

Effects of Liposome Assisted Dyeing on PET Fabric Properties

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Abstract

Liposome technology is applied in numerous fields, such as pharmaceuticals, cosmetics, foods, detergents, textiles and other applications, because of the ability to liberate the encapsulate slowly. Application of this technology's result is the energy saving by reducing time and temperature which should be higher in conventional wool-dyeing method and avoiding the use of any other synthetic auxiliaries. In this study, the effect of liposome, which is constituted from soya lecithin and cholesterol, on dispersion dyeing of PET fabric was investigated. Thin lipid layer method was performed for the liposome production. On the other hand the effect of the commercial liposome was also investigated. PET fabrics were dyed using different dispersion dyes and color measurement values, tensile strength, light, rubbing, washing and perspiration fastness analyses were carried out. Fastness results were evaluated according to ANOVA statistical analysis. Different temperatures (between 115°C-130°C) were compared by performing color dyeing yields to examine the effect of liposome addition to the temperature in the dyeing process. The results were showing that PET fabrics which were dyed with liposome had better fastness, color strength values as compared with non-liposome dyed fabrics. In addition, the energy saving by reducing temperature was obtained.

Keywords: Liposome; PET dyeing; Dispersion dye

Introduction

Liposomes are generally spherical structures constituted by a phospholipid bilayer that entraps an aqueous core. Depending on the nature of the lipids, different types of liposomes (i.e., multilamellar, unilamellar) ranging from very small (nanometre diameter) to very large vesicles (micrometers) can be formed [1-3]. These are surface-active biological lipids that have two parts of hydrophobic and hydrophilic in their structure. The hydrophilic part is composed of phosphate and choline groups, and the hydrophobic part is made of two hydrocarbon chains [4].

Liposome technology is applied in numerous fields, such as pharmaceuticals, cosmetics, foods, detergents, textiles and other applications, because of the ability to liberate the encapsulate slowly. Application of this technology results in energy saving by reducing time and temperature which should be higher in conventional wool-dyeing method, avoiding the use of any other synthetic auxiliaries. In addition, fibers are protected by dyeing at low dyeing temperatures by use of liposomes. Liposomes are known to be easily biodegradable than those conventionally synthesized auxiliaries. Therefore, liposomes cause a distinct decrease in the contamination of dye bath. Using liposomes in dyeing process gives a more natural handle and improved quality properties to fibers with a lower temperature and lower environmental impact. Liposomes release the encapsulated dye slowly with promoting a retarding effect, which is comparable with the one obtained with retarding agents, making them a good alternative to commercial levelling products. The liposomes are also highly effective in bleaching of wool. The presence of liposomes in bleaching bath increases the quality of bleached wool by reducing the concentration of basic component-hydrogen peroxide significantly [4-14].

The aim of this research is to examine the effect of liposome in PET dyeing process with dispersion dyes. Soybean lecithin and cholesterol was used to form the structure of the liposome membrane to be used in the dyeing bath. Liposome production was done according to the thin lipid layer method (Bangham Method) with rotary evaporator. On the other hand the effect of the commercial liposomes was also investigated. After dyeing process, color strength, tensile strength and the fastness to washing, perspiration, rubbing and light of PET fabrics values were

determined. Fastness results were evaluated according to ANOVA statistical analysis. Different temperatures (between 115°C-130°C) were compared by performing color dyeing yields.

Materials and Methods

Materials

In this research, 100% PET fabric (150 g/m² and warp/weft yarn density of 32/28 yarns/cm). Lecithin (phosphatidylcholine), anticreasing agent, levelling agent, pH adjuster and dispersion dye Setapers Red E3BN (large molecular and CI Disperse Red 226), Setapers Red P2G (middle molecular and CI Disperse Red 19) and Setapers CE-RN (small molecular and CI Disperse Red 1), were provided by Setaş Kimya A.Ş. (Turkey). Cholesterol, commercial liposome, sodium hydroxide were purchased from Sigma Aldrich Co. (USA). Chloroform and ethanol were supplied by Merck (Germany).

Methods

The trials were performed according to optimum lecithin/cholesterol ratio (Table 1) study, which was determined in our previous [11].

In order to obtain liposome, Bangham Method was employed. Lecithin and cholesterol was homogenously dissolved in chloroform/ethanol mixture. Afterwards, liposomes were obtained by evaporating of solvent mixture using rotary evaporator (IKA-Germany) equipment.

The dyeing procedure depicts in Figure 1. The dyeing recipe was:

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1% of Setapers Red E3BN, Setapers Red P2G ve Setapers Red CE-RN, 1 g/L anticreasing agent (blend of special phosphate esters), 1 g/L levelling agent (aliphatic glycol ether carboxylic acid ester), and 2 g/L pH adjuster. The washing procedure after dyeing, was rinsing at room temperature for 10 min., rinsing at 50°C for 10 min. and rinsing at room temperature for 10 min. The liquor ratio was 10:1 for both bleaching and dyeing.

