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Colouration of Polyester Using Bio-Shell Microcapsules: Efficient Resource and Waste Water Management

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Abstract

The present work aimed at efficient utilization of resources viz., water, dyes and chemicals (without using any supportive chemical) for colouration of polyester. The method of complex coacervation was attempted for obtaining the microcapsules. Bio-shelled (gelatin and gum acacia) microcapsules of disperse dyes were analysed for their resource efficient auxiliary chemicals free colouration on polyester (PET) over conventionally dyed one. The remnant liquor recovered from colouration of polyester was recycled for subsequent three colouration cycles (without treatment) showing negligible shade difference and the fastness rating. The effluent of fourth colouration cycles treated with primary water treatments and was found to be translucent, neutral in pH and low effluent load (TDS >231 ppm, BOD >114 mg/l, and COD > 469 mg/l). The solids recovered from bath were analyzed and found to be nontoxic (LD_{50} > 8000) as well. Cost of disperse dye microcapsules was calculated to be USD $ 4.17 /kg. Cost involved in microencapsulated colouration is much lower (USD $ 2.19) than conventional process of colouration (USD $ 3.93) due to absence of auxiliary chemicals, post treatment, much lower electrical energy consumption. Thus, microencapsulated colouration is easily adoptable in existing process line of polyester colouration, which leads to small liquid discharge of low effluent load.

Keywords: Bio-shell, Colouration, Disperse Dye Microcapsules, Polyester, Recycling

Introduction

Polyester, also known as polyethylene terephthalate (PET), has become the preferred fibre for both technical and clothing textile applications. The fibre has many beneficial qualities for use, including low cost, ease of care, and endurance, but its colouration process using disperse dye based on anthraquinone or substituted benzenoid mono- or diazo-compounds, along with a large quantity and number of chemical additives, raise doubts about its acceptance in the future. Despite the fact that the dispersed dyes are completely trapped by the polyester micro molecular system, there is a threat to the process industry owing to its moderate uptake, which can be significantly reduced by using an appropriate colouration technique. Thus an advance technique may enable a higher uptake of the dyes inside the core of fiber, resulting in low dye residue on cloth and in leftover liquor is a need of the time. Additionally, the wet processing of textiles uses a lot of water (1.6 million l/day) and has a negative effect on the environment when it comes discharge the effluent [1]. The current textile industry's main concerns are therefore resource-efficient processes that maximize the utilization of input materials for low solid as well as liquid leftovers [2].

Conventional polyester colouring results in a 60–90% uptake of dye particles (exhaustion), depending on the class of dyes and depth of its shade [3]. It is important to note that all commercial disperse dyes have a high dispersant content (40–60%) [4]. Even then, the movements (migration) of dye molecules during colouration is highly uncontrolled. Thus, it further required a high temperature and high pressure (HTHP) equipment to facilitate slow rate of heating to control the migration of dyes from aqueous bath to the substrate (polyester). Still, inadequate dispersibility of dye particles, subsequent random and poor adsorption, results in faulty (patchy) dyeing with conventional polyester colouration. Thus, the process of polyester colouration further requires a post wet treatment commonly called as “Reduction Clearing (R/C)” involving additional chemicals, such as reducing agents and alkali at moderate temperature [5].

A number of approaches, including air dyeing, liquid paraffin, supercritical carbon dioxide and microcapsules have been used in textile wet processing to colour polyester fibre in an effort to circumvent the issues [1,4,6-8]. The non-aqueous media (liquid paraffin,

