	International Wool Textile Organisation I.W.T.O.
	Florence Meeting June 1999

Technology and Standards Committee

Commercial Technology Forum

Chairman : D.J. Ward (Australia)
Techn. Coordinator: G. Mercier (France)

Report Nrº CTF 04

INTERNATIONAL WOOL TEXTILE ORGANISATION

TECHNOLOGY & STANDARDS COMMITTEE — FLORENCE MEETING

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Industrial Use of Liposornes in Wool Dyeing

By

L. Coderich, M. Marti, A. De La Maza, A. M. Manich, S. Serra*, J.M. Fiadeiro** and J.L. Parra

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BRIEFING PAPER

SUMMARY OF FINDINGS

Liposorne is considered as a new biocornpatible product more suitable and prornising than conventional synthetic auxiliaries to reach a new clean dyeing technology. A cornparative rnethodology has been used dyeing wool and wool blends with conventional auxiliaries or with a cornrnercial Liposorne (Ecotrans W-8814) to check three rnain pararneters: the quality of the dyed textile, the energy saving and ecological irnpact of the new process.

The usefulness of Liposornes to dye wool and wool blends presented in raw, top material and spun yarn is indicated. The dyeing ternperature could be 10°C lower than conventional dyeing, with a dye exhaustion of the sarne level and a lower environmental irnpact. However, this Liposorne does not favour dye rnigration to achieve good leveling for woven fabric without presence of synthetic auxiliaries. Design of new Liposorne formulations is envisaged.

COMMERCIAL IMPLICATIONS – CURRENT AND FUTURE

The design of industrial process using rnilder experimental conditions (e.g. lower ternperatures, lower contarnination, etc.) still rernains one of the rnost irnportant needs for the textile field. At present, this new process for wool dyeing is being investigated by 13 partners frorn Portugal, Italy and Spain in an EC Project. Several wool presentations (raw material, top, spun yarn, woven and knitted fabric) are considered and sorne other textile rnaterials (polyester, viscose, polyarnides, and acrylics) are also envisaged in blends with wool.

This process rnay be considered a new clean technology approach already used by sorne Textile Industries. The final econornical optirnisation of the dyeing process using Liposornes irnply:

- an irnprovernent of quality of the wool dyed in terrns of leveling, dye fixation. wool srnoothens, tensile strength and better weight yield of the wool processed.

- econornical advantages in terms of Liposorne cost, dyestuff cost (higher exhaustion in the bath) and energy saving (the dyeing process rnay be performed at 85-90°C instead of the conventional ternperature 98°C).

- a lower ecological irnpact of the dyeing process, since the use of Liposornes, frorn biological origin, instead of synthetic dyeing auxiliaries rnay perrnit a clear reduction of the wastewater negative charge.

NOTE

This paper will be discussed at the Cornrnercial Technology Forurn, at 0900 on Sunday 30'" May, 1999.

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SUMMARY

Liposome is considered as a new biocompatible product more suitable and promising than conventional synthetic auxiliaries to reach a new clean dyeing technology. A comparative methodology has been used dyeing wool and wool blends with conventional auxiliaries or with a commercial Liposome (Ecotrans W-8814) to check three main parameters: the quality of the dyed textile, the energy saving and ecological impact of the new process.

The usefulness of Liposomes to dye wool and wool blends presented in raw, top material and spun yarn is indicated. The dyeing temperature could be 10°C lower than conventional dyeing, with a dye exhaustion of the same level and a lower environmental impact. However, this Liposome does not favour dye migration to achieve good leveling for woven fabric without presence of synthetic auxiliaries. Design of new Liposome formulations is envisaged.

INTRODUCTION

Over the last decade, a number of investigations have been carried out using different carriers capable of reducing the degradation brought about in conventional wool dyeing. At present, there is a commercial Liposome in the textile market, Ecotrans W-8814, with competitive cost to conventional auxiliaries. This new dyeing auxiliary has been demonstrated in the laboratory to control the rise of the colour giving up to good levelness with the advantage to promote higher dye exhaustion than other synthetic auxiliaries. Furthermore, the final temperature of the dye process can be reduced on 10°C, favouring the handle characteristics of the fibre with energy saving. The biological nature of the Liposome is an important ecological benefit of this new dyeing process.

To demonstrate the industrial feasibility of this dyeing process, 13 Industries participate in an European project comparing their particular dyeing process with the one in presence of Liposome. In the present work some of these experiences are presented and the processes are evaluated in terms of quality of the textile dyed, energy saving and ecological impact of the new process.

As regards to Quality, an improvement of the dye exhaustion and dye migration onto the fibre is the main goal. It has been demonstrated this parameter mainly in the dyeing of wool and other natural fibres (angora, mohair, silk, etc) at a raw material and spun yarn presentations. The main reasons for this better performance are: The use of liposomes as an appropriate vehicle, their biological characteristics, the possibility to reduce the final temperature of the dyeing bath avoiding a deleterious effect on the fibre, etc. Moreover, the use of liposomes during the dyeing of wool (raw material or top) increases the industrial yield of the subsequent spinning, weaving and knitting processes (3-5%).

As regards to energy saving, this innovative process permits a reduction of about 10°C in the final dyeing temperature resulting in an 8-10% energy saving. Reduction of the Chemical Oxygen Demand (COD) in the wastewater (about 1000 units) of the dyeing bath is another important benefit. About 2 Euro reduction of the cost of wastewater treatment per 1 TM of wool dyed may be expected. Furthermore, the cost of liposomes is similar or cheaper (about 3.5 - 4 Euro/l) than the cost of conventional auxiliaries (about 4.5 Euro/l).

However, the wool industry demands a new generation of liposomes able to be used in the dyeing of wool fabrics submitted previously to different chemical treatments during their processing before the final dyeing. In particular, it could be very convenient to improve the dye migration phenomena. This is an important industrial objective that we will try to manage in the future designing new strategic Liposome formulations.

DYEING OF WOOL AT DIFFERENT PRESENTATION FORMS

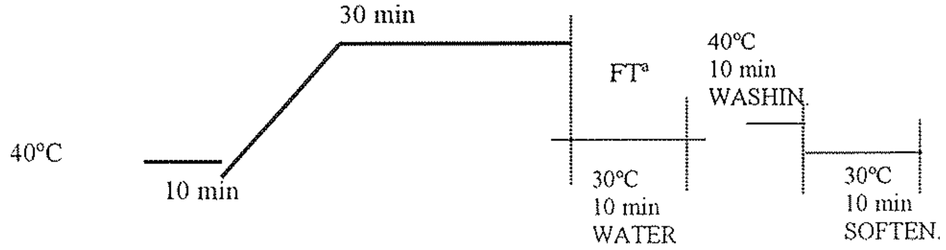
RAW AND TOP WOOL

Raw material dyeing has been performed using *pre-metallised 2:1 dyes (Lanaset dyes)* with 0.7% owf of Ecotrans W-8814 Liposome, at a final temperature of 90°C while in the case of conventional dyeing 0.3% owf of Tanapal and 1% owf of Tanaterge NWA, at a final temperature of 98°C was applied (Table 1).