In this research we used liposomes with different types of usage. In the first one, liposomes were used such as an auxiliary. Then dye solution was added to liposome and PET fabric was dyed. In the second one, dyes were encapsulated with liposome. These two different methods were compared with conventional dyeing.

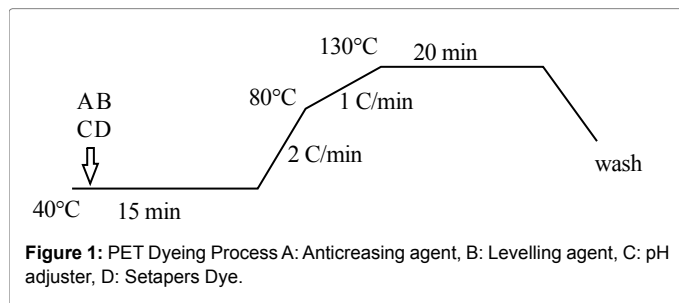
Color strength values of dyed samples were analysed by Minolta Spectrophotometer CM-3600d (D65, specular inclusion, 10°). Different temperatures (between 115°C-130°C) were compared by performing color dyeing yields to examine the effect of liposomes addition to the temperature in the dyeing process. Color strength values were determined by Kubelka-Munk formula.

$$K/S = (1 - R) / 2R \quad (1)$$

Where, K is the scattering coefficient, S is the absorption coefficient and R is the reflectance.

L:CH w/w	L (lechitin) (gr)	CH (Cholesterol) (gr)	Chloroform (mL)	Ethanol (mL)
9.0-1.0	0,5	0,055	4 ml	2 mL

Table 1: Selected optimum liposome contents.



Fastness to washing, perspiration, light and rubbing of the PET fabrics which were dyed with large macromolecular red disperse dyes, were tested according to ISO 105-C06, TS EN ISO 105-E04, ISO 105-B02 and ISO 105-X12, respectively. The changes in shades and staining to adjacent multifibre fabrics were related to the standard grey scale rating (where 1 is poor and 5 are excellent). The changes in shades under artificial light were evaluated according to standard blue wool fabrics (SDC) protocols. ECE non-phosphate standard detergent was used in wash fastness trials. Fastness results were evaluated according to ANOVA statistical analysis.

Tensile properties of the fabrics were observed according to TS EN ISO 13934-1 "Textiles-Tensile properties of fabrics - Part 1: Determination of maximum force and elongation at maximum force using the strip method" using Instron 4411 Tensile Strength Tester.

Results

Color yield

In this study, fabrics were dyed with dispersion dyes. The maximum absorption at a wavelength of 400-700 nm spectral regions, K/S values was calculated in order to determine the efficiency of the liposome. K/S values are shown in Table 2.

In order to determine the optimal final temperature of the liposomal dyeing, isotherms in the temperature range 115-130°C facilitate detection of the color strength promoted. We determined K/S and ΔE values of dyed fabrics. Higher K/S values indicate higher dyeing yield and the higher ΔE values indicate that more color difference.

The small molecule dyes were found to give better results in dyeing with conventional dyeing method for all temperatures. So, it showed that no need to usage of liposome for small molecular dyes. On the other hand, when the size of the dye molecules increases, K/S and ΔE values were increased in cases where the presence of liposome especially in liposomes which were used as auxiliaries. So that shows the importance of the usage of liposomes in large molecule dyes.

When examining the effect of liposomes to the dyeing temperature, although 130°C which is there commended temperature for dyeing, higher K/S values were obtained at 120°C for all three dyes. Especially, best K/S and ΔE values for dyeing were obtained with liposomes

Large Macromolecular Red Disperse Dyes (Setapers RED E3BN)						
	115°C		120°C		130°C	
	K/S	ΔE	K/S	ΔE	K/S	ΔE
Conventional Dyeing	6,8404	X	11,376	X	13,5213	X
Liposome Dyeing	10,342	5,421	19,365	7,315	20,9474	6,335
Dye Encapsulated Liposome Dyeing	8,4128	3,485	16,3289	5,478	17,485	4,487
Commercial Lipsome Dyeing	8,1233	3,014	16,9562	6,103	17,9963	5,193
Middle Macromolecular Red Disperse Dyes (Setapers RED P2G)						
	K/S	ΔE	K/S	ΔE	K/S	ΔE
	Conventional Dyeing	4,5985	X	12,051	X	13,066
Liposome Dyeing	7,3083	9,597	19,845	7,181	20,848	6,942
Dye Encapsulated Liposome Dyeing	6,2548	5,148	15,148	5,886	16,15	4,948
Commercial Lipsome Dyeing	6,4124	5,476	15,634	5,941	16,614	4,941
Small Macromolecular Red Disperse Dyes (Setapers RED CE-RN)						
	K/S	ΔE	K/S	ΔE	K/S	ΔE
	Conventional Dyeing	13,249	X	10,291	X	11,437
Liposome Dyeing	13,839	9,034	15,375	4,563	16,295	3,124
Dye Encapsulated Liposome Dyeing	13,6847	7,412	14,464	4,054	14,813	2,048
Commercial Lipsome Dyeing	13,5621	7,065	15,035	2,945	15,593	0,945

Table 2: Color yield results of PET fabrics with dispersion dyes.

which were used as auxiliaries. Therefore, the dyeing of PET fabrics were achieved at lower temperatures in the presence of liposome as an auxiliary and this situation provides enormous energy savings for textile companies. It also provides a contribution to the environment in ecologically.

