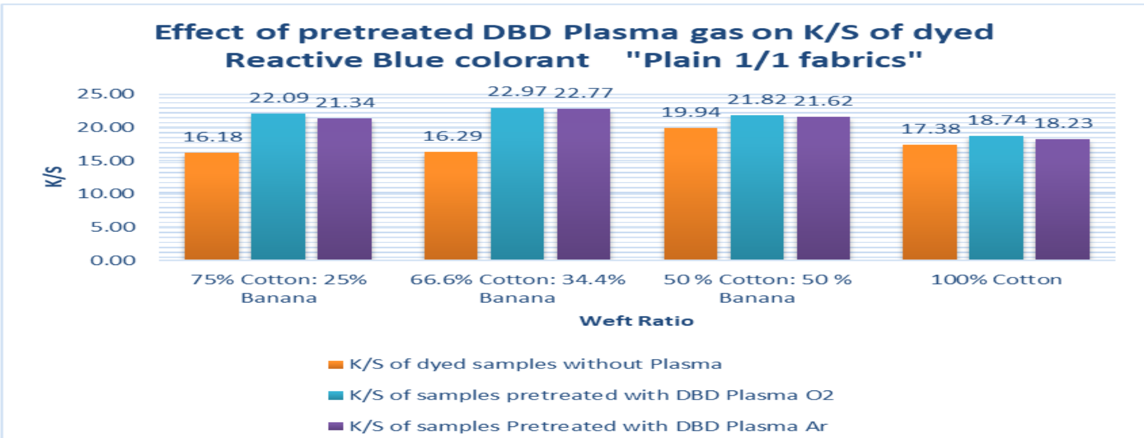

Fig. (7): Effect of using Pre-treatment plasma on dyeing plain fabrics with reactive Blue dye in presence of different gases

It is clear from the data of table (3) and figure (7) that, irrespective of the type of plasma's gas used, the obtained K/S values (λ 625) of dyed Pre-treated plasma samples is higher than the untreated samples.

Besides, the K/S values of dyed Pre-treated plasma samples with Oxygen is higher than Argon gas, irrespective of banana weft ratio. By comparison banana cotton blended fabrics with 100% cotton fabrics, banana's blended samples obtained higher K/S than 100% cotton samples, regardless the weft ratio used. It is also clear from the data that, the highest K/S values were obtained on using 66.6% Cotton 34.4% Banana blended fabrics, (22.97, 22.77) with using oxygen and argon respectively. Therefore the increasing of K/S value of treated samples were (40.01% and 37.78%) than the untreaded dyed samples. This confirm that the using of Plasma DBD increasing the active groups which increases the dye uptake and reflect on K/S of dyed samples.

4.1.2. Effect on Twill 2/2 fabrics:

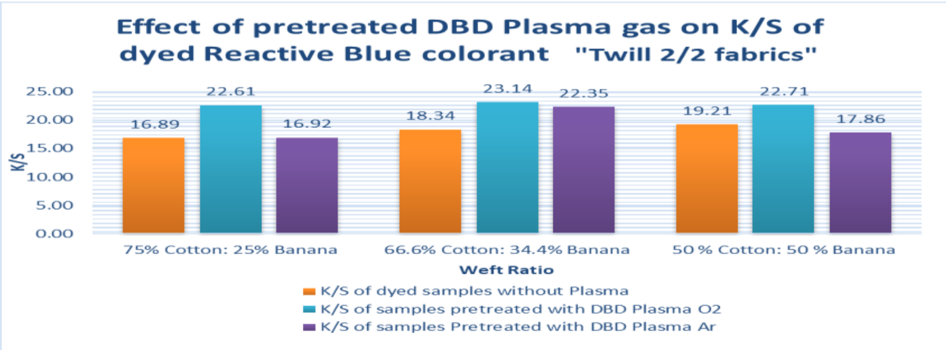

Fig. (8): Effect of using Pre-treatment plasma on dyeing Twill 2/2 fabrics with reactive Blue dye in presence of different plasma gases.

It is clear from the data of table (3) and figure (8) that, the Twill 2/2 samples pre-treated with oxygen gas DBD plasma dyed with reactive blue dye, acquire the highest K/S values irrespective of banana weft ratio used.

In addition, the increasing percentage of K/S of dyed samples with pre-treatment by oxygen gas was higher than without plasma treatment by (33.87%, 26.17%, 18.22%) on banana ratio (75% cotton: 25% banana, 66.6% cotton: 34.4% banana, 50% cotton: 50% banana). This was confirmed that Plasma edges the surface of fiber and generate the active sites (OH group) which reacts with dye as the fiber of cotton and banana are cellulosic fiber.

