Utilization of MLV Liposomes as a Carrier in Dyeing of Wool/Polyester

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Abstract

Liposomes are lipid-water systems that can carry hydrophobic and hydrophilic materials because of their amphiphilic structures. Application of liposomes in dyeing and finishing textiles is a new technology based on targeting and slow release which can lead to dyeing at lower temperature along with energy savings and lower environmental impacts. In this research work, a practical method for dyeing wool/polyester blends with disperse dye using liposome-forming compounds is proposed. Multi-lamellar liposomes (MLV) were prepared from Soya lecithin with 45% phosphatidylcholines and applied as an auxiliary in dyeing of wool/polyester fabric with disperse dye under different experimental conditions of the temperatures, time and liposome concentrations. The effect of liposomes in dye-bath on dye exhaustion and dyed fabric properties was investigated to achieve optimum conditions. The results were compared with those obtained with and without conventional dyeing auxiliary which showed that the presence of liposomes in the dye-bath helps to enhance the absorption of disperse dye on the wool/polyester fabric which was evaluated by colour strength (K/S). An increase on K/S was observed more significant for the samples dyed at 110ºC for 60 min using 2% owf (on weigh of fabric) liposomes. Dyeing at higher temperature and longer time with higher liposome concentrations doesn't increase the final exhaustion remarkably. The tensile strength, wash and light fastness of samples have not been changed significantly.

Keywords: MLV, Wool/polyester dyeing, Colour strength (K/S)

1. Introduction

Liposomes are defined as any structure composed of lipid vesicle bilayers that enclose a volume, and liposomes containing a dye are generally large, irregular, and unilamellar [1].

Liposomes have attracted a great deal of scientific interest because of two reasons. First, liposomes can provide an excellent model for membranes. Second, these phospholipic bilayers are being developed as a controlled delivery system for therapeutic agents [2].

Although initially slow to exploit the technology of liposomes, the textile industry has now produced a wide variety of innovations using the basic principles of targeting slow release, and protection of sensitive chemicals, principally in dyeing and finishing [3]. The schematic structure of liposomes is illustrated in Figure 1.

Blending polyester with wool is an attempt to achieve a combination of the most desirable features of both fibers, providing fabrics with good properties. Dyeing wool is usually carried out in a boiling bath, but wool damage during dyeing process is not severe provided suitable dyeing condition are chosen [4].

Polyester has a high glass transition temperature, approximately 80°C, and so dyeing with disperse dyes is done at high temperature. If a low dyeing temperature is selected in order to avoid damaging the wool, the disperse dye uptake on the polyester will not be adequate to achieve a good dyeing. On the other hand wool maybe damaged unacceptably if high dyeing temperature or prolonged dyeing times are adopted in order to increase dye uptake on polyester. Carriers are useful agents for wool/polyester blends and permit dyeing at relatively low temperatures, although they have some disadvantages, e.g. being toxic and harmful to the environment [5, 6].

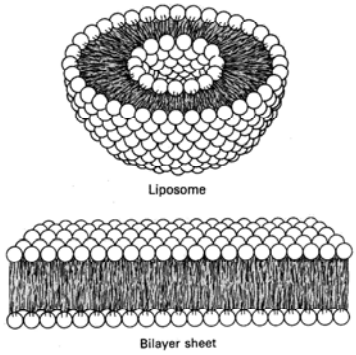

Fig 1. Liposome structure.

In attempt to decrease high energy costs, expensive machinery investment, and undesirable effects such as wool damage during the conventional dyeing process and protect environment, alternative method for dyeing wool/polyester blends with disperse dye is using liposome-forming compounds.

Although wool/polyester blends are industrially dyed simultaneously with wool and polyester dyes and previous studies have already determined the effect of liposomes on wool dyeing, this study focuses on the action of liposomes on wool/polyester blend dyeing with disperse dyes. Therefore, we try to prepare and produce multi-lamellar liposomes (MLV) from Soya lecithin with 45% phosphatidylcholine and study the influence of liposomes in dye-bath at different temperature, exhaustion time and concentration during in wool/polyester dyeing with disperse dye. The dyeing temperature and time was optimized with optimum concentration of liposomes. The tensile strength, wash and light fastness properties of samples have also reported.

