Single-Bath Bio-Treatment and Dyeing of Cotton Fabrics with Reactive or Direct Dyes

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Abstract

Cotton fabrics(unscoured and scoured) were bio-treated with cellulase enzyme and dyed in one bath using reactive (MCT , VS) and direct dyes.

Factors affect enzyme role such as enzyme concentration and time of treatment were studied .Effect of using non- ionic surfactant at the optimum condition of enzyme treatment using MCT and direct dyes on unscoured cotton fabrics was studied. The action of enzyme concentration on the degree of wettability of treated cotton fabrics(unscoured and scoured) dyed with MCT and direct dyes was investigated. The pilling resistance of treated unscoured and scoured cotton fabrics dyed with MCT at the optimum condition was investigated to determine the effect of enzyme on the appearance of cotton fabric, comparing the results with control sample .Colour strength ,tensile strength and the fastness colour properties such as fastness to washing , crocking , perspiration and light were measured for bio-treated and dyed samples.

The results showed an enhancement in the colour strength especially with MCT and direct dyes while VS did not succeed with this process due to the hydrolysis of dye .The improvement in colour strength was found to depend on ; degree of hydrolysis of cotton cellulose ; characteristics of dyes used ; degree of impurities in cotton fabric as well as on addition of surfactant .Using one-bath bio- treatment and dyeing technique was observed to improve the fibre wettability and the pilling resistance of cotton fabric along with slight reduction in tensile strength.

Fastness properties showed results ranged from fair to very good which depended on the type of fabrics , enzyme treatment and dyes used.

Key words : Cotton fabric ; Cellulase enzyme ; One bath ; Reactive and direct dyes ;Colour strength ;Wettability ; Pilling resistance .

1-Introductionm

Various types of enzymes have been applied at different stages of the fabric manufacturing process to obtain less energy ,fewer process stages and hydrolysis of proteins, starches, lipids, pectins, celluloses and hemicelluloses substrates .[1] A variety of new enzyme based products and process (using cellulases, amylases, lipases, as well as proteases) have already been marketed .[2] Biotechnology involves the production, isolation, modification and using of substances derived by means of biosynthesis , including enzyme. Enzymes being natural products which completely biodegradable and accomplish their work quietly and efficiently without leaving any pollution behind. Also, the process would operate at relatively low temperature and atmospheric pressure with little by- product formation. [3]

Cellulase is used to modify the surface and properties of cellulosic fibres and fabrics in order to achieve desired hand or surface effect.[4] Because the cellulase enzyme, being a biocatalyst, offers advantages such as energy savings through lower temperature of 40-50^{0}C, low environmental impacts by avoiding the use of chemicals and low cost by using only the catalytic amount, better use of cellulase enzyme can be an answer to the desire for both cleaner and less pollution textile technology and high-grade goods with added value.[5] Cellulase and pectinase were very effective in scouring raw or unpurified cotton. The structural changes in the surfaces of cotton caused by the enzymatic treatment and resulting properties were also studied.[3] The rate of catalytic hydrolysis of cotton fabrics by a cellulase enzyme in the presence of surfactants in treatment solution , the study of dye-surfactant interactions and their influences in the dyeing textile fibres were investigated . [6-9] The effect of direct and reactive dyes especially bifunctional reactive dyes on the enzymatic hydrolysis of cotton was investigated. It has been revealed that direct and reactive dyes in the substrate inhibit the cellulase catalytic reaction.[10-14] It was also found an inhibitory effect of ionic dyes and ionic surfactants on cellulase activity in the treatment solution and proposed an electrostatic dye-enzyme interactions. [5,10] It is well established that controlled treatment with cellulases optimizes surface properties of cotton fabric whereas decrease in tensile strength , stiffness and a looser structure are observed.[15,16] Promising research areas include bioscouring of cotton, bleaching aids for cellulose fibres , biostoning, new approaches to finishing cotton including cellulase enzyme have been reported.[17-19]

The advent of new enzymatic technology in recent years has prompted the feasibility of combining-polishing and dyeing by adding a cellulase enzyme at the beginning of dyeing cycle.[20]

Cellulase treatment is usually carried out subsequently to dyeing process . Only a few studies have been published dealing with the effect of dyes in conjunction with enzyme treatment[21,22] .Accordingly the present work is under taken to study the possibility of using cellulase enzyme in dyebathes containing direct and reactive dyes for simultaneous bio-treatment and dyeing of cotton fabric, in order to improve the colour depth , wettability and pilling resistance.