4.1.3. Effect on Satin 4 fabrics:

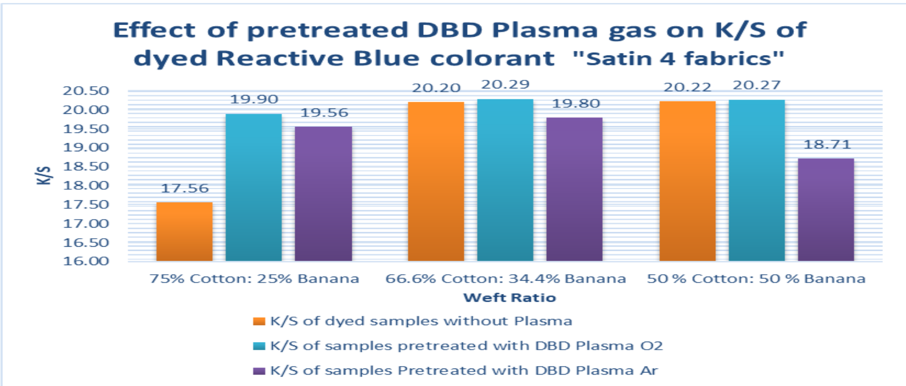

Fig. (9): Effect of using Pre-treatment plasma on dyeing Satin 4 fabrics with reactive blue dye in presence of different gases.

It is clear from the data of table (3) and figure (9) that, the highest K/S values were obtained on using 66.6% Cotton 34.4% Banana blended fabrics, (22.29, 1980) with using oxygen and argon respectively.

By comparison pretreatment plasma gases "oxygen and argon" effect on K/S values of dyed samples, it is found that samples pretreated with oxygen obtained higher K/S than argon on Satin 4 samples, irrespective of the banana weft ratio used.

4.2. Effect of weave structure of fabrics on K/S of dyed samples with reactive red dye:

To study different weave structure (Plain, Twill2/2, and satin4) and their effects on dyeing Reactive red on banana/cotton blended with different banana weft ratio (25%, 50%, or 34.4 %) or 100% cotton samples, in presence of Plasma gas (Oxygen and Argon) and compared with non-treated samples, The K/S values were remarked as shown in Tables (4), (5) and (6).

4.2.1. Effect on weft ratio 75% cotton: 25% banana:

Table (4) effect of weave structure (Plain, Twill2/2, and satin4) and their effects on dyeing Reactive blue dye on banana/cotton blended or 100% cotton samples

Weft Ratio	Weave structure	K/S of samples without treatment	K/S of samples with plasma oxygen pre-treatment	K/S of samples with plasma argon pre-treatment
75 % Cotton: 25 % Banana	Plain1/1	16.18	22.09	21.34
	Twill 2/2	16.89	22.61	16.92
	Satin 4	17.56	19.90	19.56
100 %Cotton	Plain1/1	17.38	18.74	18.23

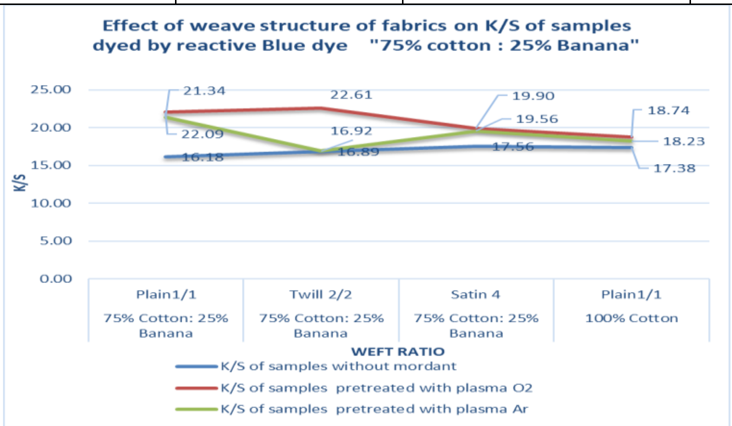

Fig. (10): Effect of weave structure of fabrics on K/S of dyed samples with Reactive blue in presence and absence of plasma treatment.

It is clear from the data of table (4) and figure (10) that, the highest K/S was obtained on using oxygen gas DBD plasma on Twill 2/2 sample dyed with reactive blue dye (22.61) with using oxygen gas DBD on satin 4, and (21.43) on plain samples using argon gas, and (17.56) on satin 4 sample without using Plasma DBD.

By comparing "100% cotton" with blended "banana/cotton" dyed samples, using Plasma DBD with blended banana cotton obtain higher K/S values than 100% cotton samples. Moreover, the plasma treated blended samples obtain higher K/S values than untreated samples.

4.2.2. Effect on weft ratio 66.6% cotton: 34.4% banana:

Table (5) effect of weave structure (Plain, Twill2/2, and satin4) and their effects on dyeing Reactive blue dye on banana: cotton blended or 100% cotton samples.