carbon dioxide), which efficiently transport dyes to the corners of polyester matrix, required large-scale processing facilities, which made them uncompetitive in terms of cost for commercial use. The reported methods of colouring polyester with microcapsules was aqueous based (like the traditional one), and it has the ability of sustained release of entrapped dye from capsules, necessitating no support of auxiliary chemicals for the entire colouration cycle [7, 8]. The microencapsulated colouration also produced uniform dye absorption, improved surface colour strength (11%–16%), without the need of post treatment (R/C) compared to conventionally dyed materials. Zhong et al. [7] reported, coloureation technology of polyester fibre utilizing a synthetic shell (diphenyl methane 4, 4 di-isocyanate) microencapsulated disperse dyes produced by interfacial polymerization [7]. Mishra et al. inspired by the benevolent technology reported a much simpler and economic methods (simple coacervation, complex coacervation, spray drying) for microencapsulation of disperse dyes using bio-shell materials (gelatin and gum acacia) with comparable properties (shape, size and its distribution, sustained rate of release and temperature stability) and performance level for the colouration of polyester [8].

However, none of the authors address the prospects for managing effluents (water and sludge) and the cost of colouration involved in microencapsulation approach over the conventional, to suggest the industrial viability of the microencapsulated disperser dyes over the conventional disperse dyes. Thus, the novelty of the present work is to further investigate the eco-sustainability of the research undertaken under Mishra et al. [8] to explore the possibilities of reusability/ recycling of the remnant liquor which should not have any adversity on performance of the colouration of polyester, and characterization of the effluent for efficient resource management [8]. The present work investigate the possibilities of recycling the remnant liquor and its effect on colouration performance and fastness properties, characterization of the effluent and estimated cost involvement of the microencapsulated colouration over the convention colouration of polyester.

Materials and Methods

Materials

The fabric used was plain weave polyester (PET) having areal density 61 g/m^2 (ends per inch, 76; picks per inch, 61) and bio-shell coated disperse dyes microcapsule. Materials used for preparation of shell were gelatin-A (alkali extracted high IEP 8.7), and gum acacia (*Acacia Senegal*) supplied by Aragum Flavor, India. Disperse dye CBENE Yellow SGL (C.I. Disperse Yellow 114, λ_{max}, 410 nm) was supplied by Colourbrand Dyestuff (P) Ltd., India. Other chemicals used acetic acid, di-methyl formamide, sodium hydroxide, sodium dithionite dispersing agent (SPAN 20) and non-ionic surfactant (Auxipon NP) was supplied by S.D. Fine Chemicals, India for preparation and analysis of microcapsules. All the above chemicals were of laboratory regent grade.

Details of Complex Coacervate Bio-shell Microcapsule

According to the study, complex coacervation produced disperse dye microcapsules that were superior to those made by simple coacervation and spray drying in terms of their efficiency of microencapsulation, size distribution, release rate, and thermal stability Complex coacervation microcapsules were obtained by a simple physico-chemical batch type method carried out under continuous stirring for getting smaller and uniform particle distribution. The ratio of core (disperse dye) to shell (gelatin and gum acacia) were kept at the levels of 1:2 for the present study. Accordingly, an aqueous solution was prepared by adding 3g, gelatin and gum acacia (1:1 ratio) each in 100 ml of water containing 1% non-ionic surfactant. To the solution, disperse dye (3 g) was added slowly under continuous stirring. The slurry was further placed in an ultrasonic bath for 30 min at ambient temperature (30 ± 5º C). After 30 min, the slurry was placed under the stirrer revolving at a speed of 800 rpm and the pH of the slurry was gradually lowered to 4.1-4.15 through addition of 1% acetic acid solution. At the particular pH, the oppositely charged gelatin and gum acacia reacts and phase out from the aqueous solution containing the disperse dye at its core. The temperature of the solution was then lowered to 20º C under stirring to facilitate gelation of gelatin. After 10 min, sodium hydroxide (0.5%) was added to the aqueous bath and temperature of bath raised to 50º C for 15 min, for hardening of the shell. The microcapsules were than separated by decanting the excess water. Microcapsules were then washed thrice using a centrifuge (4000 rpm, 5 min) by adding fresh water to remove residual hardening agent and dried in an oven at 60° C for 2 h. The brief characterization of the microcapsule as reported in Mishra et al. is given in Table 1 [8].