2-Experimental

2-1-Materials

Fabrics

Cotton fabric: 100% raw cotton fabric [130 gm/m^2] was used throughout this investigation .It was received from Misr Helwan Co. for Spinning and Weaving, Helwan, Egypt.

Dyestuffs*:*

Reactive dyes

***** Modercion Red H-E3B, monochlorotriazine (C.I. Reactive Red 120).

*Moderzol Brill. Blue R , vinyl sulphone (C.I.Reactive Blue 19).

Direct dyes

* Moderdirect Blue 4G (C.I. Direct Blue 202).

The reactive and direct dyes were received from Modern Dyestuff &Pigments Co.,Ltd. Thailand.

Cellulase enzyme:

Cellusoft®L (acid cellulase solution) is a cellulase (EC 3.2.1.4) produced by submerged fermentation of a Trichoderma and a genetically modified Aspergillius microorganism. , supplied by Novozymes.

Chemicals and auxiliaries:

Kieralon AE 3D (non-ionic wetting , BASF),Antisil Conz.(sequestering agent ;Eksoy,Turk.), sodium hydroxide , sodium sulphate , sodium carbonate , and glacial acetic acid .

2-2 Methods:

The biotreatment and dyeing were carried out for unscoured and scoured cotton fabrics which performed in lab- scale incubator-shaker.

**Scouring of cotton fabrics:-*

Cotton fabrics were scoured in a bath containing 2g/L non-ionic wetting agent, 4ml/L sodium hydroxide (32.5%), 0.5g/L sequestering agent, at 95^{O}C for 60 min. at L R 1:50 . The fabrics were rinsed, neutralized with acid then rinsed with hot and cold water and dried

**One bath bio- treatment and dyeing process*

The dyeing operation was carried out in two steps at one bath:-

1-Biotreatment step :

1gm of unscoured and/or scoured cotton fabrics were entered to the bath which contained 1% owf (Modercion Red H-E3B),(Moderzol Brill. Blue R)and/or (Moderdirect Blue 4G) at L.R 1:50 , (0 – 2ml/L) cellulase ,at pH value 5.5 , temperature raised to (50- 55^{O}C) for (15 – 75min.).

2-Dyeing step:

Dyeing with "Modercion Red H-E3B"(MCT) :

The dyebath temperature was raised to 80^{o}C at (1.6^{O}C/min.) the sample was lifted from the dyebath before adding 20g/L sodium sulphate in three portions through 30 min., after 10 min. alkali (20g/L sodium carbonate) was added in two portions through 10 min. , then the dyeing was continued for 60 min.

(The temperature as well as the alkali deactivated the enzyme. After the addition of alkali, the normal recommended procedure was followed).

Dyeing with" Moderzol Brill. Blue R "(VS) :

The dyebath temperature was raised to 80^{o}C for 15min. to deactivate the cellulase enzyme then the temperature decreased to 60^{o}C., sodium sulphate 20g/L was added after 10 min in three portions through 30 min. After 10 min. Sodium carbonate 20g/L was added in two portions through 20 min . , then dyeing operation was continued for another 50 minutes.

Dyeing with (Moderdirect Blue 4G):

The temperature increased to 90^{o}C(at 1.6^{o}C/min.) ,the sample was lifted from the dyebath and 15g/L sodium sulphate was added in three equal portions every 10 min., then dyeing continued for another 30 minutes.

After dyeing the samples rinsed, soaped with 3g/L non-ionic detergent , for 15 min. at 70^{o}C then rinsed and dried.

Effect of non- ionic surfactant concentration:

Unscoured cotton fabrics were biotreated and dyed with (*Modercion Red H-E3B*) and (*Moderdirect Blue 4G*) at optimum condition of enzyme treatment using (0-2g/L) of non-ionic surfactant in order to detect the action of surfactant on the efficiency of enzymatic treatment .

2-3 Measurements and testing

2-3-1 Colour measurements:

The dyed samples were subjected to colour measurement by using reflection spectrophotometer model ICS-Texicon Limited, Kennetside Park, New Burg, Berkshire, England. The colour strength expressed as K/S values was assessed by applying the Kubelka Munk equation:

$$K/S= \frac{(1- R)}{R_O}$$

Where, R=Decimal fraction of the reflectance of the dyed sample , R_0=Decimal fraction of the reflectance of the undyed sample , K=Absorption coefficient, S=Scattering coefficient.

2-3-2 Determination of wettability of cotton fabric:

This test was intended for use in determining the effect of enzyme conc. on the rate of absorption of cotton fabric. This test was carried out by putting drop of water on the fabric surface and calculating the passed time until the fabric absorbed the water drop.

