First Runnerup: Delaware Valley Section

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1989 Intersectional Technical Paper Competition

Use of Heavy Metals in Textile Wet Processing

ABSTRACT

The currently recommended concentrations of aftertreatments containing heavy metals often prevent a textile finisher from meeting effluent discharge regulations. This study involved optimizing the application procedures and concentrations of copper sulfate for copperizing direct dyes on cotton and of tartar emetic (potassium antimony tartrate) for insolubulizing tannic acid on dyed nylon. The results of lowered concentrations and alternative application methods show the possibility of reducing effluent while maintaining the colorfastness qualities of textiles.

KEY TERMS

Aftertreatment
Colorfastness to Washing
Copper Sulfate
Cotton
Direct Dyes
Finishing
Nylon
Tartar Emetic

Because of harmful ecological effects, practically all organic and inorganic chemical emissions to the environment must be reduced or eliminated. Strict regulations are imposed on aqueous effluents to surface waters as well as to municipal sewage plants. Metals constitute an important part of textile mill effluents.

Metals, generally in the form of soluble organic or inorganic salts, are different from nonmetallic pollutants in that they cannot be decomposed by biological or chemical treatments. No matter what happens to the organic molecule containing a metal—i.e., a dye or some other organic metal salt or complex—the metal will remain in its metallic form or as an inorganic salt. Metals can be chemically precipitated or coagulated as salts or reduced to the metallic form. In any case, they must be separated from the liquid phase by filtration, settling, centrifuging or electrodeposition. Unless a metal can be economically recovered, it will ultimately end up as a sludge that must be disposed of safely.

Among priority pollutants, EPA lists the following: Sb, As, Be, Cd, Cr, Cu, Pb, Hg, Ni, Se, Ag, Tl, Zn, Sr, U, V and Zr (*1*). In the Reading, Pa., area (*2*), aluminum must also be monitored although no concentration limit was established. The Easton, Pa., Sewer Authority has a limit on iron (*3*). Fortunately not all these metals are of concern to the textile industry.

In textile wet processing, cobalt, chromium and occasionally copper and nickel form part of some dyes, especially neutral metallized acid dyes for nylon and wool. Copper salts are also used to fix an important group of direct dyes and to enhance the lightfastness of neutral metallized dyes on nylon for automotive applications. Antimony, in the form of tartar emetic or antimony lactate, insolubilizes tannic acid on nylon fibers to improve washfastness properties. Potassium dichromate is used in the wool afterchrome process and as an oxidant. Zinc, zirconium, aluminum and other salts are or have been used extensively in textile processing.

All these applications are sources of metal pollution which must be controlled not just to comply with the law but more importantly to protect the environment. The allowable effluent concentrations depend on the discharge site. Thus the maximum 24-hour composite discharge of copper to a stream may be 2.56 ppm (*2*), while to one municipal sewage system it is 3 ppm (*4*) and to another it is as low as 0.2 ppm (*3*). The same is true for other metals; i.e., the allowable concentration of chromium varies from 1.6-3 ppm (*3,4*).

Possible Solutions

The first and obvious solution to meeting some discharge limits lies in the dilution factor. However, most regulations limit not only the daily concentrations but also the maximum pounds of pollutants per day. This may require spreading the metal generating processes over a number of days, which is seldom practical.

Some metal pollution problems can be solved by substituting a nonpolluting metal for a regulated metal. Such was the case with zinc salts which were used to prevent the color bleeding and migration of wet cellulosics before drying. Magnesium salts can and are being used for this purpose. The afterchrome dyeing process has been greatly improved by decreasing the amount of potassium dichromate without sacrificing the quality of dyed wool (*5,6*). This process was critically examined and it was found that in some cases a 200% excess of chromium was being used. Another application for chromium, in the form of sodium or potassium dichromate, was in the oxidation of sulfur dyes. Today sulfur dyes are oxidized with sodium bromate or iodate (*7*).