Weft Ratio	Weave structure	K/S of samples without treatment	K/S of samples with plasma oxygen pre-treatment	K/S of samples with plasma argon pre-treatment
66.6 % Cotton: 34.4 % Banana	Plain1/1	16.29	22.97	22.77
	Twill 2/2	18.34	23.14	22.35
	Satin 4	20.20	20.29	19.80
100 %Cotton	Plain1/1	17.38	18.74	18.23

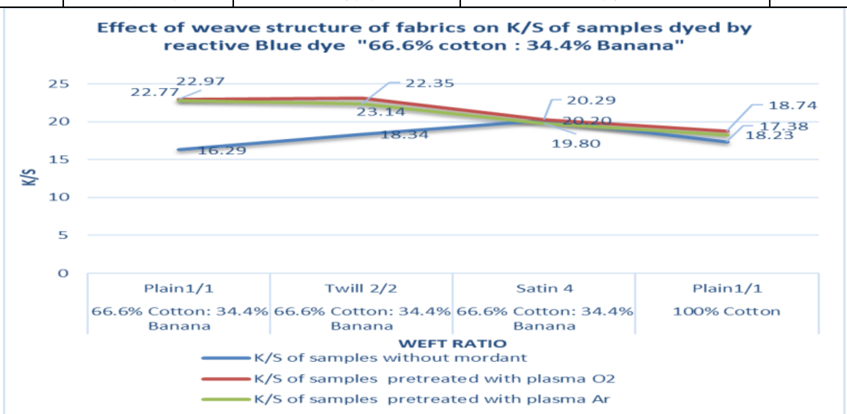

Fig. (11): Effect of weave structure of fabrics on K/S of dyed samples with Reactive blue in presence and absence of plasma treatment.

It is clear from the data of table (5) and figure (11) that, the same trend with weft ratio 75% cotton: 25% banana, the highest K/S was obtained on using oxygen gas DBD plasma on Twill 2/2 sample dyed with reactive blue dye (23.14) with using oxygen gas DBD on satin 4, and (22.77) on plain samples using argon gas, and (20.20) on satin 4 sample without using Plasma DBD.

Besides by using oxygen Plasma pretreated with banana: cotton blended samples present the K/S values higher than the un-treated samples.

4.2.3. Effect on weft ratio 50% cotton: 50% banana:

Table (6) effect of weave structure (Plain, Twill2/2, and satin4) and their effects on dyeing Reactive blue dye on banana/cotton blended or 100% cotton samples.

Weft Ratio	Weave structure	K/S of samples without treatment	K/S of samples with plasma oxygen pre-treatment	K/S of samples with plasma argon pre-treatment
50 % Cotton: 50 % Banana	Plain1/1	19.94	21.82	21.62
	Twill 2/2	19.21	22.71	17.86
	Satin 4	20.22	20.27	18.71
100 **%**Cotton	Plain1/1	17.38	18.74	18.23

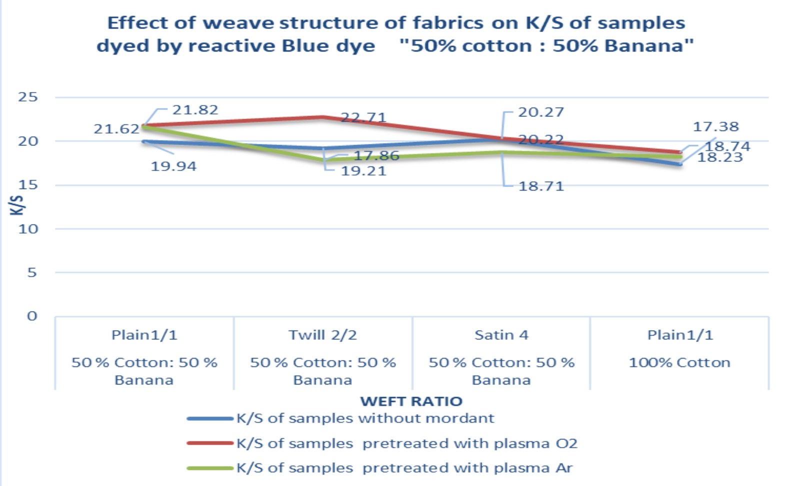

Fig. (12): Effect of weave structure of fabrics on K/S of dyed samples with Reactive blue in presence and absence of plasma treatment.

It is clear from the data of table (6) and figure (12) that, the using of oxygen gas DBD plasma on blended samples or 100% cotton samples obtain higher K/S values than other samples irrespective of weave structure used.

Moreover, the highest K/S value obtained on using oxygen gas DBD plasma on Twill 2/2 sample, was (22.71).

In case of Plain 1/1 blended banana/cotton samples obtained the higher K/S values than Plain 1/1 100% cotton samples on using reactive blue dye in presence and absence of Plasma treatment..

5.1. Effect of pretreated DBD Plasma gas on K/S of dyed samples with Reactive Red:

To study different pre-treatment plasma gases and their effects on dyeing Reactive Red dye on banana/cotton blended or cotton samples, and compared with non-mordanted samples, The K/S values were remarked as shown in Table (7).

Table (7) represents the data of K/S values of using different pre-treatment plasma gases and their effects on dyeing Reactive red (λ 356) , on plain 1/1, Twill 2/2 or satin 4 samples, and compared with non-pretreated samples.