Table 1: Characterization of microcapsules

Parameters	Microencapsulated
Size, µ	16.375
Shape	Spherical in collapsed form with smooth surface
Size distribution, µ	19.37 (3.6- 36.9) (Binomial distribution)
Thermal stability, °C	≥ 300
Dye release rate, min	≥ 150
Efficiency of microencapsulation, %	74.13

Methods

Method of Colouration

Colouration was carried out using control and microencapsulated disperse dyes (2%) on weight of fabric separately (Figure 1). The appropriate concentration of microcapsulated dye for producing 2% shade depth as similar as control (disperse dye) was estimated. For this, 0.0025% of control dye solution was prepared with DMF (solvent) and its absorbance was determined. Different concentration of microencapsulated dye solution was prepared with DMF (dipping the microcapsules for 12 h) to match with the absorbance of control dye. From the study, it was observed that, to obtain same shade and depth, the weight of microcapsules had to be 4.7 times of control dye. Colouration was carried out in a closed exhaust bath (pressure 1.8 kg/cm2) maintaining material to liquor ratio, 1:15.

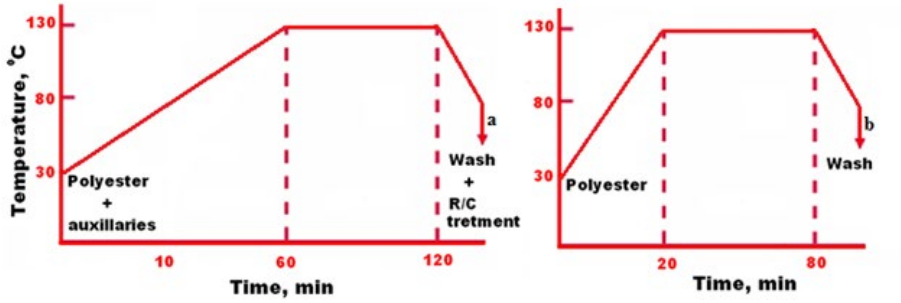

Figure 1: Method of colouration of polyester using disperse dye (CBENE Yellow SGL) a) conventional, b) microencapsulated

Conventional colouration of polyester fabrics was carried out with essential chemicals viz., dispersing agent (2%) and acetic acid (1%). The dyeing temperature was raised slowly to 130° C at the rate of 2° C/min having 1 h holding time at 130° C [9]. The dyed samples were further treated with reducing agent (3 g/l sodium hydro sulphite) and alkali (2.5 g/l sodium hydroxide) for 30 min at 70-80° C having material to liquor ratio, 1:15 to remove the unfixed dyes and additives, popularly known as reduction clearing (R/C) treatment. Control samples were then given a hot wash, neutralized with acetic acid followed by further wash before air drying.

Colouration with microcapsules was carried out similar to the conventional one other than the comparatively faster rate of heating (about 5° C/min) without any essential auxiliary chemicals. The microencapsulated dyed samples were simply washed in water before drying in air without any reduction clearing (R/C) treatment.

Fastness Measurement

Colour fastness to washing, light and sublimation fastness was tested using the ISO 105-CO3, IS 2454 and ISO 105-P01 test methods respectively [10-12]. The assessment of fastness properties was done by grey scale for washing and sublimation fastness and by corresponding fading of blue wool standards for light fastness [13].

Recycling Possibility

Microencapsulated colouration on Polyester fabrics dyed in fresh water and in remnant water (from consecutive dyeing baths) was carried out using similar amount of microencapsulated dyes (2% on weight of fabric) in each cycle separately. The difference in surface colour uptake (K/S) of the dyed fabrics was evaluated up to four dyeing cycles.