Table I. Dyeing recipes and ecological impact analysis of raw wool

	LIPOSOME DYEING	*CONVENTIONAL DYEING*
Liquor ratio	1: 9.5	
Dyes	Yellow Lanaset 2R: 0.075 % owf Brown Lanaset B: 0.071 % owf Brown Lanaset G: 0.048 % owf	
Textile auxiliary	Ecotrans W-8814: 0.7 % owf Acetic Acid 80%: 1 % owf Formic Acid 85%: 0.5 % owf	Tanapal LM: 0.5 % owf Tanaterge NWA: 1% owf Acetic Acid 80%: 1 % owf Formic Acid 85%: 0.5 % owf
Ecological impact analysis		
Dye Exhaustion (%)	95	88
COD (mgO_2/l)	2205	3850
BOD (mgO_2/l)	671	996
COD/BOD	3.28	3.8
Conductivity (mS/cm) and SOL ($\mu S/cm$)	2.72 3489	4.53 5945
PH	No influence	No influence
Phosphor (mg phosphor total/l)	3	8
Nitrogen ammoniac (mg NH_4^+)/l	12	160

Dyeing Cycle



FT=90°C for Liposome dyeing, FT=98°C for Tanapal dyeing

In Table I is possible to appreciate a better behaviour of Liposome dyeing compared with Tanapal dyeing. When Liposome is present in the dye-bath the dye exhaustion increases, and environmental parameters decrease.

The material weight balance of the wool samples dyed in the presence or absence of liposomes during the subsequent textile processing steps were evaluated. Part of the raw material dyed using liposomes (1700 Kg) was spun in an industrial process and it was compared with a raw material dyed with conventional auxiliaries.

The results attained were satisfactory. A very high yield was obtained, 97.46% and the physical properties evaluated gave the following results, tenacity: 4.49 CN/TEX, elongation: 17.83% and maximum friction force: 347.8 CN (6% higher than the ones obtained in conventional dyeing).

It is important to point out that till now 70 tons of raw material and top wool have been industrially satisfactorily dyed with 32 different dyes.

SPUN YARN

Worsted Yarn material (one single strand) was dyed using pre-metallised 2:1 dyes (Lanaset dyes) with 1% owf of Ecotrans W-8814 Liposome, at a final temperature of 90°C and with the industrial process, in presence of a 1% owf of Tanapal LM at a final temperature of 98°C. The similar kinetic profile obtained bearing in mind the lower temperature in the Liposome process also supports the use of this Liposome in preference to Tanapal LM.

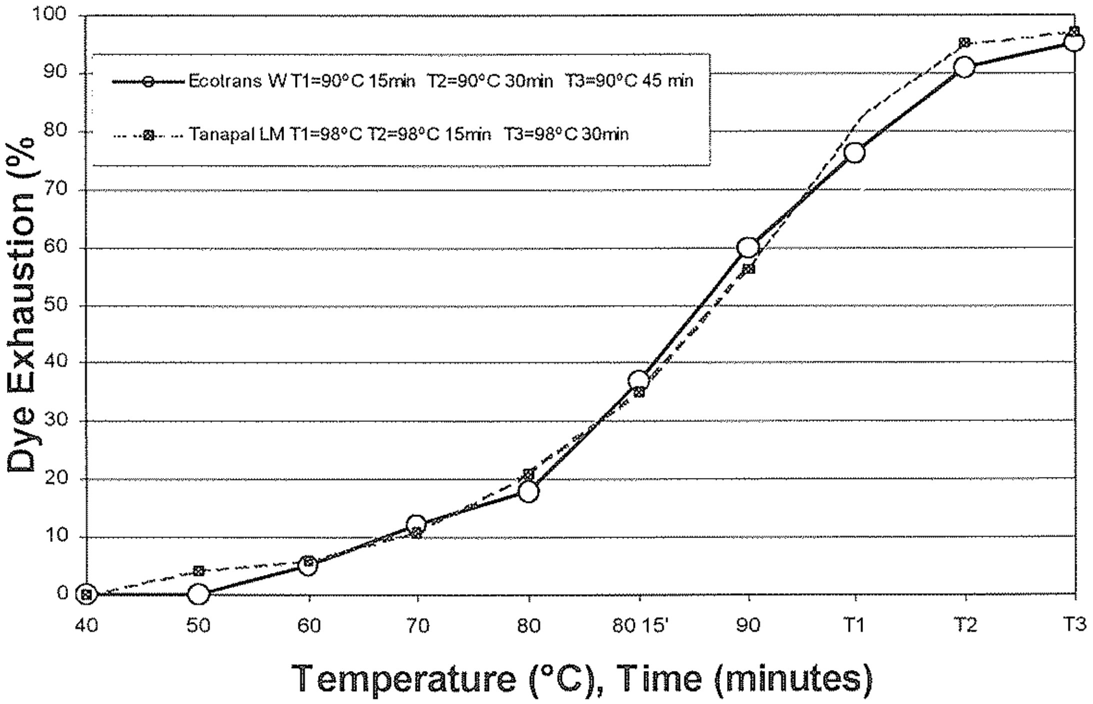
Dyeing Recipe

	LIPOSOME DYEING	*CONVENTIONAL DYEING*
Liquor ratio	1: 10	
Dyes	Grey Lanaset G: 1.235 % owf Orange Lanaset RN: 0.795% owf Navy Blue Lanaset R: 0.730% owf Navy Blue Lanasyn SDNLS: 0.72% owf Blue Polyamid CBL 150: 0.345% owf Red Lanaset G: 0.055% owf	
Textile auxiliary	Emectol SMA:0.2 g/l Ecotrans W-8814: 1% owf Acetic Acid 80%: pH=4.5-5	Emectol SMA:0.2 g/l Tanapal LM:1 % owf Acetic Acid 80%: pH=4.5-5

Posterior treatment

Posterior Washing	Hostapon T dust a. c.: 0.2% owf
Softening Treatment	Steramine PNA 160: 1% owf Formic Acid 85%:0.3% owf

Dye exhaustion of Pre-metallised 2:1 Dye



A similar kinetic profile was obtained bearing in mind the lower temperature in the case of Liposome process compared to the Tanapal LM process. Also, spun yarn of Shetland wool (two plied yarn) was dyed using either Ecotrans W-8814 or Tanapal LM to measuring mechanical properties.