2-3-3Determination of tensile strength of fabric:

This test was intended for use in determining the strength of dyed cotton fabric without enzyme and change in the tensile after biotreatment and dyeing using cellulase enzyme. This test was carried out according to ISO standard method [ISO 13934-1].

2-3-4 Determination of pilling resistance:

The pill rating on the interlock fabrics before and after five cycles were carried out to determine the action of using cellulase enzyme in the dyebath on the physical properties of cotton fabric especially pilling resistance.

2-3-5 Colour fastness:

Fastness properties of dyed samples were tested according to ISO standard methods. The specific tests were: S 105-X12(1987), colour fastness to rubbing; ISO 105-C02 (1989), colour fastness to washing; and ISO 105-E04, colour fastness to perspiration. The dyed samples were subjected to tests, for fastness to light by AATCC test method 16-1993.

3- Results and Discussion

The enzymes contain true active centers in the form of three- dimensional structures as fissures, holes, pockets, and cavities or hollows. The active site is a part of the enzyme molecule that combines with the substrate. The number of active sites per enzyme molecule is very small. To catalyze a reaction, the enzyme molecule makes a complex adsorbed onto the surface of substrate in lock and key fashion. [4]

Commercial cellulases used in the textile industry are usually crude mixture, consisting of a multiple enzyme system. The crude mixture secreted by Trichoderma Reesei fungi consists of the three major types of cellulase, endoglucanases, exogluca-nasesand and B-glucosidases. All three types of enzyme exhibit different activities to cellulose. Endoglucanases cut at random amorphous sits of the cellulose chain producing oligosaccharide of various length and new reducing and non-reducing ends on the fibre surface. Exoglucanases attack the reducing or non- reducing ends of cellulose chain, liberating glucose or cellobiose as major products; and β-glucosidases remain in the solution hydrolysing small chain reducing sugars to glucose. [2,23, 24]

The cotton fibre consists of structural and reserve polysacharides. The cuticle is the outer layer and it is a mixture of waxes, pectin and proteins. It is a soft cover that functions as water- resistance and protective layer to other parts of the fibre.This hydrophobic outer layer is removed in the scouring process. [25]

The present study is interested in finding the relationship between cellulose fabric (unscoured and scoured) ,cellulase enzyme , and the dyes used when the biotreatment and dyeing were carried out in one bath and acceptability of improving the colour strength . This study was focused on the factors that may affect the enzyme mechanism at the stage of treatment and the effect of using this enzyme on the colour strength and the physical and mechanical properties of cotton fabric.

The action of enzyme treatment is presented in terms of increasing enzyme conc. (dosages)and treatment time , which are considered the two major factors in the effectiveness of enzymatic treatment on cotton.

3-1 factors affect the biotreatment step of scoured and unscoured cotton fabrics during dyeing with reactive and direct dyes:

3-1-1 Effect of enzyme concentration:

The effect of enzyme concentration on the colour strength of dyed scoured and unscoured cotton fabrics using MCT, VS and direct dyes are cited in **Fig.1**