Colour Yield Measurement

Dyed samples were evaluated for tone and depth of the colour using a spectrophotometer (Data Colour SpectraflashÒ SF 300, USA) using CIE Standard Illuminant D65 and 10° observer. Tone of the colour was measured in terms of CIE L* (lightness or darkness), *a** (redness or greenness) and *b** (blueness or yellowness) values of the colour. In order to derive the CIE, the parameters *L, a*, and *b* colour space values (based on the opponent colour theory) the following expressions were used.

$L^* = 116\,(Y/Y_n)^{1/3}$, $a^* = 500\,[(X/X_n)^{1/3} - (Y/Y_n)^{1/3}]$, and $b^* = 200\,[(Y/Y_n)^{1/3} - (Z/Z_n)^{1/3}]$

where, *X, Y, Z* and *Xn, Yn, Zn*, are tristimulus values of the object and the white point of the illuminant respectively.

Depth of the colour of both conventional and microencapsulated dyed samples was evaluated by reflectance values (Data Colour SpectraflashÒ SF 300, USA). An average of five readings of reflection taken at different places of a sample was used to calculate the surface colour uptake (K/S) and change of colour (ΔE) [14, 15].

$$(\Delta E) = [(l_{sam}-l_{std})^2 + (a_{sam}-a_{std})^2 + (b_{sam}-b_{std})^2]^{1/2}$$

Where, l_{sam}-l_{std}, a_{sam}-a_{std}, b_{sam}-b_{std}, is the difference in lightness, redness or blueness and brightness respectively between standard (control) and the sample. The differences in hue and chroma value were determined by h_{sam}-h_{std}, c_{sam}-c_{std} respectively.

Effect of Colouration On Exhaustion Of Dye

The effect of colouration process (conventional and microencapsulation) on exhaustion of dye from bath liquor to polyester was studied. Four cycles of colouration was carried out using fresh cloth in each time. The first dying cycle was carried out similar to the chemical recipe and conditions mentioned in the *sub section*

2.2.2 respective to the controlled and microencapsulated disperse dyes. However, in the subsequent cycles, colouration was attempted using leftover liquor from their previous batch of corresponding conventional and microencapsulated colouration cycle without addition of dyes or/and chemicals.

Estimation of Quantity of Dye Particles in Remnant Bath After Microencapsulation and Conventional Colouration

The residual bath liquors after preparation of microcapsules and colouration cycles were assessed for the residual dye content. For assessment of absorbance, residual bath liquors (5 ml) were mixed with di-methyl formamide (5 ml) to make a solution, which was analyzed against the blank solvent prepared by mixing water and DMF in the ratio of 1:1. The absorbance of the dye present in remnant liquor was measured at their corresponding λ_{max} using an UV-1201 single beam spectrophotometer (SHIMADZU, Japan) and the concentration of dye particles present in them were determined by using the calibration curve.

Result and Discussion

Analysis of Extent of Dye Migration During Microencapsulation

To plot the calibration graph, pure dyes were collected by extracting in benzene in a Soxhlet apparatus for 48 h. The removal of impurities from disperse dyes was confirmed by thin layer chromatography (TLC) method.

Assessment of Colour, PH, TDS, BOD and COD of the Remnant Liquor

The pH, total dissolved solid (TDS) and conductivity of the effluent at different stages were measured by using a pH electrode (PCS Tester 35, Make-EVTECH). Change in colour of the treated effluent was assessed using UV-1201 single beam spectrophotometer (SHIMADZU, Japan). Chemical oxygen demand (COD) [16] and biological oxygen demand (BOD) [17] of the effluent was analyzed by the open reflux methods [16,17].

Toxicity of Sludge

Sludge was examined in a double beam FTIR spectrophotometer (ALPHA-Bruker-Germany) using attenuated transmittance resonance (ATR) technique.Toxicity of the sludge was obtained through analysis of lethal dose concentration (LD_{50}).