Mechanical properties of wool processed were evaluated to evidence the quality improvement imparted to the wool samples dyed by liposomes in comparison with the wool dyed by a conventional procedure.

Mechanical properties and characteristics have been measured on raw yarns and dyed yarns using conventional auxiliaries, and liposomes. Table II shows the results obtained when linear density and twist have been measured on yarns. As it can be expected there were not significant differences between these parameters measured on yarns dyed with auxiliaries and yarns died with liposomes. Yarn linear density was measured on a sample of 100 m of yarn and twist was assessed as a mean value of 30 samples of 50 cm of length using the conventional twist-untwist method.

Table II. Results on linear density and twist.

	No. (Tex)	Twist (v/m)
Shetland Wool (two plied yarn)		
Untreated wool	231.41	65.26 S
Tanapal LM	211.13	59.63 S
Ecotrans W-8814	214.24	59.20 S
Wool Yarn 2/43 (one single strand yarn)		
Untreated wool	30.80	466.53 S
Tanapal LM	30.34	497.20 S
Ecotrans W-8814	31.10	494.96 S

Load and Elongation to break were determined on 30 samples of yarn 250 mm of length, submitted to a traction test at a 60%/min gradient of stretching (150 mm/min), according to the conditions shown in the ASTM Standard D 885 with some modifications. Breaking load [daN], Tenacity [cN/tex] and Elongation at Break were given as a mean value. Also the coefficient of variation were calculated. Results are shown in Table III. No significant differences between results were observed. However, higher values were always obtained in the case of Liposome related to the Tanapal LM dyed sample.

Table III. Results on mechanical properties.

Yarn Breaking Tests			
	Break. Load daN / C.V.%	Tenacity cN/tex /CV%	Elongation % / CV%
Shetland Wool (two plied yarn)			
Untreated wool	0.76 / 4.4	3.29 / 4.4	15.00 / 9.1
Tanapal LM	0.61 / 8.4	2.87 / 8.4	10.15 / 12.9
Ecotrans W-8814	0.64 / 7.5	2.99 / 7.5	10.23 / 26.5
Wool Yarn 2/43 (one single strand yarn)			
Untreated wool	0.23 / 10.6	7.57 / 10.6	17.73 / 19.6
Tanapal LM	0.21 / 10.6	6.91 / 10.6	15.47 / 23.8
Ecotrans W-8814	0.21 / 10.4	6.92 / 10.4	18.57 / 25.5

Handle assessment were done through the determination of yarn to yarn friction coefficient and yarn to metal friction coefficient according to the ASTM Standards D 3108 and D 3412 respectively with some modifications Results are shown in Table IV.

Yarn to yarn friction shows that yarn dyed with Ecotrans has a handle more similar to the raw wool yarn than yarn dyed with Tanapal. Considering yarn to metal friction, when Ecotrans were used as auxiliary in the case of two plied yarn, the handle were more similar to the raw wool yarn than when Tanapal was used. In the case of one single strand yarns, there were no differences between Ecotrans and Auxiliary dyeing.

Table IV. Results on friction.

	Yarn to Yarn	Yarn to Metal
Shetland Wool (two plied yarn)		
Untreated wool	75.20	65.68
Tanapal LM	66.60	50.08
Ecotrans W-8814	77.60	61.52
Wool Yarn 2/43 (one single strand yarn)		
Untreated wool	27.44	35.30
Tanapal LM	22.00	34.56
Ecotrans W-8814	23.68	34.24

All parameters considered leads to a conclusion that Liposome dyeing gives no significant differences in relation to the conventional auxiliary dyeing. Other measurements like yield during weaving and mechanical properties and handle of woven fabrics are planned to be performed in the future.

WOOL YARN WITH SUPERWASH TREATMENT

Wound packages cones of worsted yarn, Nm 29, 100%wool with Superwash treatment was submitted to dyeing process with metal complex dyes 1:2 by the conventional and Liposome methods.

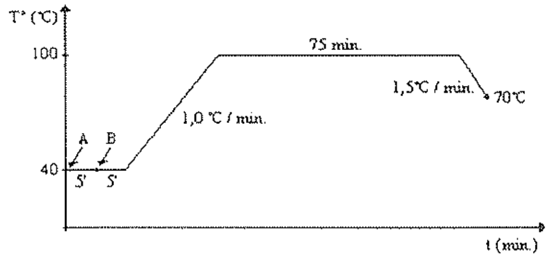
DYEING CONDITIONS:

	Recipes		
	CONVENTIONAL	LIPOSOME 1	LIPOSOME 2
A – Auxiliaries:			
Scourol S-520	0,5 g/l	-----	-----
ECO TRANS W - 8814	-----	0,8 % o.w.f.	0,8 % o.w.f.
Protintex 1779/P Conc.	1,0 % o.w.f.	-----	-----
Protisol STA	1,5 % o.w.f.	-----	-----
Protintex HR	1,0 g/l	-----	-----
Avolan UL 75	-----	-----	1,0 % o.w.f.
Ammonium Sulphate	3,0 % o.w.f.		3,0 % o.w.f.
Sodium Sulphate	-----		2,0 g/l
Eulisin S	0,8 % o.w.f.	0,8 % o.w.f.	0,8 % o.w.f.
	(pH: 5,0)	(pH: 5,0)	(pH: 5,0)
B – ACIDOL dyestuffs:			
MBL Brown	0,9 % o.w.f.	0,9 % o.w.f.	0,9 % o.w.f.
GNW Yellow	0,1 % o.w.f.	0,1 % o.w.f.	0,1 % o.w.f.
MTR dark blue	0,7 % o.w.f.	0,7 % o.w.f.	0,7 % o.w.f.