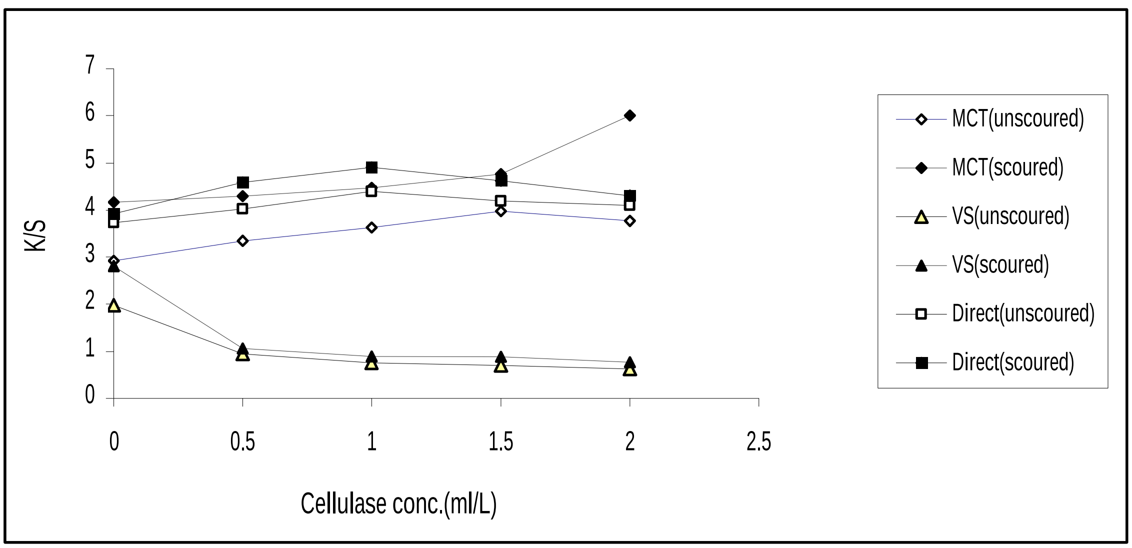

Fig. 1 : Effect of cellulase conc. on the colour strength of treated and dyed cotton fabrics(unscoured and scoured) with MCT,VS and Direct dyes.

Biotreatment condition:-
MCT, VS, direct : pH5.5 , Time : 30 min., Temp. : 50^{O} C .

It is noticed that in case of MCT the unscoured and scoured cotton fabrics showed an increase in the colour strength (K/S) as the concentration of enzyme increased till 1.5ml/L then the colour strength declined ,while VS dye showed decreasing in K/S as the concentration of enzyme increased with unscoured and scoured samples . Direct dyeing gave gradual increase in K/S till 1ml/L cellulase enzyme then declined and that was true in case of unscoured and scoured samples.

The colour strength of pre-scoured cotton fabric dyed with both reactive and direct dyes was found to be relatively higher than unscoured cotton which is attributed to the higher accessibility of pre-scoured cotton to the action of cellulase enzyme as a result of removing the hydrophobic cuticle layer on fibre surface.

The rate of enzymatic hydrolysis of cellulose is known to depend to great extent on i) its physical form , ii) degree of swelling , orientation and crystallinity , iii) prior wet processing of fibre and/or fabric.[26]

The colour strength (K/S) of pre-scoured cotton is found to increase by about 21.74% compared to unscoured ones when dyed with reactive dye(MCT) and at 1.5ml/L cellulase enzyme. The difference in K/S, in case of direct dye , not exceed about 14.45% in favor of pre-scoured cotton and at 1ml/L cellulase enzyme.

The increase in colour shade (K/S) on unscoured cotton material by adding cellulase enzyme in the dye bath with reactive and direct dyes is attributed to the catalytic action of enzyme on the outer surface of cotton fibres. It was established that cellulase enzyme can destroy the cuticle structure by digesting the primary wall cellulose under the cuticle of cotton resulting in faster rate of water absorption and diffusion of dye molecules inside the fibre. [26,27] By increasing the enzyme concentration over the suitable levels (1.5ml/L for reactive dye and 1ml/L for direct dye)the K/S was decreased which may be proposed to the increased electrostatic dye-enzyme interaction resulting in an inhibitory effect of cellulase activity.[6,28]

The electrostatic attraction between enzyme and anionic dyes may be represented as follows :[29]

$$Enz - NH^{+}_{3} \ldots\ldots {}^{-}O_{3}S - D$$

It may be also suggested that the formation of dye–enzyme complexes is increased by increasing the enzyme conc. resulting in diminishing the rate and degree of dye exhaustion leading to final lower colour strength on cotton fabric.[30]

In case of remazol dye (VS) the situation was different since adding of small amount of cellulase enzyme in dyebath containing the vinyl sulphpne dye resulted in sharp decrease in the obtained colour strength on both pre-scoured and scoured cotton materials. This result illustrates the unsuitability of this type of reactive dyes for applying by this new technique.

Vinyl sulphone dyes are known to be of higher reactivity compared to monochlorotiazine. Therefore, it is suggested that a chemical reaction between reactive dye and enzyme protein may be carried out under the treatment condition (pH=5.5 and 50^{o}C temp.)

Vinyl sulphone dye owing to its relatively high reactivity may react with the amino group of enzyme protein through a covalent bond between them, leading to formation of enzyme-dye complex compound. In this case there are two possibilities:

a)- The enzyme- dye complex compound still in the medium as inactive form.

b)- A further catalytic hydrolysis may be carried out with debinding of dye from the enzyme active site to yield hydrolysed dyes , in both cases the reactive dye will be transformed into a form having no ability to react chemically with cotton cellulose . This result is of good agreement with the hydrolysis of dichlorotiazine dye by cellulase enzyme which was established in previous study.[31]

3-1-2 Effect of enzymatic treatment time:

Pre- scoured as well as unscoured cotton materials were subjected to treatment with cellulase enzyme in a bath containing reactive or direct dyes for various duration (15-75 min.) in order to determine the most suitable time for achieving highest colour strength.