These values may be attributed two reasons, increasing of whiteness on the back color and effect of cholesterol residues on PET fibre which were responsible for interaction between the dyes substantively.

Fastness properties

To study the effect of liposomes on the PET samples which dyed with Setapers RED E3BN, fastness to washing, light, rubbing and perspiration were tested and the results listed in Table 3.

The results revealed that the wash, light and perspiration fastness of the samples dyed along with liposomes are higher than the samples dyed without liposomes about half or one point. However, the wash fastness of the samples dyed along with liposomes improved marginally, which can be due to the lipid precipitation on the fabric surfaces. This can be acted as a barrier against bleeding of the dye from the fabric.

When fastness analyses were evaluated according to the ANOVA variation statistical analysis, a significant improvement provided for all fastness analysis in the presence of liposome (Table 4).

Tensile strength

Tensile strength values of the PET samples which dyed with Setapers RED E3BN, are depicts in Table 5. In the presence of liposomes, the breaking load reached 94 N, whereas without liposomes, it was 86

N. These fabrics had both greater elongation capabilities and greater strength also. Although an increased was observed, this increase was thought to result from the shrinkage of the fabric.

Conclusion

In this work, the effect of liposome in PET dyeing process was investigated. Soybean lecithin and cholesterol was used to form the structure of the liposome membrane to be used. K/S and ΔE values were increased in cases where the presence of liposome especially in liposomes which were used as auxiliaries. When examining the effect of liposomes to the dyeing temperature, although 130°C which is there commended temperature for dyeing, higher K/S values were obtained at 120°C for all three dyes. The small molecule dyes were found to give better results in dyeing with conventional and liposomal dyeing method for all temperatures, nevertheless when the size of the dye molecules increases, K/S and ΔE values were increased in cases where the presence of liposome. Application of this technology results in energy saving by reducing temperature which is higher in conventional PET-dyeing method.

In our research, when the analysis considered all the fastness of dyeing with liposome that better results are emerging. The usage of PET fibers with the use of liposomes with improved properties and a significant improvement provided for all fastness analysis in the presence of liposome according to the ANOVA variation statistical analysis.

As a final statement, this work shows liposome, which can be easily prepared by commercial lecithin and cholesterol. This study showed

Liposome	Fastness to light	Fastness to Rubbing		Fastness to Washing							Fastness to Perspiration													
		Dry	Wet	Colour Change	CA	CO	PET	PA	PAC	Wool	Alkali			Acid										
											Colour Change	CA	CO	PET	PA	PAC	Wool	Colour Change	CA	CO	PET	PA	PAC	Wool
Conventional Dyeing	7	4	3-4	4-5	4-5	4	4	3-4	3-4	3-4	4-5	4-5	4-5	4	3-4	4	4	4-5	4-5	4-5	4	4	4	4
Liposome Dyeing	7	4-5	5	4-5	4-5	4-5	4-5	4	4-5	4	4-5	4-5	5	4-5	4	4-5	4-5	4-5	4-5	5	4-5	4	4-5	4-5
Dye Encapsulated Liposome Dyeing	7	4	4-5	4-5	4-5	4-5	4	3-4	4-5	4	4-5	4-5	4-5	4-5	4	4-5	4	4-5	4-5	4-5	4-5	4	4	4-5
Commercial Liposome Dyeing	7	4	4-5	4-5	4-5	4	4	3-4	4-5	3-4	4-5	4-5	4-5	4-5	4	4	4	4-5	4-5	4-5	4-5	4	4	4

Table 3: Fastness analysis of PET fabrics.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1,900	3	,633	12,667	,000
Intercept	369,800	1	369,800	7393,000	,000
Liposome	1,900	3	,633	12,667	,000
Error	,800	16	,050		
Total	372,500	20			
Corrected Total	2,700	19			

Table 4: Variation analysis of fastness results.

Liposome	Load (N)	Extension (%)
Raw Fabric	86,72	45,08
Conventional Dyeing	85,53	43,23
Liposome Dyeing	93,77	53,85
Dye Encapsulated Liposome Dyeing	90,17	51,95
Commercial Liposome Dyeing	88,27	50,95

Table 5: Tensile strength results.

that liposomes are effective in PET dyeing with dispersion dye at low temperatures and also they can use as an alternative dyeing auxiliary.

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