In the case of neutral metallized dyes, which can be sources of cobalt, chromium and occasionally copper and nickel [cobalt is not listed by EPA as a priority pollutant but is mentioned in the Title III list (*8*)], the most reasonable way to solve the pollution problem is to exhaust as much dye as possible from the bath. Lower liquor ratios and proper pH control contribute to higher exhaustion of dyes. Moreover, the use of leveling agents—anionic or nonionic-cationic types—must be rationalized. If excessive amounts are used, the dye cannot be fully exhausted even with good pH control. A well designed leveling agent should retard the strike of a dye during the critical temperature rise stage and allow good exhaustion at the dyeing temperature. Exhaustion of the dyebath does not have to be sacrificed for levelness. In this case, reducing pollution also saves money and decreases the color of the effluent, which needs to be decolorized to meet discharge regulations.

In this work the use of copper sulfate pentahydrate for copperizing direct dyes on cotton and of tartar emetic for improv-

Second Place Paper

THE Delaware Valley Section took runnerup honors in the 1989 Intersectional Technical Paper Competition conducted in October at Philadelphia at AATCC's International Conference & Exhibition. The Southeastern Section won the competition with a study on the Effect of Dyebath pH on Color Yield in Indigo Dyeing of Cotton Denim Yarn (TCC, December, p25). The Palmetto Section took third place with its study on Single-Stage Preparation: A Viable Alternative for Selected Fabrics. The Gulf Coast and Midwest Sections tied for fourth place with studies on Approaches for Producing Simulated Yarn Dyed Denims and The Influence of Fluorescent Whitening Agents on Silk Phototendering and Dye Fading, respectively. The Palmetto, Gulf Coast and Midwest entries will be published in upcoming issues of TCC.

ing the washfastness of nylon was examined.

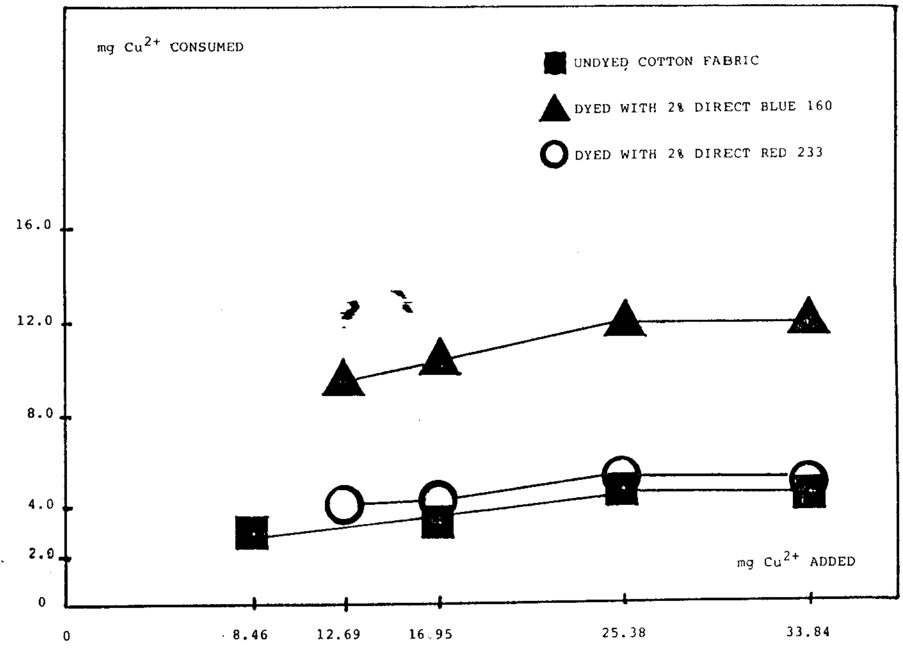

Fig. 1. Copper consumed (mg) by 10 grams of fabric as a function of mg copper added to the bath.