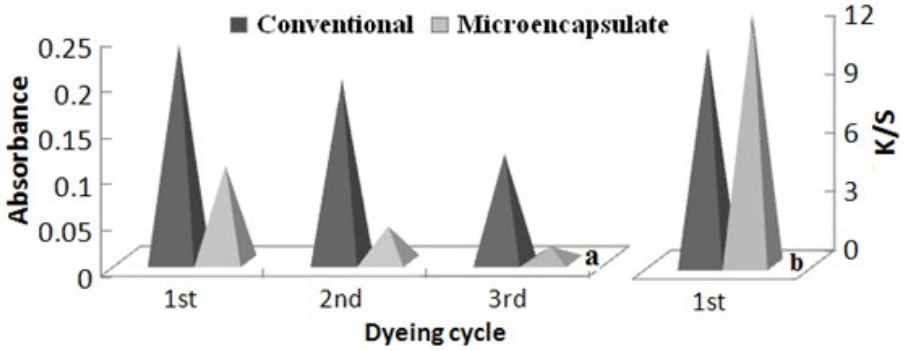

Figure 2: Dye concentration in successive dyeing cycle in a) bath liquor after and b) surface colour strength (K/S) of polyester fabric

The absorbency values of dye from waste water after successive colouration cycles are shown in Figure 2. The figure reveals that, a much higher concentration of dyes were remained (absorbance, 0.263 Au) in the residual liquor in first colouration bath in the conventional process of polyester colouration, as compared to microencapsulated process (absorbance, 0.104 Au). Recycling of bath liquor of conventional colouration (second and third trial) was intended to understand the effect of remnant auxiliary chemicals on inducing the migration of the dyes or self-transferability of the disperse dyes present in the bath liquor. The concentration of dyes quantified in terms of absorbance value (0.117 Au) in remnant bath liquor for third cycle of conventional colouration was even higher than the absorbance (0.104 Au) of remnant liquor of first cycle of microencapsulated colouration. This proves that, the conventional disperse dye is not self-transferable, so, in the process of colouration a lot of dye particles were not able to exhausted and get wasted. However, in the process of microencapsulation, which consumed no additional chemicals, had much improved dye transfer capacity over conventional colouration. Thus, the surface colour strength (K/S, 12.94) for the microencapsulated coloured polyester fabric was found to be much higher than the surface colour strength (K/S, 10.15) obtained by conventional process (Figure 2).

Reuse of Remnant Bath Liquor

Table 2 shows the colour parameters of the microencapsulated dyed polyester fabric up to four colouring cycles. It is noteworthy that, surface colour strength (*K/S*) and elementary colour values (*L, a, b, c, h)* of the fabrics dyed with fresh and remnant liquor are almost similar. The tristimulities colour difference (ΔE, 0.086) up to the fourth dyeing cycles samples was much less than 1.0, thus the difference in shades was undifferentiable visually and may be considered to be similar also [18].

Table 2: Surface colour strength and tone of microencapsulated coloured polyester cloth

Colour indices	Colouring cycle			
	Fresh	Remnant liquor		
	(1st)	2nd	3rd	4th
R_{max}, %	2.93	2.99	2.97	2.95
K/S	12.82	12.75	12.84	12.79
L	82.75	82.68	82.79	82.84
a	-5.87	-6.11	-6.13	-6.06
b	90.65	89.71	89.68	89.79
c	90.84	89.93	89.96	89.91
h	93.70	94.03	94.11	94.08
ΔE [a]	-	0.44	0.054	0.086