Fig.2 illustrates the effect of enzymatic treatment time on the (K/S) of the dyed cotton samples using reactive and direct dyes . The colour strengths were noticed to increase by lasting the period of enzymatic treatment and reach their maximum values after treatment for 60 min. for direct dye on both pre–scoured and scoured cotton materials. For reactive dye maximum K/S are attained when enzymatic treatment is performed for 45and 60 min. for pre- scoured and unscoured cotton samples respectively.

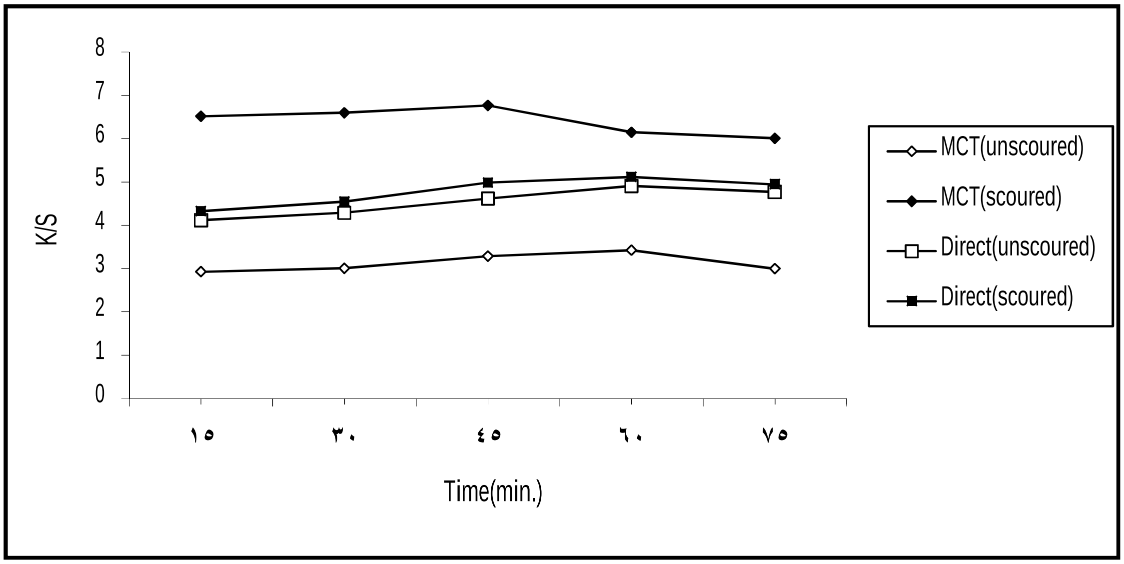

Fig.2 Effect of time treatment of cellulase on the colour strength of treated and dyed cotton fabrics (unscoured and scoured) with MCT and Direct dyes.

Biotreatment condation:-
MCT : - 1.5 mL/l enzyme, pH 5.5 , 50°C .
Direct:- 1ml/L enzyme, pH 5.5 , 50°C .

The digestion rate of fibres is increased by lasting the treatment time , at the early stage of treatment , the digestion rate is quit fast . however , after 60 min. of treatment , the rate of digestion slightly decreases .

The difference in results between unscoured and scoured samples may be because the scouring operation accelerated the rate of digestion as a result of removing the hydrophobic cuticle layer of cotton fibres.

3-2Ef fect of non-ionic surfactant

The surface active agents, specially the non-ionic surfactants have found wide industrial application as dyeing assistants , leveling , retarding , wetting , emulsifier and frothing agents . A large proportion of commercial non-ionic surfactants consists of an alkalyl chain bonded to a polyethyloxy chain of variable length. Surfactants molecules are made up of two parts a relatively large elongated part and a small solubilizing polar group, and the balance between these two parts gives surface activity. The effectiveness of enzymatic treatment can be influenced by many factors , one of which is addition of surfactants . Therefore, the influence of using non-ionic surfactant at different conc. (zero up to 2g/L) during the enzymatic treatment and dyeing in one bath was also studied in details.

Fig 3 represents the relation between surfactant conc. and K/S of the dyed unscoured cotton samples. Colour strength of dyed samples was found to increase as a result of using non-ionic surfactant and maximum increase is realized at 1 and 1.5 g/L surfactant for direct and reactive dyes respectively.