Weave structure	Weft Ratio	Weight undyed (g/m2)	K/S of dyed samples without Plasma	K/S of dyed samples pretreated with Plasma gas	
				O2	Ar.
Plain1/1	75% Cotton 25% Banana	145	3.30	3.35	3.40
	66.6% Cotton 34.4% Banana	143.8	3.33	3.63	3.56
	50 % Cotton 50 % Banana	141.7	3.82	3.95	3.87
	100 “control” **%**Cotton	147.1	3.74	3.61	3.19
Twill 2/2	75% Cotton 25% Banana	143.7	3.14	3.30	4.22
	66.6% Cotton 34.4% Banana	142.7	3.57	3.96	4.30
	50 % Cotton 50 % Banana	138.9	3.72	3.85	3.98
Satin 4	75% Cotton 25% Banana	142.2	3.71	4.16	3.21
	66.6% Cotton 34.4% Banana	141.3	4.11	4.39	3.82
	50 % Cotton 50 % Banana	137.5	3.30	3.63	3.35

5.1.1. Effect on Plain 1/1 fabrics:

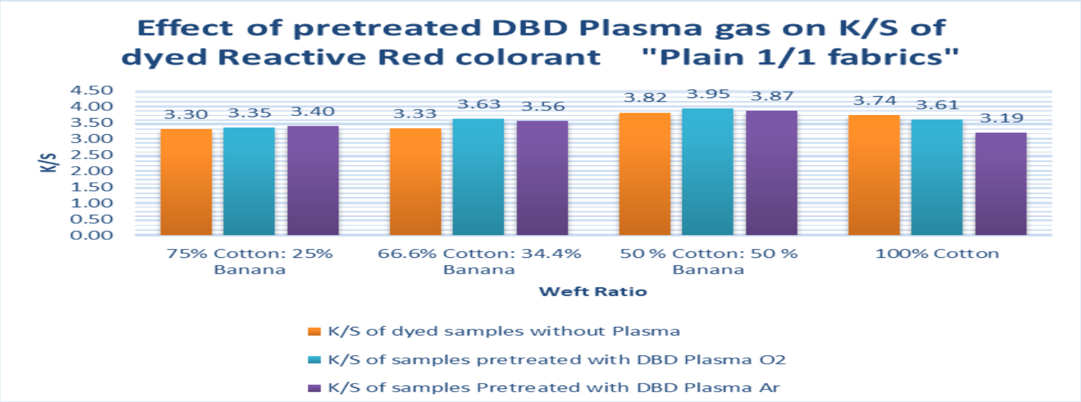

Fig. (13): Effect of using Pre-treatment plasma on dyeing plain fabrics with reactive Red dye in presence of different gases.

It is clear from the data of table (7) and figure (13) that, irrespective of the type of gas used, the obtained K/S values (λ 356) of dyed Pre-treated plasma samples increases, by increasing the banana fibre ratio.

It is also clear from the data that, the highest K/S was obtained on using banana 50:50 cotton blended fabrics.

By comparison banana 50:50 cotton blended fabrics with 100% cotton fabrics, banana's blended samples obtained higher K/S than 100% cotton samples regardless the treated plasma used.

5.1.2. Effect on Twill 2/2 fabrics:

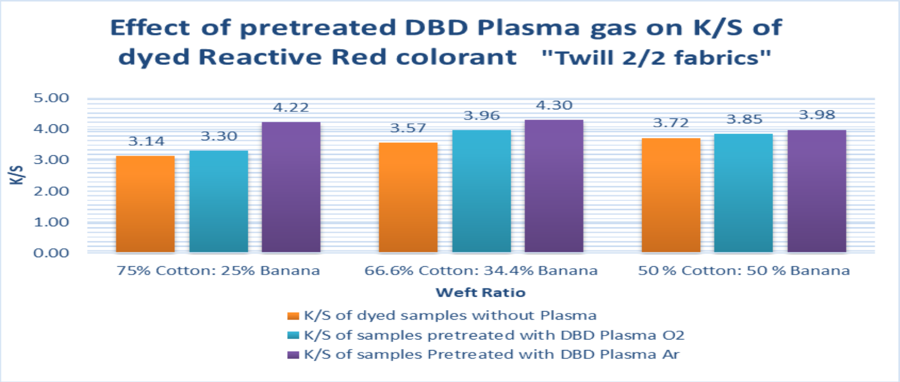

Fig. (14): Effect of using Pre-treatment plasma on dyeing twill 2/2 fabrics with reactive Red dye in presence of different gases.

It is clear from the data of table (7) and figure (14) that, the highest K/S was obtained on using argon gas DBD plasma on Twill 2/2 dyed samples dyed with reactive red dye, irrespective of the banana weft ratio used.

The increasing percentage of K/S of samples dyed with pre-treatment by argon gas was higher than without plasma treatment by (34.39%, 20.45%, 6.99%) on banana ratio (75% cotton: 25% banana, 66.6% cotton: 34.4% banana, 50% cotton: 50% banana) respectively.