[a] colour difference calculated from the immediate previous batch

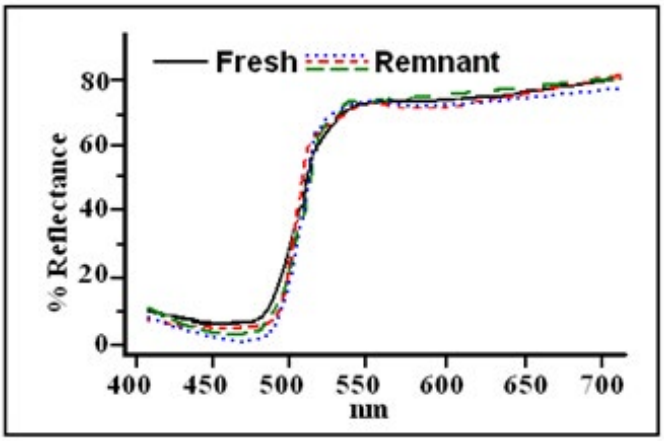

Figure 3: Reflectance curves of fabric dyed using the fresh water and remnant liquor from the successive microencapsulated dyeing

Further, the reflectance curves of fabric dyed with fresh water and leftover liquor from subsequent microencapsulated dyeing cycles (Figure 3) revealed very similar reflectance trend. So, it may be interpreted that, each dyeing cycle was initiated with similar concentration of dyes and also, the uptake rate for every successive cycle were much consistent so as to have similar residual dye concentration in the dye baths leftover liquor. Additionally, the fastness values are also consistent enough for the recycled coloration (Table 3). Therefore, we may say that subsequent microencapsulated dyeing can utilize the leftover liquor without further treatment efficiently. A significant amount of water may be saved as a result, and the issue of effluent treatment and disposal would also be resolved.

Table 3: Rating for washing, sublimation and light fastness testing of microencapsulated dyed fabrics

Fastness testing	Colouration cycles							
	Fresh		Recycled					
	1st		2nd		3rd		4th	
	Cotton	PET	Cotton	PET	Cotton	PET	Cotton	PET
Washing	5	5	5	5	4-5	4-5	5	5
Light	8	8	8	8	7-8	7-8	7	8
Sublimation	5	5	5	5	5	4	5	4

Analysis of Remnant Solids and Wastewater

Table 4 lists the characteristics of the remnant wastewater collected from the encapsulation and the fourth cycle of the coloration processes after being subjected to primary treatments. The procedure for primary treatments involved storing to precipitate the undissolved solids and centrifuging the mixture to separate the dissolved solids. The initial treatments took place over the course of roughly 6 hours, and the solids were separated using centrifu-

gation at a speed of 7000 revolutions per minute for 5 minutes at a temperature of 30 ± 5° C. In comparison to effluent discharged from traditional processes (TDS, 3600 - 6540 ppm; BOD, 360-370 mg/l; COD, 130-1400 469 mg/l), the treated liquid was discovered to be translucent, have a neutral pH, and have considerable low effluent load, which were in permitted ranges [1].

According to analysis of the median lethal dosage (LD_{50}) values conducted on rats, the solid recovered from the leftover liquors was determined to have very low toxicity. The LD_{50} values for the solids recovered from the coloration and microencapsulation residual baths were 10845 mg/kg and 8968 mg/kg, respectively. This dose is quite high and supports the sludge's nontoxic status (LD_{50} > 2500 mg/kg).

Table 4: Water quality parameters of residual bath water

Parameters	Residual water	
	After microencapsulation	After colouration
Visual observation	Translucent	Translucent with little turbidity
Dye, % (w/w)	0.0004	0.0011
Absorbance, Au	0.018	0.13
pH	6.8	7.2
TDS, ppm	29	231
BOD, mg/l	56	114
COD, mg/l	149	469

TDS-Total dissolved solid; BOD-Biological oxygen demand; COD- Chemical oxygen demand;