Experimental

Cotton

Bleached cotton knit fabric samples, (Testfabrics Style 459) were dyed in a Launder-Ometer with commercial versions of C.I. Direct Blue 160 (400%), C.I. Direct Black 91 (Conc.), C.I. Direct Brown 157 and C.I. Direct Red 233 at a liquor-to-goods ratio of 20:1 in soft water at pH 7.5, adjusted with soda ash. The dyebaths, containing 0.5% owf of an anionic-nonionic leveling agent and the appropriate amount of common salt, were heated to 212F over 30 minutes and held at this temperature for 30 minutes. They were cooled to 160F and held for 20 minutes. The baths were then cooled to 90F and the fabrics rinsed twice in a 5 g/L common salt solution. Following a cold water rinse, the goods were extracted and dried at 225F.

The amounts of dye were 0.5%, 1.0% and 2.0% owf; the concentrations of salt were 10%, 25% and 40% owf, respectively.

The samples were aftertreated at a liquor-to-goods ratio of 30:1 with copper sulfate (technical grade $CuSO_4 \cdot 5H_2O$, crystal) at 0-2.0% owf as follows:

X% owf copper sulfate, 1% owf glacial acetic acid, 20 minutes at 140F; the fabrics were extracted without rinsing and dried at 225F. In some cases a direct dye fixing agent (polyamine nonformaldehyde cationic type) was used in conjunction with the copper aftertreatment at concentrations indicated elsewhere in the paper.

Table I. Application of Copper Sulfate to Cotton Dyed with C.I. Direct Blue 160

C.I. Direct Blue 60	Copper Sulfate	Cu2+ Initial[a]	Cu2+ Left in Bath[b]	Cu2+ Consumed[c]
0.5% owf	0.5% owf	42.3 ppm	20.5 ppm	21.8 ppm
	0.75	63.45	38.2	23.2
	1.0	84.6	61.4	23.2
	1.5	126.9	103.0	23.9
1.0	0.75	63.45	26.2	37.25
	1.0	84.6	47.9	36.7
	1.5	126.9	88.0	38.9
	2.0	169.2	127.0	42.2
2.0	0.75	63.45	15.3	48.15
	1.0	84.6	33.2	51.4
	1.5	126.9	66.8	60.1
	2.0	169.2	109.0	60.2

[a] Calculated on the basis of copper sulfate added at L.R. 30:1. [b] Determined by AAS. [c] Calculated by difference.

Table II. Application of Copper Sulfate to Cotton Dyed with C.I. Direct Red 233

C.I. Direct Red 233	Copper Sulfate	Cu2+ Initial[a]	Cu2+ Left in Bath[b]	Cu2+ Consumed[c]
0.5% owf	0.3% owf	25.4 ppm	17.7 ppm	7.7 ppm
	0.5	42.3	31.5	10.8
	0.75	63.45	49.7	13.75
	1.0	84.6	71.2	13.4
1.0	0.5	42.3	29.9	12.4
	0.75	63.45	50.7	12.75
	1.0	84.6	71.2	13.4
	1.5	126.9	108.0	18.9
2.0	0.75	63.45	42.8	20.65
	1.0	84.6	63.2	21.4
	1.5	126.9	100.0	26.9
	2.0	169.2	143.0	26.0

[a] Calculated on the basis of copper sulfate added at L.R. 30:1. [b] Determined by AAS. [c] Calculated by difference.

In one series, the fabrics were dyed and aftertreated without intermediate drying, as is normal in plant practice (Table V).

In the next series a dyed fabric was sprayed with a copper sulfate and fixing agent solution using a hand operated spray bottle and subsequently dried at 225F (Table VI).

The fabric samples were tested for washfastness using AATCC Test Method 61-1986, IIA Test. Preliminary lightfastness tests (AATCC Test Method 16A-1982), exposed for 40 hours, did not show significant variations as a function of copper sulfate applied and are not reported here.