Surfactants enhance the wetting of cotton fibres and facilitate the entry by enzyme molecules to inner fibre structure. As a result the enzyme molecule will reach the contact sites of the fibres and orient themselves in suitable position for hydrolytic activity.[32]

The rate and amount of water absorption by cotton fibre is increased in presence of wetting agent resulting in fibre swelling which promote the enzymatic attack.[33].

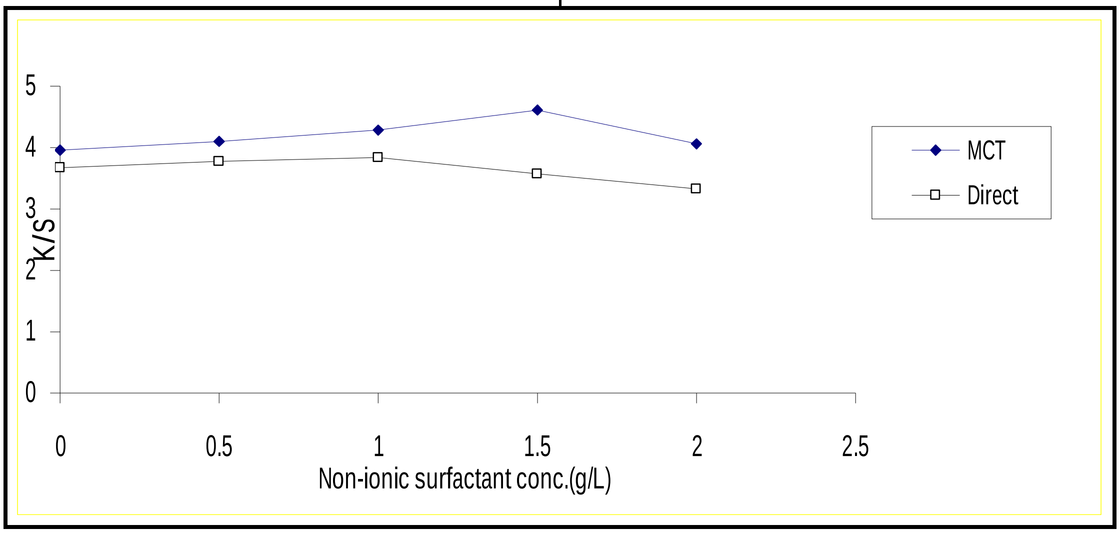

Fig.3 Effect of non-ionic surfactant conc. on the colour strength of biotreated and dyed unscoured cotton fabics with MCT and Direct dyes.

3-3 Determination of the wettability of cotton fabric:

To evaluate the effect of enzyme on absorbability of cotton fabric ,the wettability of the biotreated and dyed unscoured and scoured cotton fabrics with MCT and direct dyes were carried out at different conc. of cellulase enzyme(0-2ml/L)comparing the results with the blank. The data are illustrated in **Table 1.**

The wettability of blank cotton fabrics without enzyme was low because of the cotton impurities which prevent the water penetration whereas when treated with enzyme the wettability showed improved results beginning with using lower conc. which may be attributed to the rapid hydrolysis of cotton cellulose even by using small amount of cellulase enzyme . The results showed increasing in the wettability of unscoured dyed samples where it gave a constant and higher values with MCT and these results were better than the direct dye results and that may be due to the type of dye and dyeing condition which may play a role in the increasing of the wettability where the high temperature(80^{O}C) and adding sodium carbonate to the MCT dye bath which enhancing scouring of the cotton sample through the dyeing process leading to improvement in wettability whereas direct dyeing operation carried out at (90^{O}C) without adding any alkali .

The wettability of scoured undyed sample was improved and showed higher value compared to unscoured fabric and that reflects the effect of scouring operation on the absorbability of cotton fabric to water .

3-4 Determination of the tensile strength:

Enzyme treatment of fabrics is known to have a negative impact on the fabrics tensile characteristics .Cellulase act on the fibre by splitting the cellulose chain causing weakening and fragmentation of cotton fabrics. Mechanical agitation will prevent the enzyme from diffusion into the interior of fabric.[34,35]

Table 2 indicates the effect of using enzyme on the tensile strength of the (unscoured and scoured) fabrics dyed with MCT and direct dyes where from the results it can be observed that the tensile strength followed the decreasing order: dyed unscoured fabric with enzyme > dyed unscoured fabric + enzyme + non ionic surfactant >dyed scoured fabric + enzyme comparing the results with control samples .

The tensile strength of unscoured cotton sample that treated with cellulase enzyme in presence of non-ionic surfactant is found to substantially decrease which may be attributed to the increased catalytic reaction of enzyme by the surfactant.