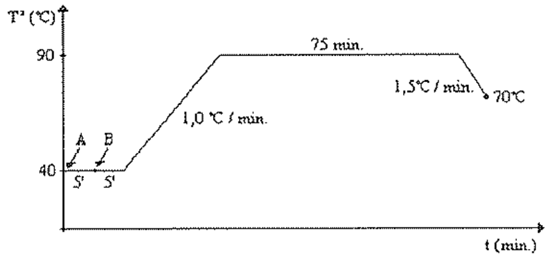
R.B.: 15 l/Kg

DYEING DIAGRAM:

CONVENTIONAL



LIPOSOME



RESULTS:

		CONVENTIONAL	LIPOSOME 1	LIPOSOME 2
COD initial bath (mg/l O_2)		2895	2395	2327
BOD_5 initial bath (mg/l O_2)		777	460	495
COD final bath (mg/l O_2)		2542	1420	1625
BOD_5 final bath (mg/l O_2)		545	400	420
Tensile strength of undyed yarn (cN)		186±6		
Coefficient of variation (%)		12,12		
Tensile strength after dyeing (cN)		201±6	186±7	210±6
Coefficient of variation (%)		10,24	14,45	11,1
Colour fastness to washing (ISO 105 C06 A2S)	Colour change	4-5	4	4
	Staining (WO/PA/CO)	4-5 / 4 / 4-5	4-5 / 4 / 4-5	4-5 / 4 / 4-5
Colour fastness to water (ISO 105 E01)	Colour change	4-5	4-5	4-5
	Staining (WO/PA/CO)	4-5 / 4-5 / 4-5	4-5 / 3-4 / 4-5	4-5 / 4-5 / 4-5
Dyebath Exhaustion (%)		89,10	99,01	88,20
Optical density of final bath (%)		1,15633	1,15077	-----
Colour levelness		GOOD	POOR	GOOD
Costs (PTE/Kg):	- Dyes and auxiliaries	96,03	67,55	79,93
	- Electrical energy	17,62	15,91	15,91
	- Thermal energy	21,06	14,45	14,45
Total		**126,39**	**97,91**	**110,29**

Dyeing with liposomes under acid conditions similar to those used in conventional process (Recipe 1) was not satisfactory, about 80% of the dyestuff being exhausted onto the fibres after 5 min. at 40°C and consequently a pronounced dyeing unevenness between the inside and the outside of the cones was produced.

In an attempt to reduce the dyeing rate and to improve evenness some further experiments employing a neutral bath (pH≅ 6,8) and a low temperature at the beginning of the dyeing process (30°C) were then carried out but these conditions had a very little effect on the results, even when the temperature was maintained at 30°C during 30 min. It therefore was decided to employ a retarding agent (AVOLAN UL 75). It was found that an add-on level of 1% of this agent and 2g/l of sodium sulphate (Recipe 2) reduced the dyeing to an acceptable level, similar to that of the conventional dyeing.

The colour evenness was increased significantly, the dyeing costs being still lower than those of conventional dyeing.

From the tabled data the following can be observed for Liposome – leveling agent dyeing:

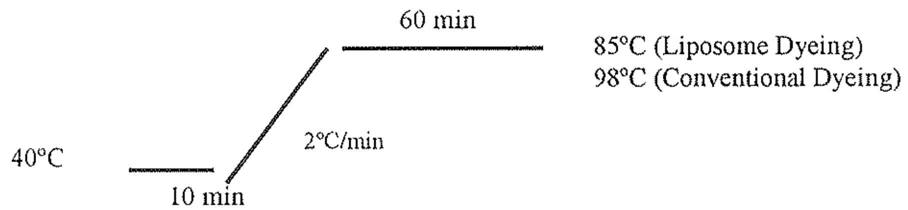
- A slightly higher tensile strength of the dyed yarn;
- A slightly higher change of colour concerning fastness to washing (difference of a half-step);
- A polluting charge reduction of about 40% for COD and 20% for BOD_5;
- A reduction of about 12% for dyeing costs.

WOVEN WOOL FABRIC

Woven fabric dyeing has been made using *pre-metallised 1:1 dyes (Neolan dyes).* In this case two different kinetics were compared, first with conventional auxiliaries using a final temperature of 98°C and second with Liposome Ecotrans W-8814 instead of sodium sulphate at 85°C of final temperature. In this case, the presence of conventional auxiliaries such as Matexil and Avolan are necessary to achieve even dyeing.

Liposomes mainly restrain the rise of colour at low temperatures without a pronounced action as migrator. Woven fabrics have suffered previous chemical treatments that need a strong migrator to achieve even dyeing. Therefore, in this case the salt that mainly retains the raise of colour has been substituted by Liposome, being necessary the presence of conventional migrators to achieve a high quality of the textile dyed.

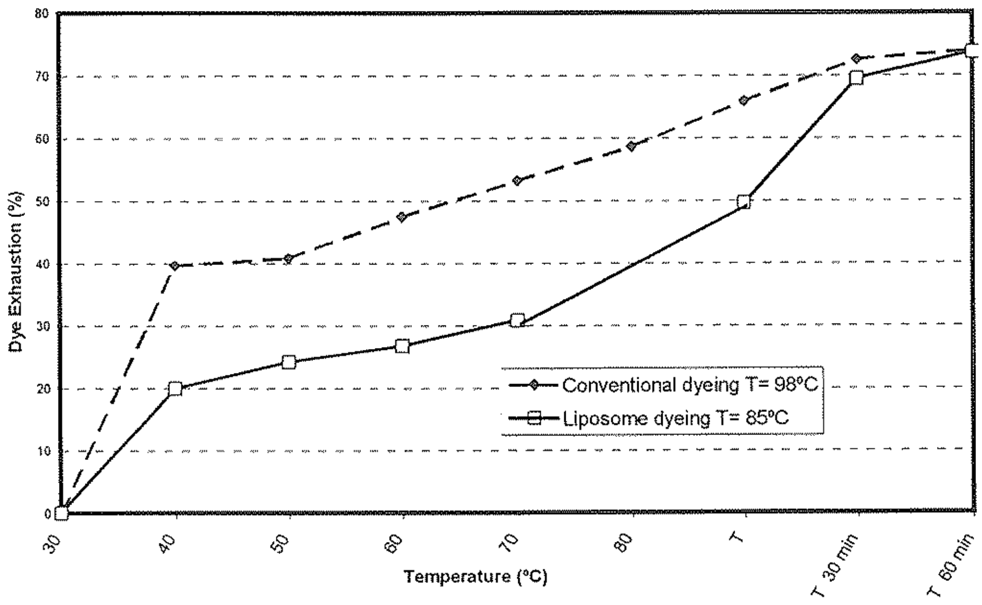
Dyeing Cycle



Dyeing Recipe

	LIPOSOME DYEING	*CONVENTIONAL DYEING*
Liquor ratio	1: 12	
Dyes	Yellow Stenamina GR 175: 0.174 % owf Burdeos Premelan RM: 0.242 % owf Blue Cocelan 2G 250: 0.50 % owf Yellow Neolan RE 250: 0.176 % owf	
Textile auxiliary	Liposome: 0.2 % owf Matexil Wash: 0.5 % owf Avolan SCN: 0.3 % owf Nofelt WA: 1.5 % owf Sulfuric Acid: 3 % owf	Sodium Sulphate: 7.5 owf Matexil Wash: 0.5 % owf Avolan SCN: 0.3 % owf Nofelt WA: 1.5 % owf Sulfuric Acid: 3 % owf

Dyeing kinetics of woven fabric



It can be observed the higher controlled dye absorption during the dyeing in presence of liposomes, being the final exhaustion similar for both dyeing. Furthermore, the final temperature of the Liposome dyeing process can be reduced on 13°C that will greatly favours the handle characteristics of the woven fabric with an additional energy saving.