Nylon

Texturized nylon T-66 stretch fabric samples, (Testfabrics Style 314) were dyed in a Colourpet 12 laboratory dyeing machine with commercial versions of C.I. Acid Blue 113, C.I. Acid Blue 24, C.I. Acid Red 299 and C.I. Acid Red 151, all at 2% owf and at a liquor-to-goods ratio of 30:1 in soft water. The dyebaths, containing 2% owf ammonium sulfate and 1% of a nonionic wetting agent, were heated to 205F at a rate of 2-3F/minute and held at this temperature for 60 minutes. The fabrics were rinsed in warm and cold water, extracted and dried at 225F. All

Table III. Application of Copper Sulfate to Undyed Cotton

Copper Sulfate	Cu2+ Initial[a]	Cu2+ Left in Bath[b]	Cu2+ Consumed[c]
0.5% owf	42.3 ppm	26.7 ppm	15.6 ppm
1.0	84.6	66.7	17.9
1.5	126.9	103.3	23.6
2.0	169.2	146.7	22.5

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[a]Calculated on the basis of copper sulfate added at L.R. 30:1. [b]Determined by AAS. [c]Calculated by difference.

samples were then treated with 2% owf tannic acid (gall nut quality, 90% minimum tannins) together with 1% owf glacial acetic acid for 20 minutes at 180F. This aftertreatment was followed in the same baths with the application of 0-2% owf tartar emetic [technical grade $K(SbO)C_4H_4O_6 \cdot 1/2H_2O$] for another 20 minutes at 180F. The samples were rinsed and dried as indicated above.

A dyed tannic acid treated sample was also sprayed with a tartar emetic solution and dried (Table IX).

The fabrics were tested for washfastness by the earlier mentioned test. The antimony content in the spent aftertreatment liquors was determined colorimetrically according to ASTM method F-350.

Results and Discussion

Copper Aftertreatment

Copper aftertreatable direct dyes have an excellent reputation for dyeing cellulosic substrâtes because of their high washfastness, lightfastness properties and economy. However, to achieve the high fastness properties and to develop their true shade, these dyes must be aftertreated with a copper salt, commonly copper sulfate. Since not all of the applied copper salt is exhausted on the fabric, substantial amounts are left in the residual bath. For this reason, many mills are faced with problems in meeting copper effluent limits and some may be prevented from using this class of dyes.

Traditionally, 2% owf copper sulfate was recommended regardless of the dyes used or their concentrations. Older shade cards recommending such high amounts of copper sulfate are still being used across the industry. Copper-containing fixing agents are increasingly being offered in technical bulletins (*9*). The recommended concentrations of these fixatives usually amount to less than 2% owf of copper sulfate. More recent company literature recommends lower amounts of copper sulfate (*10*), 0.8-1.5% owf depending on the depth of shade in exhaust applications.

The goal of this investigation was to find the lowest possible copper concentrations necessary to produce the expected shade and fastness properties, and measure the effect on the effluent.

The applications of increasing amounts of copper sulfate (0.5-2.0% owf) on cotton fabric samples dyed with 0.5%, 1.0% and 2.0% owf C.I. Direct Blue 150 and C.I. Direct Red 233 showed that the copper consumed increased with the level of dye applied as shown in Tables I and II.

The amount of copper left in the bath increased to a much greater degree than the copper consumed by the dyed fabric as the concentration of applied copper sulfate was increased. Thus, in Table I, it is shown with the 2.0% owf dyeing that when the amount of applied copper sulfate was increased from 0.75% to 2.0% owf, the concentration of copper remaining in the bath increased from 15.5 ppm to 109 ppm, while the amount of copper consumed increased much less, from 48.15 ppm to 60.2 ppm. The consumed amounts were expressed also in ppm for convenience. For example, 60.2 ppm of copper consumed plus 109 ppm left in bath equals 169.2 ppm of copper originally applied at 2% owf. The same situation is evident in Table II with the 2.0% owf dyeing where an increase of applied copper from 0.75% to 2.0% owf resulted in an increase of residual copper from 42.8 ppm to 143 ppm, while the amount of consumed copper increased only from 20.65 ppm to 26 ppm. The same holds true for the other concentrations of dye.