Table1:Effect of enzyme conc. on the wettability of treated (unscoured and scoured) cotton fabrics .

Enzyme conc.(ml/L)	***Wettability (absorption time of water drop)***					
	Unscoured			***Scoured***		
	Undyed control	***Dyed with (MCT)***	***Dyed with (Direct)***	***Undyed control***	***Dyed with (MCT)***	***Dyed with Direct***
0	***3.03 h.***	***3min.***	***3.00 h.***	***15 sec.***	***4 sec.***	***10 sec.***
0.5		***30sec.***	***55 sec.***		***4 sec.***	***10 sec.***
1		***30sec.***	***90 sec.***		***5 sec.***	***10 sec.***
1.5		***30sec.***	***90 sec.***		***5 sec.***	***10 sec.***
2		***30sec***	***90 sec.***		***5 sec.***	***10 sec.***

Table2: The effect of enzyme treatment on the tensile strength of dyed cotton fabrics with MCT and direct dyes.

Dyes	***Tensile strength(Kg/cm^2)***			
	Unscoured fabric(control sample)	***Unscoured fabric +enzyme***	***Unscoured fabric+ enzyme +non-ionic surfactants***	***Scoured fabric+enzy-me***
(MCT)dyes 1- Modercion Red H-E3B	***32***	***31.5***	***27.5***	***24.5***
Direct dyes: 1-Moderdirect Blue 4G	***31.3***	***30.6***	***27.7***	***23.5***

3-5 Determination of pilling rating:

The enzymatic treatment improved the pill rating both before and after five cycles when the treated unscoured and scoured fabrics dyed with MCT dye compared with the untreated dyed fabric. The data in Table 3 showed that adding enzyme to the dye bath can significantly improve fabric appearance without crippling fabric performance which is due to the ability of cellulase enzyme to eliminate the superficial microfibrils of the cotton fibres [29].

Table 3: The effect of enzyme treatment on the pill rating.

Fabrics types	***Pilling ASTMD3512***	***Pilling SHLTD ASTMD33512***
1-Dyed unscoured cotton	*3.4*	***3***
2-Dyed unscoured cotton + enzyme.	***4***	***3.7***
3-Dyed scoured cotton +enzyme	***4***	***3.7***

3-6 Application of different MCT and direct dyes at the enzymatic optimum condition:

Table4 represents the effect of using different MCT and direct dyes on the colour strength and its percentage increase when applied by the one –bath bio – treatment and dyeing process under the optimum condition.

It can be observed that using different dyes gave various colour strength results depend on the kind of dyes used. The rate of increase for scoured was higher than unscoured samples and that was true for all dyes used and it can be noticed also that the rate of increase for scoured samples dyed with reactive dyes was higher than that of direct dyes and all that confirmed the effect of fabric type(unscoured and scoured) and dye characteristic on the biotreated and dyed cotton fabrics results.

Table 4 :The colour strength and rate of increase of biotreated and dyed cotton(unscoured and scoured)fabrics with MCT and direct dyes .

Dyes	***Blank (without enzyme)***	*Unscoured*		***Scoured***	
	K/S	***K/S***	*Rate of increase (%)*	***K/S***	*Rate of increase (%)*
MCT dyes: ***1-Modercion Red HE-3B***	*2.92*	*3.34*	*14.38*	*6.15*	*131.85*
2-Suncion Orange H-ER .	*5.26*	*6.39*	*21.48*	*8.95*	*70.15*
3-Modercion Blue HE-RD	*2.82*	*3.12*	*10.64*	*5.22*	*85.11*
4-Suncion Yellow H-E6GN.	*1.82*	*2.01*	*10.44*	*3.54*	*94.51*
Direct dyes: ***1-Moderdirect Blue 4G.***	*3.37*	*4.91*	*45,69*	*5.12*	*51.93*
2-Best direct Red BWS.	*3.32*	*3.88*	*16.87*	*4.95*	*49.10*
3-Direct Blue 4BL 200 new	*3.28*	*4.04*	*23.17*	*5. 88*	*34.77*
4-Direct Orange 2GL	*2.17*	*2.98*	*37.33*	*3.88*	*78.80*

3-7 Fastness properties

Tables (5a and **5b)** show the fastness rating of washing, perspiration, rubbing and light fastness of samples that have been biotreated and dyed with different MCT and direct dyes. As shown from tables there are different results which depended on the dyes and the treatment. The results range from fair to very good and show an improvement in washing fastness with some dyes depending on the enzymatic treatment and give almost the same results in case of rubbing and light and different results of perspiration.