2. Experimental

2.1 Materials and Methods

The material to be dyed was woven wool/polyester fabric supplied by Iran Merinous (Ghom, Iran). Soya lecithin (containing 45% phosphotydilcholin) with phase transition temperature (Tc) of -18ºC was prepared by Lipoid (Germany). The disperse dye Sumikaron Blue EF-BL (C.I.Disperse blue 56) was used; its chemical structure indicated in Figure 2 [7]. Carrier used was TANAVOL supplied by Tanatex Chemical Co. (Netherlands), CATA PON 310N as a nonionic detergent and CATA PERS 200 NDF as a dispersing agent from Catan Chemical Co. (Iran).

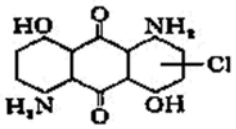

Fig 2. Chemical structure of C.I.Disperse blue 56 dye.

Dyeing was done in an Ahiba Polymat Data Color dyeing machine and the reflectance spectras of the dyed samples determined by ACS Spectra Sensor II integrated with an IBM-PC. The wash-fastness of the liposomes treated dyed fabric was measured according to ISO 150-C03 [8]. For light-fastness measurements, the samples were exposed to the daylight for 7 dyes according to the daylight ISO 105-B02 in Xenotest 150S machine [9] and changes in the colour (fading) were assessed bye the blue scale. Also the tensile strength of the samples evaluated according to ASTM 5035:1974 [10].

2.2 Preparation of MLV Liposomes

Multilamellar Liposomes were prepared following the thin film hydration method [11]. A lipid film was formed by removing the organic solvent under low vacuum along with temperature by rotary evaporation (temperature bath being 35- 40ºC) from Soya lecithin solution in chloroform. Aqueous phase containing distilled water was added to the lipid film. The solution was then swirled to remove the lipid from the walls of the flask and glass beads, also to disperse large lipid aggregates; glass beads were added to facilitate dispersion. After preparation, the resulting milky liposome suspension was left to equilibrate for 15 minutes and applied in wool/polyester dyeing process.

2.3 Dyeing Procedure

Before dyeing, the wool/polyester samples should be cleaned to become free from the impurities. Therefore, samples were scoured using 1 gr/l nonionic detergent at a liquor ratio of 40:1 for 30 min at 60ºC. The samples were then rinsed with warm water and tap water and then dried at room temperature.

Wool/polyester samples were treated with liposomes, without liposomes or with conventional auxiliaries. The dye bath were prepared with different concentrations of prepared MLV liposomes (0%, 1%, 2%, 3% o.w.f.), 2% o.w.f (on weight of fabric) disperse dye (Sumikaron Blue EF-BL) and dispersing agent at a liquor ratio of 40:1; acetic acid was added to adjust the pH to 4.5-5.5.

Dyeing in Polymat dyeing machine was initiated at room temperature and the temperature raised by 2ºC/min until the maximum temperature (95ºC, 110ºC or 120ºC) was reached, remaining there for 45, 60 or 75 minutes. The samples were then rinsed with tap water and dried at 60ºC for 10 minutes [4].

The reflectance values and the corresponding CIE L^*, a^*, b^*, C^* and h^0 of the dyed samples were measured using a Datacolor Texflash spectrophotometer interfaced to a digital PC under illuminant D_{65}, using a 10^0 standard observer with UV component included and specular component excluded.

The distribution of disperse dye on the wool/polyester samples were determined by the K/S values calculated according to the Kubelka-Munk equation from the amount of reflectance (R) at the maximum wavelength (λ_{max}).

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

3. Results and Discussions

3.1 Dyeing Profiles

The color strengths (K/S value) were calculated according to the equation1 from the reflectance amount of samples at the maximum wavelength (which give maximum dye absorption). All of the dyed samples indicated the minimum value of reflectance at 460nm (λmax).