Since it became obvious that the amount of copper consumed was directly proportional to the amount of dye, it was interesting to find the amount of copper absorbed by undyed cotton. The results, summarized in Table III, appear very similar to the results on dyed fabrics. It seems that cellulose competes for copper with the dye.

Fig. 1 shows the amount of copper consumed by undyed cotton, by cotton dyed with 2% owf C.I. Direct Blue 160, and with 2% owf C.I. Direct Red 233 as a function of copper added. All curves show a gradual rise ending in a practically horizontal (or saturation) region. It is

Table IV. Washfastness of Untreated and Copper Sulfate Treated Dyed Cotton Fabrics

Direct Dyed Shade		Copper Sulfate	AATCC IIA Wash, Stain on Cotton[a]
Blue 160	0.5% owf	0.0% owf	2-3
	0.5	0.5[b]	3
	0.5	0.75	3
	0.5	1.0	3
	0.5	1.5	3
	1.0	0.0	2
	1.0	0.75[b]	2-3
	1.0	1.0	2-3
	1.0	1.5	2-3
	1.0	2.0	2-3
	2.0	0.0	2
	2.0	0.75[b]	2-3
	2.0	1.0	2-3
	2.0	1.5	2-3
	2.0	2.0	2-3
Brown 157	0.5	0.0	3-4
	0.5	0.3[b]	4-5
	0.5	0.5	4-5
	0.5	0.75	4-5
	0.5	1.0	4-5
	1.0	0.0	3
	1.0	0.5[b]	4
	1.0	0.75	4
	1.0	1.0	4
	1.0	1.5	4
	2.0	0.0	2-3
	2.0	0.75[b]	3
	2.0	1.0	3
	2.0	1.5	3
	2.0	2.0	3
Red 233	0.5	0.0	4
	0.5	0.3[b]	4-5
	0.5	1.0	4-5
	1.0	0.0	3
	1.0	0.5[b]	3-4
	1.0	1.5	3-4
	2.0	0.0	2
	2.0	0.75	2+
	2.0	1.0	2-3
	2.0	2.0	2-3
Black 91	0.5	0.0	2
	0.5	0.3[b]	3
	0.5	1.0	3
	1.0	0.0	1-2
	1.0	0.5[b]	2-3
	1.0	0.75	2-3
	1.0	1.5	3
	2.0	0.0	1
	2.0	0.75[b]	2-3
	2.0	2.0	2-3

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[a]AATCC Test Method 61-1986. [b]Denotes a fully veloped shade.

Table V. Dyed Cotton Treated with a Minimum of Copper Sulfate and a Fixing Agent

Direct Dyed Shade	Dye Quantity	Fixing Agent	Copper Sulfate	AATCC IIA Wash, Stain on Cotton[a]	Cu2+ Left in Bath
Red 233	1% owf	3% owf	0.3% owf	3-4	23.6 ppm
Brown 157	1	3	0.3	4	24.0
Blue 160	2	4	0.5	3	29.6
Black 91	2	4	0.5	2-3	15.7

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[a]AATCC Test Method 61-1986.

Table VI. Continuous Application of Copper Sulfate and Fixing Agent to Cotton Dyed with 1% owf C.I. Direct Blue 160

Sample	AATCC IIA Wash, Stain on Cotton[a]
Dyed Only	1
Sprayed to Apply Copper Sulfate 0.5% owf, Fixing Agent 2.0% owf, Dried at 225F	3

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[a]AATCC Test Method 61-1986.

Table VII. Application of Tartar Emetic to Nylon Dyed with 2% owf C.I. Acid Blue 113 and Aftertreated with 2% owf Tannic Acid

Tartar Emetic	Sb^{3+} Initial[a]	Sb^{3+} Left in Bath[b]	Sb^{3+} Consumed[c]
0.3% owf	44.3 ppm	4.0 ppm	40.3 ppm
0.5	73.9	13.0	60.9
1.0	147.7	19.0	128.7
2.0	295.5	44.0	251.5

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[a]Calculated on the basis of tartar emetic added at L.R. 20:1. [b]Determined colorimetrically. [c]Calculated by difference.