FTIR Analysis of Remnant Solids

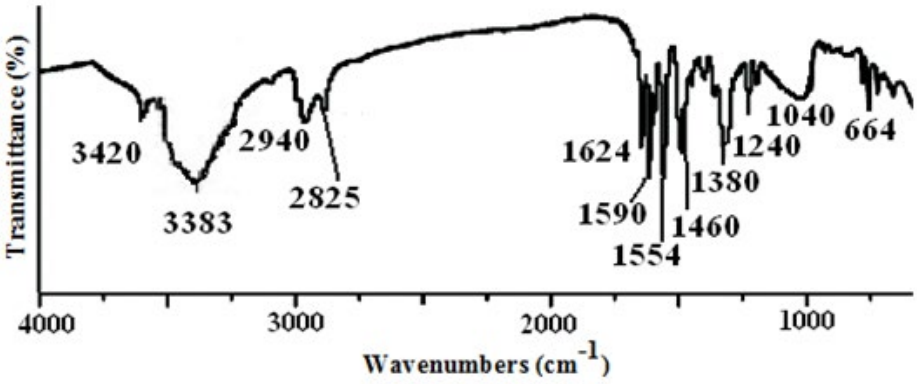

Figure 4: FTIR of solids recovered from colouration using bio shell microcapsules

Effluent obtained from the microencapsulated colouration process found to have 6.8 g solid residues over the weight of total solid added (9.0 g) during formation of microcapsules. The functional group analysis (Fig 4) through FTIR showed significant traces of residues of gum acacia and gelatin than disperse dyes. The absorption peaks at 3433 and 3383 cm-1 attributed to the presence of hydrogen bond may belong to gelatin and gum acacia both. Peak at 1624 cm^{-1} corresponds to the occurrence of amide-I (C=O stretching/hydrogen bonding coupled with COO), at 1554 cm^{-1} indicates amide-II (vibration of N-H groups and stretching vibrations of C-N groups), peak at 1240 cm-1 indicates the amide-III in plane vibrations of C-N and N-H groups. Peaks ranges from 1460 to 1380 cm^{-1} were attributed to the symmetric and asymmetric vibrations of methyl group present in gelatin. Being a protein, gelatin macromolecules characterized to contain polyamide groups [19]. Gum acacia has exhibited characteristic peaks at 3420, 2940 and 1419 cm^{-1}, which represent the -OH, -CH2, and $-CH_3$ aliphatic groups respectively for its carbohydrate structure [20]. The peaks at 1618 and 1426 cm^{-1} are due to asymmetric stretching of COO− group of gum acacia. Presence of disperse dyes were associated with the peaks at 2825 cm, 1590, 1040 and 664 cm^{-1}, which were also may be associated with peaks of amide at 1586 and 1040 cm^{-1} whereas others are the characteristic presence of aliphatic -CH, -CH3 groups of gum acacia.

Table 5: Cost (USD $) of formation of disperse dyes microcapsules/kg

	Quantity	Price USD $
Dye, g	500 g	2.50
Gelatin, g	250 g	0.56
Gum acacia, g	250 g	0.50
Span 80, ml	10 ml	0.10
5% Sodium hydroxide, g	10 ml	-
2% Acetic acid, ml	25 ml	
Duration for electricity consumed, h	3	0.42

(for ultrsonication, stirring and separation through centrifuge);
Rate of electricity/kWh @ US$ 0.14

Table 5 shows a breakup for formation of microencapsulated disperse dyes considering its efficiency of microencapsulation (74%). A comparison of cost of colouration involved in conventional as well as microencapsulated colouration methods detailing the quantity and costing for chemicals and energy consumed is given in Table 6. Cost of disperse dye microcapsules was calculated to be USD $ 4.17/kg. In the analysis, cost of civil infrastructure, space, labour, hazards in material handling and consumption of water and its effluent treatments have not been included. Cost involved in microencapsulated colouration is much lower (USD $ 2.19) than that of conventional process of colouration (USD $ 3.93) per 5 kg batch. Low process cost of microencapsulated colouration was due to absence of auxiliary chemicals, and much lower the quantity of electrical energy consumed than that of conventional colouration technique as well as needed in post treatment. In addition, the method is cost effective in terms of infrastructure building, space, labour and requires no effluent management, and thus ensures more user friendliness and industrial viability as compared to the conventional method.