The K/S values of wool/polyester samples dyed with disperse dye, applied liposome concentrations from 0% to 3% o.w.f at three different temperatures (95ºC, 110ºC and 120ºC) and exhaustion times (45, 60 and 75 min) were obtained

It can be observed from figure 3, 4 and 5 that any increase in time of dyeing and concentrations of liposome caused an increase in the values of K/S. Enhancement of (K/S) values is more significant at 110ºC than 95ºC and 120ºC. Because of compact crystalline structure of polyester dyeing at low temperature (95ºC) doesn't lead to achieve satisfactory dye absorption. Increasing of temperature to 120ºC, with different exhaustion time and liposomes concentrations doesn't raise the K/S values significantly even in some samples, decrease in K/S values observed. This could be related to the liposomes stability. The liposome above the 85ºC gradually converted to the smaller particles of phospholipids. These changes of the particle size of phospholipid lead to coating of wool/polyester surface with a layer of phospholipid at 120ºC which leads to decrease the value of K/S.

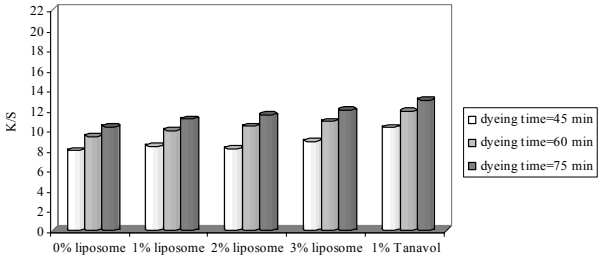

Fig 3. K/S values of the dyed samples with different liposomes concentration and exhaustion time and at 95ºC.

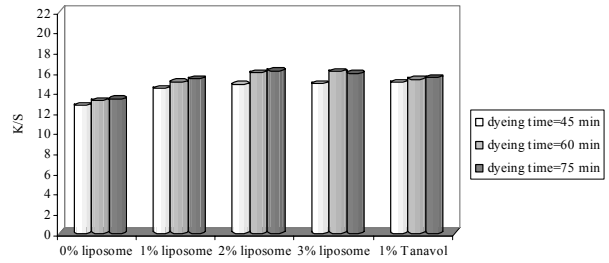

Fig 4. K/S values of the dyed samples with different and liposomes concentration and exhaustion time at 110ºC.

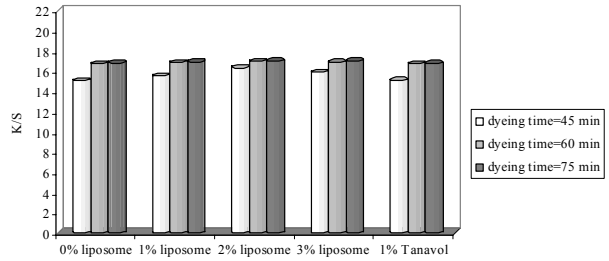

Fig 5. K/S values of the dyed samples with different liposomes concentration and exhaustion time at 120ºC

The results also indicated that although the samples dyed without liposomes at 120ºC have a higher value of K/S comparing with the samples dyed with liposomes at 110ºC according to figure 4 and 5, but their differences were not significant along with having preferences rather than synthetic auxiliaries e.g. not being toxic and harmful to the environment.

It can be concluded that in dyeing of wool/polyester with disperse dyes, utilization of 2% o.w.f liposomes in dye-bath at 110ºC for 60 min, clearly reduce the dyeing temperature about 10ºC compared with a conventional dyeing process. These results are in accordance with the results obtained by Marti for the dyeing of wool/polyester with disperse dye.

3.2 Fabric Properties in Liposome Dyeing

3.2.1 Wash & Light Fastness

In order to study the effect of liposomes on the dyed wool/polyester samples, wash and light fastness were tested and the results listed in Tables 1 and 2. The results showed that dyeing with liposome doesn't have clear effect on wash and light fastness of samples compare with those dyed with conventional dyeing process.

Table 1. Wash fastness of dyed samples.

Sample	Wash fastness	Staining on wool	Staining on polyester
Dyed without liposome at 120°C for 60 min	4-5	5	5
Dyed with liposome at 110°C for 60min	4-5	5	5
Dyed with carrier at 95°C for 60min	4	5	5

Table 2. Light fastness of the dyed samples.