Table 5(a): Rating for colour fastness of pre-scoured cotton samples dyed with MCT and direct dyes using one- bath bio- treatment and dyeing technique.

Dyes	**Bio- treated scoured cotton fabric**											
	Washing			**Perspiration**						**Rubbing**		**Light fastness**
				Acidic			**Alkaline**					
	Alt.	**St***	**St****	**Alt**	**St***	**St****	**Alt**	**St***	**St****	**Dry**	**Wet**	
MCT dyes: ***1-Modercion Red H-E3B.***	**4**	**3**	**4**	**4**	**3**	**4**	**4**	**2/3**	**4**	**4/5**	**4**	**6**
2-Suncion Orange H-ER .	**4**	**4**	**4**	**4**	**3/4**	**4**	**4**	**3/4**	**4**	**4/5**	**4**	**4**
3- Modercion Blue HE-RD	**4**	**3**	**4**	**4**	**3**	**4**	**4**	**3**	**4**	**4/5**	**3/4**	**4**
4-Suncion Yellow H-E6GN.	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**3/4**	**4**	**4/5**	**4**	**4**
Direct dyes: ***1-Moderdirect Blue 4G.***	**4**	**3/4**	**3/4**	**4**	**2/3**	**4**	**4**	**2**	**3/4**	**5**	**4**	**4**
2-Best Direct Red BWS.	**4**	**2**	**3/4**	**4**	**2/3**	**3/4**	**4**	**2**	**3/4**	**4/5**	**4**	**5**
3-Direct Blue 4BL 200 new.	**4**	**2/3**	**4**	**4**	**2/3**	**3/4**	**4**	**2/3**	**3/4**	**4/5**	**3/4**	**5**
4-Direct Orange 2GL.	**4**	**1/2**	**3/4**	**4**	**2/3**	**3/4**	**4**	**2**	**3/4**	**4/5**	**4**	**5**

Table 5(b): Rating for colour fastness of unscoured cotton samples dyed with MCT and direct dyes using one- bath bio- treatment and dyeing technique .

3 Dyes	Bio- treated unscoured cotton fabric											
	Washing			Perspiration						Rubbing		Light fastness
				Acidic			Alkaline					
	Alt.	St*	St**	Alt	St*	St**	Alt	St*	St**	Dry	Wet	
MCT dyes ***1-Modercion Red H-E3B.***	4	3	4	4	3/4	4	4	3/4	4	4/5	4	5
2-Suncion Orange H-ER .	4	4	4	4	3/4	3/4	4	3	4	4/5	4	4
3- Modercion Blue HE-RD	4	3/4	4	4	3/4	4	4	3/4	4	4/5	4	4/5
4-Suncion Yellow H-E6GN.	4	4	4	4	4	4	4	4	4	5	4	4
Direct dyes: ***1-Moderdirect Blue 4G***	4	3	3/4	4	3	3/4	4	3	3/4	4/5	4	5
2-Best Direct Red BWS.	4	1/2	3/4	4	3	4	3/4	2/3	3/4	4/5	4	5
3-Direct Blue 4BL 200 new.	4	2	3/4	4	2/3	4	4	2/3	4	4/5	3/4	5
4-Direct Orange 2GL.	4	2	3/4	4	3/4	3/4	4	3	3/4	5	4	4

Alt.:change in colour ; St*.: staining on cotton ; St.:staining on wool**

4- Conclusions

Single bath containing cellulase enzyme and reactive(MCT and VS) or direct dyes were used to dye cotton fabrics(unscoured and scoured) in two stages, where it was found that by using this process we could save time and energy beside the enhancement in the colour strength .The optimum condition of treating with cellulase enzyme in the dyeing bath was carried out for unscoured and scoured fabrics where the results were positive with MCT and direct dyes whereas VS showed negative results because of dye hydrolysis., due to its high reactivity. Reactive dyes of low reactivity are the most suitable type for applying by this new technique. Dyeing unscoured fabric using non-ionc surfactant in the same bath with enzyme at the optimum condition improved the colour strength especially with MCT dye. There are substantial increase in colour strength, wettability and a pilling resistance as a result of inclusion of cellulase enzyme in the dye bath . The tensile strength showed decreased results compared to blank samples. The results depended on the hydrolysis of cotton fabric with enzyme, the type of dye and the fabric type (scoured or unscoured) . Dyeing with different MCT and direct dyes were carried out at the optimum condition and the fastness properties were measured and found to range from fair to very good .

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