Table 6: Costing (USD $) of high temperature polyester colouration (2% shade) per 5 kg batch

Inputs	Conventional		Microencapsulation	
	Quantity	Cost	Quantity*	Cost
During colouration				
Dye, g	100	0.50	470	1.96**
2% Non-ionic detergent, ml	100	0.45	-	-
2% Retarding agent, ml	100	1.00	-	-
2% Acetic acid, ml	100	0.78	-	-
Duration for electricity consumed, h	110	0.26	70	0.23
During post treatment				
2%, Sodium dithionite, g	100	0.25	No post treatment	
2% Sodium hydroxide, g	100	0.14		
2% Acetic acid, ml	100	0.29		
Duration for electricity consumed, h	30	0.07		

*Quantity of dye for microencapsulation process = 4.7 times of conventional process
** Cost of microcapsules formation is approximately USD $ 4.17/kg

Rate of electricity/kWh @ US$ 0.14 "Electric Power Monthly – Average Retail Price of Electricity to Ultimate Customers by End-Use Sector, by State" 4 august 2020. Retrieved 14 August 2020).

Novelty of the Microencapsulated Dyes

The conventional colouration of polyester has its limitations in regard to high temperature of dyeing, controlled migration and diffusion of dyes. This necessitates the use of numerous auxiliary chemicals in the traditional dye bath, and yet the process leads to faulty dyeing, poor washing/sublimation fastness and huge effluent generation with high COD, BOD load. Polyester colouration depends on three dynamic energy levels (dispersion, migration, diffusion) of dye particles, which are mainly based on the size of the dyes. Thus, disperse dyes are milled into very fine size up to1 µm but their small size causes them to agglomerate in aqueous bath due to high surface energy [9,21]. The larger the structure of

dye molecule, more dispersing agent is required to maintain homogeneous existence in the bath and at the same time requires more heat energy to migrate them. High temperature during colouration is also required to swell the surface of polyester fibre and enlarge the pores sufficiently large enough to diffuse maximum size of dye molecules. Since, process of microencapsulation reduced the size of dyes by breaking their agglomeration through sonication, prior to the microencapsulation, the micron size capsules as tiny vessels are sustainably diffusing (through their bio cell coated porous surface) out the dye molecules to penetrate into the pores of polyester. The comparatively larger (16.37 µm) microcapsules were less tends to agglomerate and the hydrophilic coating helps them to remain dispersed in aqueous bath. Thus, microencapsulated disperse dyes exhaust well below 130°C. Further, the sustained release of capsulated dyes overcomes the need of controlled rate of heating particularly at high temperature, which in turn avoids the use of sophisticated high temperature high pressure machine and use of many auxiliary chemicals (dispersing agent, retarding/levelling agent, buffering agent), which is an existing limitation associated with polyester colouration. Additionally, the colouration based on microencapsulated disperse dyes needs shorter period (70 min) over the conventional one (110 min); thus saves resources (energy, water chemicals) and provide improved colouration performance on dyeing and also applicable to all disperse dyes.

Conclusion

The encapsulated disperse dyes formed using bio based shells (gelatin and gum acacia) would advance the process of polyester dyeing due to their enhanced colouration performance (even/regular dyeing with notably higher colour strength (K/S increased by 28%) on polyester. Additionally the process has sustainability approach i.e., requires no auxiliary chemicals, requires no post treatments involving additional chemical and water, easy and efficient recyclability and generation of substantially less effluent and easy treatments. Cost effectiveness and less requirement of water makes the process lucrative to industry. The fabrics dyed in normal and remnant liquors up to four cycles were of negligible differences in total colour values. So, adoption of the microencapsulation colouration would not only help towards resource efficient production of polyester processing with not much change in its existing industrial practice and also reclaimed the useable water effortlessly.

Statements and Declarations

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