DYEING OF WOOL BLENDS

Wool/Polyamide yarns were dyed with metal complex dyes 1:2, metal complex dyes 1:1 and milling acids dyes all by the conventional and Liposome methods (cone dyeing).

Acrylic/wool yarns were dyed with cationic and metal complex dyes 1:2 (one-bath; two-step process) by the conventional and Liposome methods (cone dyeing). Wool/Acrylic/Alpaca yarns were dyed with metal complex dyes 1:2 for wool (1st bath) and cationic dyes for acrylic (2nd bath) by the conventional and the Liposome methods (hank dyeing).

For each test the dye-bath exhaustion, the polluting load, the mechanical strength of the yarn before and after dyeing, the colour levelness, the fastness properties of dyeings and specific costs relating to dyestuffs and auxiliaries, electric power and thermic energy (vapour) were evaluated.

1. WOOL/POLYAMIDE DYEINGS

1.1 DYEING OF WOOL/POLYAMIDE BLENDS USING METAL COMPLEX DYES 1:2

Wound packages (cones) of woollen yarn, Nm 12, 70% wool 30% Polyamide (intimate blend)

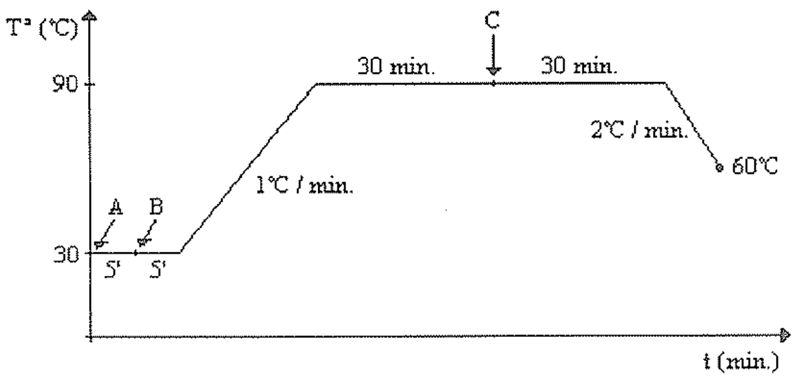
DYEING CONDITIONS:

	Recipes	
	CONVENTIONAL	LIPOSOME
A – Auxiliaries :		
Edolan PAW Líq.	1,0 % o.w.f.	1,0 % o.w.f.
Baylan CNT	2,0 % o.w.f.	-----
Avolan UL 75	0,5 % o.w.f.	-----
ECO TRANS W - 8814	-----	0,8 % o.w.f.
Sodium Sulphate	1,0 g/l	-----
Tri-Sodium Phosphate	0,5 g/l	-----
Acetic Acid	1,0 g/l (pH: 4,5)	1,0 g/l (pH: 4,5)
B – Dyestuffs:		
ISOLAN Yellow SGL	0,30 % o.w.f.	0,30 % o.w.f.
ISOLAN Bordeaux SBL	2,40 % o.w.f.	2,40 % o.w.f.
ISOLAN Dark blue 2SGL	0,22 % o.w.f.	0,22 % o.w.f.
C :		
Formic Acid	(Ph: 3,8 - 4,0)	(pH: 3,8 - 4,0)

R.B.: 10 l/Kg

DYEING DIAGRAM:

CONVENTIONAL AND LIPOSOME



RESULTS:

		CONVENTIONAL	LIPOSOME
COD initial bath (mg/l O_2)		14172	12068
BOD_5 initial bath (mg/l O_2)		3315	2665
COD final bath (mg/l O_2)		7469	7278
CBO_5 final bath (mg/l O_2)		2145	2600
Tensile strength of undyed yarn (cN)		399±8	
Coefficient of variation (%)		12,3	
Tensile strength after dyeing (cN)		291±8	290±4
Coefficient of variation (%)		17,3	15,2
Colour fastness to washing (ISO 105 C06 A2S)	Colour change	4-5	4-5
	Staining (WO/PA/CO)	4-5 / 4-5 / 4-5	4-5 / 4-5 / 4-5
Colour fastness to water (ISO 105 E01)	Colour change	4-5	4-5
	Staining (WO/PA/CO)	4-5 / 4-5 / 4-5	4-5 / 4-5 / 4-5
Dyebath Exhaustion (%)		97,7	97,8
Optical density of final bath (%)		1,1051	1,00
Colour levelness		GOOD	GOOD
Costs (PTE/Kg): - Dyes and auxiliaries		192,80	170,71
- Electrical energy		5,50	5,50
- Thermal energy		8,60	8,60
Total		**206,90**	**184,81**

1.2 WOOL/POLYAMIDE YARN, DYED WITH METAL COMPLEX DYES 1:1

Wound packages of woollen yarn, Nm 12, 70%Wool/30%Polyamide (intimate blend)

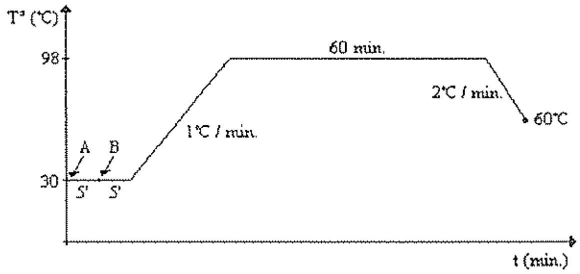
DYEING CONDITIONS:

	Recipes	
	CONVENTIONAL	LIPOSOME
A – Auxiliaries:		
Keriolan A2N	1,5 % o.w.f.	-----
ECO TRANS W - 8814	-----	0,8 % o.w.f.
Sodium Sulphate	10,0 % o.w.f.	-----
Sulphuric Acid	5,0 % o.w.f. (pH: 2)	5,0 % o.w.f. (pH: 2)
B – NEOLAN dyestuffs:		
RE Yellow 250%	0,30 % o.w.f.	0,30 % o.w.f.
RM Bordeaux 200%	2,40 % o.w.f.	2,40 % o.w.f.
3R Blue 200%	0,22 % o.w.f.	0,22 % o.w.f.