By comparison pre-treatment plasma gases "oxygen and argon" effect on K/S values of dyed samples, it is found that samples pre-treated with argon obtained higher K/S than oxygen on twill 2/2 samples.

5.1.3. Effect on Satin 4 fabrics:

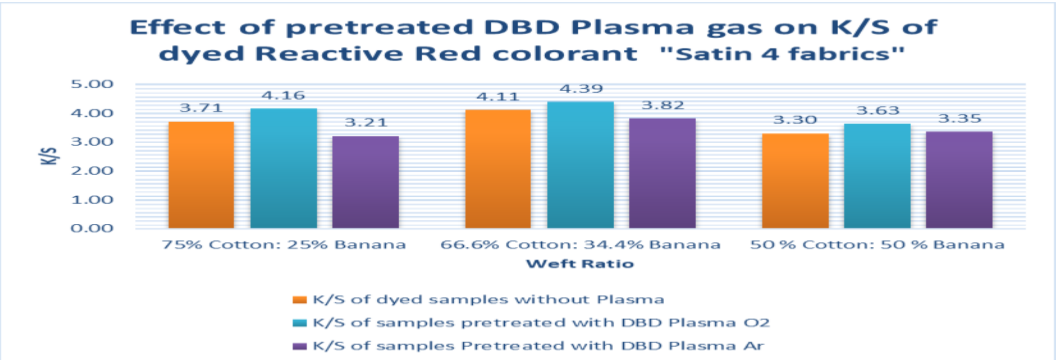

Fig. (15): Effect of using Pre-treatment plasma on dyeing Satin 4 fabrics with reactive Red dye in presence of different gases.

It is clear from the data of table (7) and figure (15) that, the highest K/S values was obtained on using banana weft ratio (66.6% cotton: 34.4% banana) for all satin 4 samples, irrespective of pre-treatment gas used.

By comparison pretreatment plasma gases “oxygen and argon” effect on K/S values of dyed samples, it is found that samples pretreated with oxygen obtained higher K/S than argon on Satin4 samples, irrespective of the banana weft ratio used.

5.2. Effect of weave structure of fabrics on K/S of dyed samples with reactive red dye:

To study different weave structure (Plain, Twill2/2, and satin4) and their effects on dyeing Reactive red on banana/cotton blended with different banana weft ratio (25%, 50%, or 34.4 %) or 100% cotton samples, in presence of Plasma gas (Oxygen and Argon) and compared with non-treated samples, The K/S values were remarked as shown in Tables (8), (9) and (10).

5.2.1. Effect on weft ratio 75% cotton: 25% banana:

Table (8) effect of weave structure (Plain, Twill2/2, and satin4) and their effects on dyeing Reactive Red dye on banana/cotton blended or 100% cotton samples.

Weft Ratio	Weave structure	K/S of samples without treatment	K/S of samples with plasma oxygen pre-treatment	K/S of samples with plasma argon pre-treatment
75% Cotton: 25% Banana	Plain1/1	3.30	3.35	3.40
	Twill 2/2	3.14	3.30	4.22
	Satin 4	3.71	4.16	3.21
100 %Cotton	Plain1/1	3.74	3.61	3.19

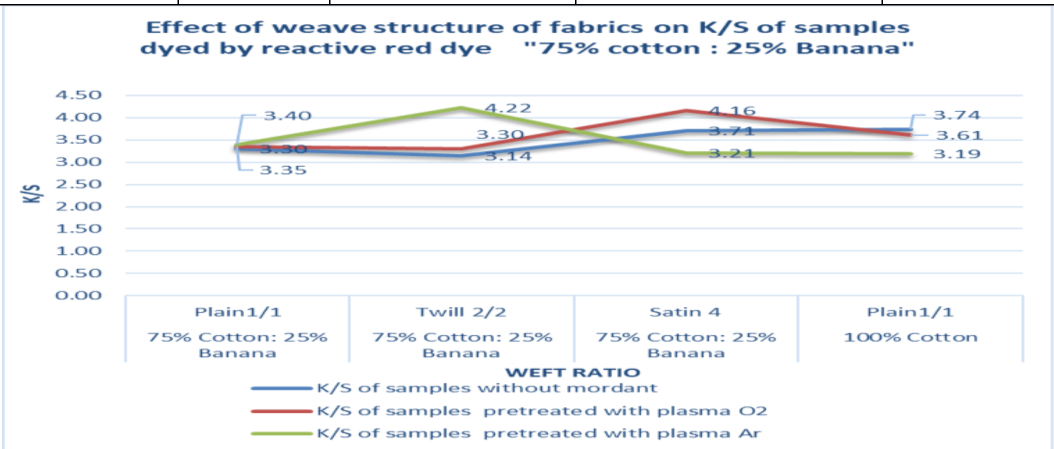

Fig. (16): Effect of weave structure of fabrics on K/S of dyed samples with Reactive red in presence and absence of plasma treatment.

It is clear from the data of table (8) and figure (16) that, the highest K/S was obtained on using argon gas DBD plasma on Twill 2/2 sample dyed with reactive red dye (4.22), and (4.16) with using oxygen gas DBD on satin 4.