Sample	Light fastness
Dyed without liposome at 120°C for 60 min	5-6
Dyed with liposome at 110°C for 60mi	5-6
Dyed with carrier at 95°C for 60min	5

3.2.2 Tensile Strength

The results of tensile strength test for dyed wool/polyester samples were shown in figure 6. The influence of dyeing temperature on the strength of wool component was found to be very significant, even at short dyeing times (45 min). The rate of decrease in tensile strength decreased with increasing dyeing temperature. For this reason it is not recommendable to expose the wool component to be dyed at above 110°C. Considering figure 6, comparing the tensile strength obtained by dyed samples with 2 % liposome and conventional dyeing (with carrier at 95°C and without auxiliaries at 120°C) for 60 min, reveals that increasing temperature and time of dyeing decrease the tensile strength which is more rapidly above 110°C and 60 minute. Also less decrease in tensile strength of dyed samples with 2% liposome is observed compared with samples dyed conventionally.

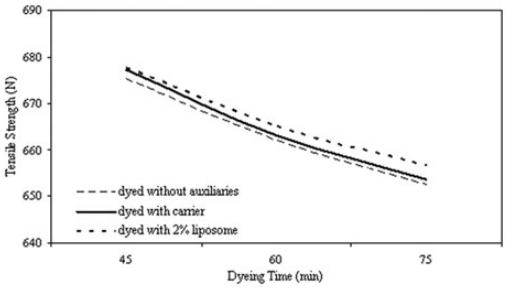

Fig 6. Tensile strength of wool/polyester samples dyed with disperse dye as a function of dyeing temperature for 60 min.

4. Conclusions

In this work, applications of liposomes as a carrier in dyeing of wool/polyester by some of the synthetic dyes have already been reported. From our results, it concluded that a new method of wool/polyester dyeing using disperse dye C.I.Disperse Blue 56 by means of large multilamellar liposomes could be considered appropriate for improving dye exhaustion on samples and reduce the dyeing temperature approximately 10ºC. The optimum dyeing condition of wool/polyester fabric with this disperse dye is under 110°C for 60 minute with 2% liposomes concentration. Also using liposomes could lead to decrease high energy costs, expensive machinery investment, and undesirable effects such as wool damage during the dyeing process and protect environment.

5. References

[1] Gomes, J.I.N.R, "Controlling Exhaustion of Reactive Dyes on wool by Microencapsulation with Liposomes", Textile Research Journal, vol. 67, no. 7, pp 537-541, July. 1997.

[2] De la Maza, A., Parra, J.L., Bosch, P., Coderch, L.A., "Large Unilamellar Vesicle Liposomes for Wool Dyeing: Stability of Dye-Liposome Systems and Their Application on Untreated Wool", Textile Research Journal, vol. 62, no. 7, pp 406-413, 1992.

[3] De la Maza, A., Parra, J.L., Manich, A.M., "Lipid Bilayers Including Cholesterol as Vehicles for Acid Dyes in Wool Dyeing Textile Research Journal, vol. 63, no. 11, pp 643-649, 1993.

[4] Marti, M., Coderch, L.A., de La Maza, A., Manich, A., and Parra, J.L., "Phosphatidylcholine Liposomes as Vehicles for Disperse Dyes for Dyeing Polyester/Wool Blends", Textile Research Journal, vol. 68, no. 3, pp. 209-218, March. 1998.

[5] Carrion Fite, F., J., "Dyeing Polyester at Low Temperatures: Kinetics of Dyeing with Disperse Dyes", Textile Research Journal, vol. 65, no. 6, pp. 362-368, June. 1995.

[6] Wang, J., Asnes, H., "One bath Dyeing of Wool/Polyester Blends with Acid and Disperse Dyes, Part 1-Wool Damage and Dyeing Conditions", Society of Dyers and Colourists., vol. 107, pp. 274-279, 1991.

[7] Colour Index, Fourth Edition, SCD, 2001.

[8] Textiles International Standard for colour fastness to washing: sections AO2 & AO3, Grey scale for assessing change in colour and staining, 1th Ed., 1978.

[9] Textiles International Standard for colour fastness to artificial light: Xenon arc fading lamp test, 3th Ed., 1988.

[10] Annual Book of American Society for Testing and Materials Standards: Section 7, Textile п, 1999.

[11] Lasic D.D., "Liposomes in Gene Delivery", CRC Press, pp 67-95, 1997.