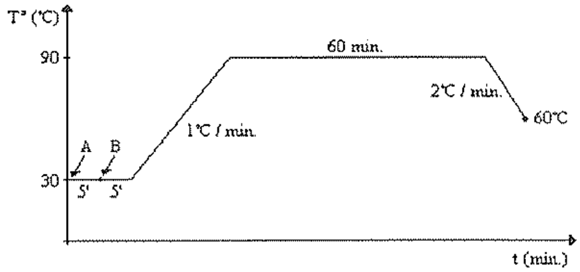
R.B.: 20 l/Kg

DYEING DIAGRAMS:

CONVENTIONAL



LIPOSOME



RESULTS:

		CONVENTIONAL	LIPOSOME
COD initial bath (mg/l O_2)		2091	1601
BOD_5 initial bath (mg/l O_2)		n. d.	n. d.
COD final bath (mg/l O_2)		1585	830
BOD_5 final bath (mg/l O_2)		163	⊐100
Tensile strength of undyed yarn (cN)		399±8	
Coefficient of variation (%)		12,3	
Tensile strength after dyeing (cN)		415±8	444±9
Coefficient of variation (%)		11,8	12,0
Colour fastness to washing (ISO 105 C06 A2S)	Colour change	3-4	3-4
	Staining (WO/PA/CO)	4-5 / 4-5 / 4	4-5 / 4-5 / 4
Colour fastness to water (ISO 105 E01)	Colour change	4-5	4-5
	Staining (WO/PA/CO)	3-4 / 2-3 / 3-4	3 / 2 / 3
Dyebath Exhaustion (%)		91,8	94,0
Optical density of final bath (%)		1,1879	0,7496
Colour levelness		GOOD	GOOD
Costs (PTE/Kg):	- Dyes and auxiliaries	168,46	156,91
	- Electrical energy	6,00	5,50
	- Thermal energy	22,86	17,20
Total		**197,32**	**179,61**

1.3 WOOL/POLYAMIDE YARN, DYED WITH MILLING ACID DYES

Wound packages (cones) of woollen yarn, Nm 12, 70%Wool/30%Polyamide (intimate blend)

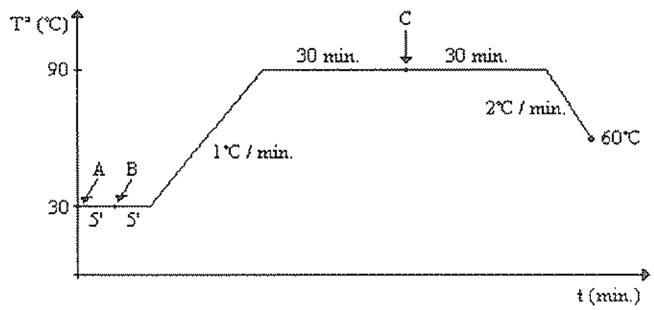
DYEING CONDITIONS:

	Recipes	
	CONVENTIONAL	LIPOSOME
A – Auxiliaries :		
Edolan PAW Líq.	0,8 % o.w.f.	0,8 % o.w.f.
Baylan CNT	2,0 % o.w.f.	-----
Avolan UL 75	0,5 % o.w.f.	-----
ECO TRANS W - 8814	-----	0,8 % o.w.f.
Sodium Sulphate	1,0 g/l	-----
Tri-Sodium Phosphate	0,5 g/l	-----
Acetic Acid	1,0 g/l (pH: 4,5)	1,0 g/l (pH: 4,5)
B – Dyestuffs:		
SUPRANOL Yellow SWP	0,50 % o.w.f.	0,50 % o.w.f.
SUPRANOL Red SWP	0,50 % o.w.f.	0,50 % o.w.f.
SUPRANOL Blue SWP	2,50 % o.w.f.	2,50 % o.w.f.
C :		
Formic Acid	(pH: 3,8 - 4,0)	(pH: 3,8 - 4,0)

R.B.: 10 l/Kg

DYEING DIAGRAM:

CONVENTIONAL AND LIPOSOME



RESULTS:

		CONVENTIONAL	LIPOSOME
COD initial bath (mg/l O_2)		14085	9245
BOD_5 initial bath (mg/l O_2)		2254	2120
COD final bath (mg/l O_2)		6538	5463
BOD_5 final bath (mg/l O_2)		2251	1401
Tensile strength of undyed yarn (cN)		399±8	
Coefficient of variation (%)		12,3	
Tensile strength after dyeing (cN)		228±8	279±8
Coefficient of variation (%)		17,8	14,5
Colour fastness to washing	Colour change	4-5	4-5
(ISO 105 C06 A2S)	Staining (WO/PA/CO)	4-5 / 3-4 / 4-5	4-5 / 3-4 / 4-5
Colour fastness to water	Colour change	4-5	4-5
(ISO 105 E01)	Staining (WO/PA/CO)	4-5 / 4 / 4-5	4-5 / 4 / 4-5
Dyebath Exhaustion (%)		99,03	99,12
Optical density of final bath (%)		0,46675	0,40196
Colour levelness		EXCELLENT	EXCELLENT
Costs (PTE/Kg): - Dyes and auxiliaries		276,27	254,18
- Electrical energy		5,50	5,50
- Thermal energy		8,60	8,60
Total		**290,37**	**268,28**

The surface uniformity of the colour, evaluated by visual examination of knit samples made with dyed yarns is identical in conventional and Liposome dyeing. The bath exhaustion is quite high in both methods, no significant differences were found in the values obtained for each one when 1:2 metal complex dyes and milling acid dyes are used. In the case of metal complex dyes 1:1 the % exhaustion achieved by Liposome method is slightly higher.

The polluting load of Liposome exhaustion baths is quite lower than in conventional dyeing process, the differences ranging from 3% to 8% for COD and from 10% to 38% for BOD_5. The high values of COD and BOD_5 for dyeings with 1:2 metal complex dyes in both processes may result form the use of a retarding agent for polyamide.