5.2.2. Effect on weft ratio 66.6% cotton: 34.4% banana:

Table (9) effect of weave structure (Plain, Twill2/2, and satin4) and their effects on dyeing Reactive Red dye on banana/cotton blended or 100% cotton samples.

Weft Ratio	Weave structure	K/S of samples without treatment	K/S of samples with plasma oxygen pre-treatment	K/S of samples with plasma argon pre-treatment
66.6 % Cotton: 34.4 % Banana	Plain1/1	3.33	3.63	3.56
	Twill 2/2	3.57	3.96	4.30
	Satin 4	4.11	4.39	3.82
100 %Cotton	Plain1/1	3.74	3.61	3.19

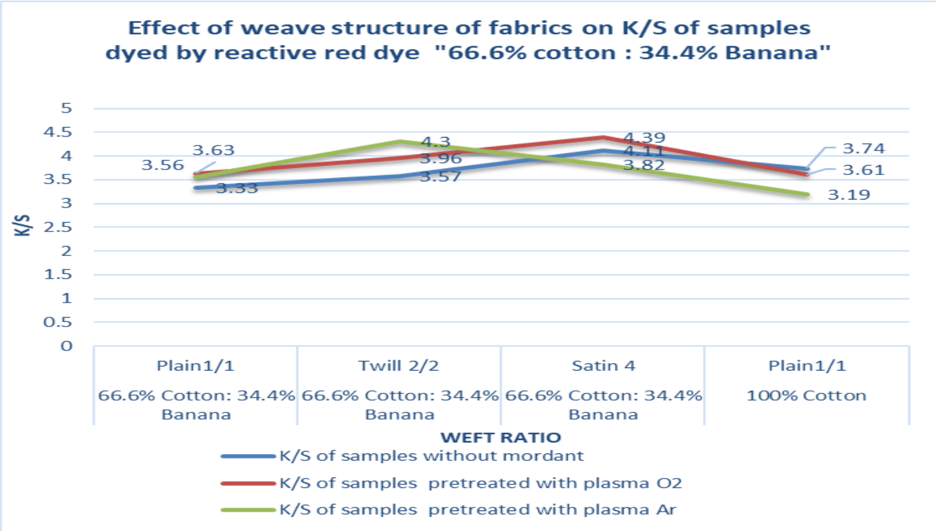

Fig. (17): Effect of weave structure of fabrics on K/S of dyed samples with Reactive red in presence and absence of plasma treatment.

It is clear from the data of table (9) and figure (17) that, the highest K/S was obtained on using argon gas DBD plasma on satin 4 sample dyed with reactive red dye (4.39), and (4.30) with using oxygen gas DBD on Twill 2/2.

Besides by using oxygen Plasma pretreated with banana: cotton blended samples present the K/S values higher than the un-treated samples.

5.2.3. Effect on weft ratio 50% cotton: 50% banana:

Table (10) effect of weave structure (Plain, Twill2/2, and satin4) and their effects on dyeing Reactive Red dye on banana/cotton blended or 100% cotton samples.

Weft Ratio	Weave structure	K/S of samples without treatment	K/S of samples with plasma oxygen pre-treatment	K/S of samples with plasma argon pre-treatment
50 % Cotton: 50 % Banana	Plain1/1	3.82	3.95	3.87
	Twill 2/2	3.72	3.85	3.98
	Satin 4	3.30	3.63	3.35
100 %Cotton	Plain1/1	3.74	3.61	3.19

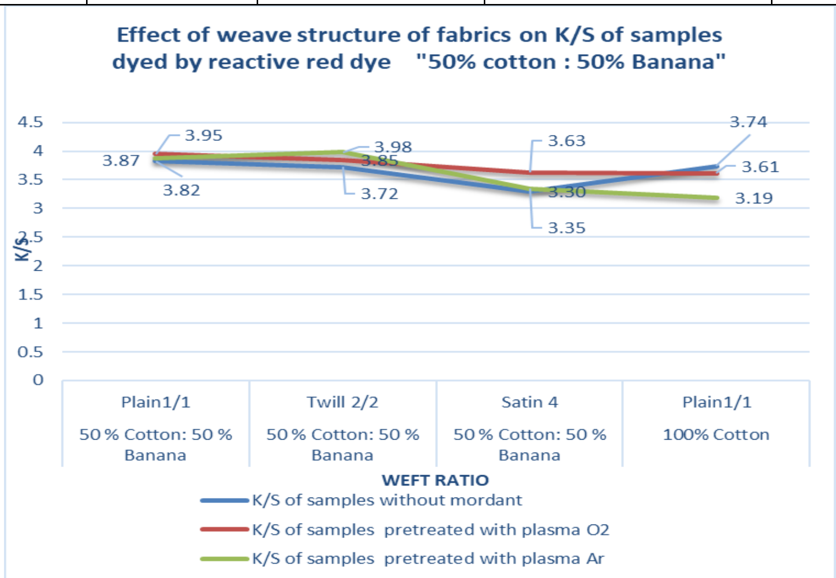

Fig. (18): Effect of weave structure of fabrics on K/S of dyed samples with Reactive red in presence and absence of plasma treatment.

It is clear from the data of table (10) and figure (18) that, the highest K/S was obtained on using argon gas DBD plasma on Twill 2/2 sample dyed with reactive red dye (3.98), and (3.95) with using oxygen gas DBD on plain 1/1.

By comparison pretreatment plasma gases “oxygen and argon” effect on K/S values of dyed samples with untreated samples, it is found that samples pretreated obtained higher K/S values than untread samples, irrespective of fabric structure.

6.1. Table (11): Colour strength (K/S) and overall fastness properties of plain 1/1, Twill 2/2, and Satin 4 dyed with reactive dye.

Samples No.	Samples Dyed with Reactive Blue dye "Remazol"					Washing fastness		Rubbing fastness		Perspiration			
	Weave structure	Weft Ratio	Weft arrangement	Treat ment	K/S of dyed fabric					Acidic		Alkaline	
						Alt.	St.	Dry	Wet	Alt.	St.	Alt.	St.
1	Plain1/1	75% Cotton 25% Banana	1 Cotton : 1 Blended	Without Plasma	16.18	3-4	3-4	4	3-4	4	3-4	4	3-4
2	Twill 2/2				16.89	3-4	3-4	3-4	3-4	3-4	3-4	3-4	3-4
3	Satin 4				17.56	3	3	3-4	3-4	3-4	3-4	3-4	3
4	Plain1/1	66.6% Cotton 34.4% Banana	1 Cotton : 2 Blended		16.29	4	3-4	4	4	3-4	3-4	4	3-4
5	Twill 2/2				18.34	3-4	3-4	3-4	3-4	3-4	3-4	3-4	4
6	Satin 4				20.20	3-4	3	3-4	3-4	3-4	3	3-4	3-4
7	Plain1/1	50 % Cotton 50 % Banana	Blended		19.94	3-4	3-4	3-4	3-4	3-4	3-4	4	3-4
8	Twill 2/2				19.21	3-4	3-4	3-4	3-4	3-4	3-4	3-4	3-4
9	Satin 4				20.22	3	3	3-4	3	3-4	3-4	3	3-4
10	Plain1/1	100% Cotton	Cotton		17.38	4	4-5	4	4	4	4	4	3-4
11	Plain1/1	75% Cotton 25% Banana	1 Cotton : 1 Blended	With O2 Pre-treatment Plasma	22.09	4-5	4	4-5	4-5	4-5	4	4-5	4
12	Twill 2/2				22.61	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
13	Satin 4				19.90	4	4	4-5	4-5	4-5	4-5	4-5	4-5
14	Plain1/1	66.6% Cotton 34.4% Banana	1 Cotton : 2 Blended		22.97	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
15	Twill 2/2				23.14	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
16	Satin 4				20.29	4-5	4	4-5	4-5	3-4	4	4-5	4-5
17	Plain1/1	50 % Cotton 50 % Banana	Blended		21.82	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
18	Twill 2/2				22.71	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
19	Satin 4				20.27	4	4-5	4-5	4-5	4	4-5	4-5	4-5
20	Plain1/1	100% Cotton	Cotton		18.74	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
21	Plain1/1	75% Cotton 25% Banana	1 Cotton : 1 Blended	With Ar. Pre-treatment Plasma	21.34	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
22	Twill 2/2				16.92	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
23	Satin 4				19.56	4-5	4	4	4-5	4	4-5	4	4
24	Plain1/1	66.6% Cotton 34.4% Banana	1 Cotton : 2 Blended		22.77	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
25	Twill 2/2				22.35	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
26	Satin 4				19.80	4	4	4-5	4-5	4-5	4-5	4	4-5
27	Plain1/1	50 % Cotton 50 % Banana	Blended		21.62	4-5	4-5	4-5	4-5	4-5	4-5	4	4-5
28	Twill 2/2				17.86	4-5	4-5	4-5	4-5	4-5	4	4-5	4-5
29	Satin 4				18.71	4	4-	4-5	4	4-5	4	4	4
30	Plain1/1	100% Cotton	Cotton		18.23	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5