Good washing and water fastness levels were achieved, the colour change and staining values being identical for conventional and Liposome dyeings when using 1:2 metal complex dyes or acid milling dyes. Form Liposome dyeings with 1:1 metal complex dyes a slightly higher staining equivalent to a half-step was found concerning the fastness to water, the results being identical to those of conventional dyeings concerning the fastness to washing.

No significant differences are found concerning the strength of dyed yarn by both processes, using 2:1 metal complex dyes at the temperature of 90°C. However, when dyeing with acid milling dyes at the same temperature a slightly higher strength was achieved for the Liposome dyed yarn. Dyeing with 1:1 metal complex dyes, at 98°C in the conventional process and at 90°C with Liposome gives up to a higher tensile strength for the yarns submitted to the Liposome process.

The total dyeing costs are about 7% to 11% lower in the Liposome process.

2. WOOL/ACRYLIC, WOOL/ACRYLIC/ALPACA DYEINGS

2.1 Acrylic/wool yarn, dyed with cationic and metal complex dyes 1:2 (one-bath; two-step process

Wound packages (cones) of worsted yarn, Nm 2/35, 75%Acrylic/25%Wool (intimate blend)

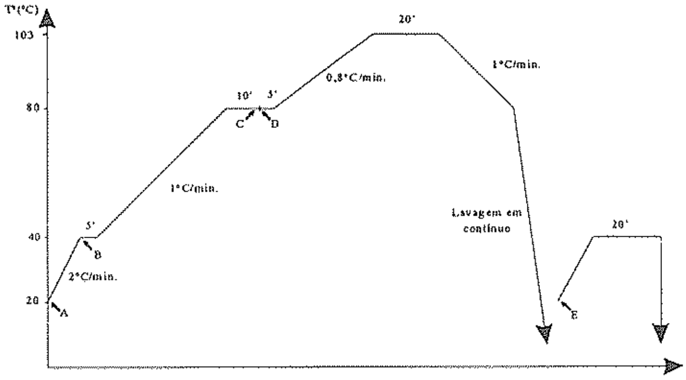
DYEING CONDITIONS:

	Recipes	
	CONVENTIONAL	LIPOSOME
A – Wool Auxiliaries:		
Avolan UL 75	1,0 % o.w.f.	-----
ECO TRANS W - 8814	-----	0,8 % o.w.f.
Sodium Acetate	2,0 % o.w.f.	-----
Acetic Acid	2,0 % o.w.f.	2,0 % o.w.f.
	(pH: 4,5)	(pH: 4,5)
B – Wool dyestuffs:		
ISOLAN Orange SRL	0,0844 % o.w.f.	0,0844 % o.w.f.
SUPRANOL Green BW	0,0364 % o.w.f.	0,0364 % o.w.f.
SUPRANOL Blue RLW	0,1600 % o.w.f.	0,1600 % o.w.f.
SUP. BL Rouge 200%	0,0137 % o.w.f.	0,0137 % o.w.f.
C – Acrylic Auxiliaries:		
Tubacryl RI	0,80 % o.w.f.	0,80 % o.w.f.
Astragal ME	1,75 % o.w.f.	1,75 % o.w.f.
D – Acrylic dyestuffs:		
VIOCRYL GRLS Yellow 200%	0,0635 % o.w.f.	0,0635 % o.w.f.
VIOCRYL GGS Red 200%	0,0020 % o.w.f.	0,0020 % o.w.f.
ASTRAZON 2RN Dark Blue	0,1209 % o.w.f.	0,1209 % o.w.f.
E – Softening:		
Belfasin OET	6,5 % o.w.f.	6,5 % o.w.f.
Acetic Acid	0,87 % o.w.f.	0,87 % o.w.f.

R.B.: 10 l/Kg

DYEING DIAGRAM:

CONVENTIONAL AND LIPOSOME



RESULTS:

		CONVENTIONAL	LIPOSOME
COD initial wool bath (mg/l O_2)		4016	1680
BOD_5 initial wool bath (mg/l O_2)		1700	940
COD final wool bath (mg/l O_2)		3937	1856
BOD_5 final wool bath (mg/l O_2)		1625	900
COD initial acrylic bath (mg/l O_2)		4277	3052
BOD_5 initial acrylic bath (mg/l O_2)		1175	730
COD final acrylic bath (mg/l O_2)		3694	1758
BOD_5 final acrylic bath (mg/l O_2)		1300	880
Tensile strength of undyed yarn (cN)		590,72	
Coefficient of variation (%)		6,65	
Tensile strength after dyeing (cN)		558,05	569,41
Coefficient of variation (%)		7,95	7,14
Colour fastness to washing (ISO 105 C06 A2S)	Colour change	5	5
	Staining (WO/PA/CO)	5 / 5 / 5	5 / 5 / 5
Colour fastness to water (ISO 105 E01)	Colour change	5	5
	Staining (WO/PA/CO)	5 / 5 / 5	5 / 5 / 5
Colour levelness		GOOD	EXCELLENT
Costs (PTE/Kg):	- Dyes and auxiliaries	78,92	58,06
	- Electrical energy	18,32	18,32
	- Thermal energy	13,38	13,38
Total		**110,62**	**89,76**

2.2 Wool/Acrylic/Alpaca yarn, dyed with metal complex dyes 1:2 for wool (1st bath) and cationic dyes for acrylic (2nd bath) (hank dyeing)

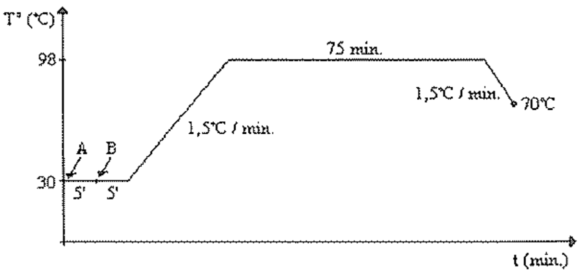
Hanks of worsted yarn, Nm 2/19, 50%Wool/30%Acrylic/20%Alpaca (intimate blend)

DYEING CONDITIONS: 1st Bath

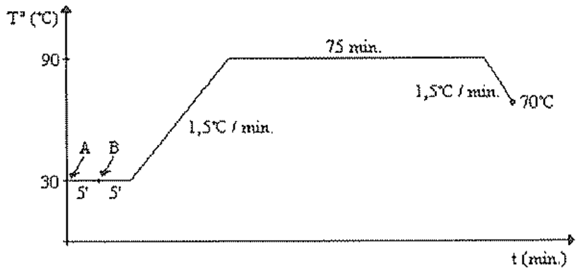
	RECIPES	
	CONVENTIONAL	LIPOSOME
A – Auxiliaries:		
Scourol S-520	1,0 g/l	-----
ECO TRANS W - 8814	-----	0,8 % o.w.f.
Protintex IWT	1,0 % o.w.f.	-----
Eulisin S	1,5 % o.w.f.	1,5 % o.w.f.
	(pH: 4,5 - 5,0)	(pH: 4,5 - 5,0)
B – ACIDOL Dyestuffs:		
MTR Dark blue		
	3,5 % o.w.f.	3,5 % o.w.f.
R.B.: 35 l/Kg		

DYEING DIAGRAM: 1st Bath

CONVENTIONAL



LIPOSOME



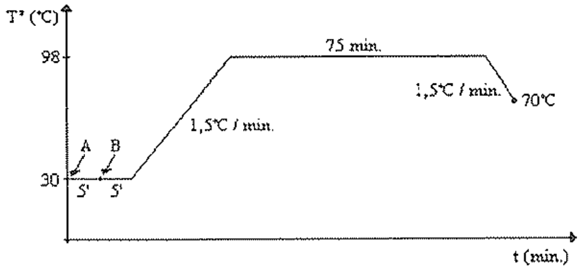
DYEING CONDITIONS: 2nd Bath

	RECIPES	
	CONVENTIONAL	LIPOSOME
A – Auxiliaries:		
Protintex IWT	1,0 % o.w.f.	1,0 % o.w.f.
Vatel Sale	5,0 % o.w.f.	5,0 % o.w.f.
Eulisin S	0,5 % o.w.f.	0,5 % o.w.f.
	(pH: 4,5 - 5,0)	(pH: 4,5 - 5,0)
B – Dyestuffs:		
ASTRAZON Blue 2RN	0,8 % o.w.f.	0,8 % o.w.f.

R.B: 35 l/Kg

DYEING DIAGRAM: 2nd Bath

CONVENTIONAL AND LIPOSOME



RESULTS:

		CONVENTIONAL METHOD	LIPOSOME METHOD
COD 1st initial bath (mg/l O_2)		2681	1187
BOD_5 1st initial bath (mg/l O_2)		573	371
COD 1st final bath (mg/l O_2)		2394	854
BOD_5 1st final bath (mg/l O_2)		527	338
COD 2nd initial bath (mg/l O_2)		881	460
BOD_5 2nd initial bath (mg/l O_2)		145	73
COD 2nd final bath (mg/l O_2)		893	432
BOD_5 2nd final bath (mg/l O_2)		218	99
Tensile strength of undyed yarn (cN)		853±14	
Coefficient of variation (%)		5,9	
Tensile strength after dyeing (cN)		748±14	757±14
Coefficient of variation (%)		6,7	6,4
Colour fastness to washing (ISO 105 C06 A2S)	Colour change	4-5	4-5
	Staining (WO/PA/CO)	4-5 / 4-5 / 4-5	4-5 / 4 / 4-5
Colour fastness to water (ISO 105 E01)	Colour change	4-5	4-5
	Staining (WO/PA/CO)	4-5 / 4-5 / 4-5	4-5 / 4-5 / 4-5
1st dyebath exhaustion (%)		97,9	98,1
Optical density of 1st final bath (%)		0,3079	0,1931
2nd dyebath exhaustion (%)		98,9	98,9
Optical density of 2nd final bath (%)		0,0808	0,0723
Colour levelness		ACCEPTABLE	ACCEPTABLE
Costs (PTE/Kg):	- Dyes and auxiliaries	133,20	115,49
	- Electrical energy	3,30	3,17
	- Thermal energy	93,45	80,5
Total		**229,95**	**199,16**

In what concerns colour levelness no difference was found when dyeing Acrylic/Wool by conventional and Liposome method. For Wool/Acrylic/Alpaca blend the appearance of small stripes has been noticed corresponding to small portions of yarn with a slightly darker shade in both processes, although with a more marked contrast in the Liposome dyed yarn. It is possible that this fault may be related to an uneven fibre blend.

The dyebath exhaustion is quite high in both processes, no significant differences in the data obtained for each one were found.

The polluting indices of 1st exhaustion bath as a result of wool dyeing with liposomes in about 53 to 64% lower than that found for the conventional dyeing in terms of COD and about 36 to 45% lower in terms of BOD_5. Concerning the 2nd exhaustion bath from the acrylic dyeing COD and BOD_5 values are also lower in the Liposome dyeing procedure, the differences being about 52% for COD and 32 to 52% for BOD_5.

The colour fastness levels are identical in both processes for Acrylic/Wool blend. For Wool/Acrylic/Alpaca blend a difference of a half step is observed in what concerns the staining on polyamide, the lower value corresponding to the Liposome dyeing. This difference was removed by a scouring after treatment of the dyed yarn.

The dyed yarn strength data using liposomes and the conventional method present no significant differences, although, a tendency to higher values is observed for Liposome dyeing.

The Liposome process allows a reduction of dyeing costs from 13% to 19%.

CONCLUSIONS

Dyeing with liposomes is a feasible process at industrial scale for technical and economical reasons, provided that liposomes are available in the market at competitive prices, its use do not needing special attentions and offering good results for a large number of dyestuffs for pure wool and wool blends.

Dyeing with liposomes at 90°C reduce fibre damage during dyeing, obtaining higher values of tensile strength. A higher yield in the spinning of raw material dyed with liposomes was obtained.

The fastness levels of Liposome dyeings are similar to those of conventional dyeings. A slightly higher staining, concerning the fastness to water and a slightly higher change of colour concerning the fastness to washing were observed for some dyeings with liposomes (wool/polyamide blend, using 1:1 metal complex dyes and wool/acrylic/alpaca blend using 1:2 metal complex and cationic dyes). An improvement of colour fastness may be possible, in these cases, by raising the temperature from 90°C to 100°C at the final steps of the dyeing process or by a scouring after-treatment of dyed material.

The Liposome dyeing process is in all cases studied less pollutant than the conventional one. The Liposome dyeing process allows reducing significantly the treatment costs in comparison with the conventional process, even in special cases where a combination Liposome-retarding agent is needed to reduce the dyeing speed.

At the moment, with the Liposome in the market it is possible to guarantee satisfactory results in raw, top material and yarn dyeing. The dyeing temperature could be 10°C lower than in the conventional dyeing, the dye exhaustion obtained is in the same level of the conventional dyeing, and the environmental impact is lower. However, this Liposome does not favour dye migration to achieve good leveling of woven fabric without presence of synthetic auxiliaries. Design of new Liposome formulations is envisaged.