Alt. : Alteration St.: Staining

Samples No.	Samples Dyed with Reactive Red "Levafix"					Washing fastness		Rubbing fastness		Perspiration			
	Weave structur e	Weft Ratio	Weft arrangement	Treat ment	K/S of dyed fabric					Acidic		Alkaline	
						Alt.	St.	Dry	Wet	Alt.	St.	Alt.	St.
31	Plain1/1	75% Cotton 25%Banana	1 Cotton : 1 Blended	Without Plasma	3.30	4	4	4	3-4	4	4	4	3-4
32	Twill 2/2				3.14	4	4	3-4	3-4	3-4	3-4	3-4	3-4
33	Satin 4				3.71	3-4	3-4	3-4	3-4	3	3-4	3-4	3-4
34	Plain1/1	66.6% Cotton 34.4%Banana	1 Cotton : 2 Blended		3.33	4	3-4	3-4	3-4	3-4	3-4	4	3-4
35	Twill 2/2				3.57	4-5	4	3-4	3-4	3-4	3-4	3-4	3-4
36	Satin 4				4.11	3-4	3-4	3-4	3-4	3	3-4	3	3-4
37	Plain1/1	50 % Cotton 50 % Banana	Blended		3.82	4-5	4	3-4	3-4	3-4	4	3-4	3-4
38	Twill 2/2				3.72	4-5	4	3-4	3-4	3-4	3-4	3-4	3-4
39	Satin 4				3.30	3	3-4	3-4	3-4	3	3-4	3	3-4
40	Plain1/1	100% Cotton	Cotton		3.74	4	4	4	3-4	4	3-4	4	3-4
41	Plain1/1	75% Cotton 25% Banana	1 Cotton : 1 Blended	With O2 Pre-treatment Plasma	3.35	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
42	Twill 2/2				3.30	4-5	4	4-5	4-5	4-5	4-5	4-5	4-5
43	Satin 4				4.16	4-5	4	4	4	4-5	4	4-5	3-4
44	Plain1/1	66.6% Cotton 34.4%Banana	1 Cotton : 2 Blended		3.63	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
45	Twill 2/2				3.96	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
46	Satin 4				4.39	4-5	4	4-5	4	4	4-5	4	3-4
47	Plain1/1	50 % Cotton 50 % Banana	Blended		3.95	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
48	Twill 2/2				3.25	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
49	Satin 4				3.63	4-5	4-5	4-5	4	4	4-5	4	4
50	Plain1/1	100% Cotton	Cotton		3.61	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
51	Plain1/1	75% Cotton 25% Banana	1 Cotton : 1 Blended	With Ar. Pre-treatment Plasma	3.40	4-5	4	4-5	4-5	4-5	4-5	4-5	4-5
52	Twill 2/2				4.22	4-5	4	4-5	4-5	4-5	4-5	4-5	4-5
53	Satin 4				3.21	4-5	4	4-5	4-5	4-5	4	4-5	3-4
54	Plain1/1	66.6% Cotton 34.4%Banana	1 Cotton : 2 Blended		3.56	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
55	Twill 2/2				4.30	4-5	4	4-5	4-5	4-5	4-5	4-5	4-5
56	Satin 4				3.82	4-5	4	4-5	4-5	4	3-4	4-5	3-4
57	Plain1/1	50 % Cotton 50 % Banana	Blended		3.87	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
58	Twill 2/2				3.98	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
59	Satin 4				3.35	4-5	4	4-5	4-5	4	4-5	4-5	4
60	Plain1/1	100% Cotton	Cotton		3.19	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5

Alt. : Alteration St.: Staining

The color fastness properties of the natural fabrics (blended banana/cotton or 100% cotton) dyed with Reactive dye (Remazol Blue, Levafix Red) in presences of DBD plasma gas (Oxygen or Argon) or without pretreated with plasma were measured.

Table (11) represents the data for the K/S values and the color fastness to washing, to rubbing, and to perspiration for deferent weave structure (Plain1/1 – Twill 2/2 – Satin 4) dyed with reactive dyes.

The first glance at the result of table would imply that the color strength (K/S) for the dyed samples with Oxygen Pretreated plasma is higher than with Argon “Pre-treated plasma” or without treatment plasma.

The research indicates that washing, rubbing, and perspiration properties range from good to very good in the absence of plasma pretreatment. While In case of plasma treatment the data shows that washing and rubbing and perspiration properties ranging from very good to excellent.

7. CONCLUSIONS:

- Using various reactive dyes, blended Banana/Cotton woven fabrics were satisfactorily dyed.
- The chemical changes in textiles caused by plasma treatment are significantly influenced by the chemical structure of the textile and the plasma gas used. By adding new chemical groups, various plasma gases can cause varied functions to appear on the surface of textiles. For instance, plasma containing oxygen (O2) can add new C=O or O-C-O groups to cellulosic fibres, whereas plasma containing nitrogen can add new C-N or O=C=NH groups [14, 24].
- Samples treated with pretreatment plasma DBD had higher K/S than untreated samples, regardless of the weft ratio and weft arrangement.
- In all banana ratios, the oxygen gas pretreatment plasma DBD technique produced the highest K/S values compared to argon gas pretreatment.
- By comparison weave structure of banana 34.4% :66.6% cotton blended fabrics dyed with Remazol Reactive blue dye, Twill 2/2 samples obtained highest K/S than plain or satin 4 fabrics.
- By comparison weft arrangement of samples on plain fabrics dyed with Reactive Levafix red dye, banana’s blended samples (Cotton 1:2 blended) obtained higher K/S than 100% cotton samples regardless the plasma gas used.
- Pretreatment samples' washing, rubbing, and perspiration properties range from very good to excellent.
- The utilization of banana fibre will enhance the community's sustainable growth.

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