interesting to note that the sample dyed with C.I. Direct Red 233 consumed on the average only about 16% more copper than undyed cotton. At the same time, the fabric dyed with C.I. Direct Blue 160 consumed about three times more copper than that dyed with C.I. Direct Red 233 at the lowest level of applied copper sulfate. Although it cannot be concluded from this how much copper is consumed by the dye itself and by the cellulosic portion of the dyed fabric, it is clear that copper is distributed in a system consisting of dye, cellulose and water. It is fair to assume that one of the reasons for the high consumption of copper by the blue dyed fabric must be the high concentration (400%) of the commercial version of C.I. Direct Blue 160 used in these experiments. A very important finding was that the dyed fabrics treated with 0.5% copper sulfate owf exhibited fully developed shades; i.e., before the curves in Fig. 1 reached the horizontal (saturated) region. Copper absorbed by the dyed fabric beyond a certain level is possibly being consumed by the cellulose.

Table VIII. Washfastness of 1% owf Dyed Nylon, 2% owf Tannic Acid Treated and Aftertreated with Tartar Emetic

Acid Dyed Shade	Tartar Emetic	AATCC IIA Wash, Stain on Nylon[a]
Blue 113	0.0% owf	3-4
	0.3	5
	0.5	5
	1.0	5
	2.0	5
Blue 25	0.0	1-2
	0.3	3-4
	0.5	4
	1.0	4
	2.0	4
Red 299	0.0	3
	0.3	4-5
	0.5	4-5
	1.0	4-5
	2.0	4-5
Red 151	0.0	1-2
	0.3	4
	0.5	4
	1.0	4
	2.0	4

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[a]AATCC Test Method 61-1986.

Table IV shows that only 0.3% to 0.75% owf copper sulfate was required to achieve equivalent washfastness results, depending on the concentration of dye, with a full shade development at these levels of copper sulfate.

In order to examine the effect of fixing agents used in combination with copper sulfate, dyed samples were aftertreated without intermediate drying with copper sulfate and with 3% or 4% owf of a direct dye fixing agent. The results are shown in Table V. The washfastness properties were satisfactory and the shades fully developed. The amount of copper left in the bath was slightly lower with the C.I. Direct Red 233 dyeing but slightly higher with C.I. Direct Blue 160 compared to copper sulfate only data in Table I.

Direct dye fixing agents may, in some cases, displace some copper from the cellulosic portion of the system. This small increase of copper left in the bath does not justify the omission of fixing agents in this process. However, in cases of light shades (about 0.5% owf), good fastness properties were obtained with copper sulfate alone as shown in Table IV.

As demonstrated above, the amounts of copper sulfate applied can be reduced to levels considerably below 1% owf with a correspondingly high reduction of copper in the effluent. However, 0% copper in the effluent could be accomplished if a solution of copper sulfate was applied continuously onto the dyed fabric prior to drying. A low volume padding system allows the opportunity to approach zero effluent. The residual amounts from the pad could be disposed of easily and legally.

Another procedure is to spray the treating solution onto the extracted, wet fabric prior to drying. This leaves no unused copper. Such an approach is described in (*11*) where it is recommended that a copper compound be sprayed on nylon for lightfastness improvement. This approach was successful with C.I. Direct Blue 160. The washfastness results are shown in Table VI.

Tartar Emetic Aftertreatment

Tannic acid-tartar emetic aftertreatment of nylon dyed with acid dyes is the best method for improving washfastness properties. It is used less frequently due to the cost of tannic acid and tartar emetic. However, it is utilized for government work. Tartar emetic is used to insolubilize the deposited tannic acid and its concentration is therefore based on the amount of tannic acid. The traditionally used amounts of tartar emetic, from about 85% to 100% on the weight of tannic acid (*12*), continue to be used today (*13*).

In our investigation we used nylon T-66 knit samples dyed with C.I. Acid Blue 113, C.I. Acid Blue 25, C.I. Acid Red 299 and C.I. Acid Red 151 each at 2% owf and aftertreated with 2% owf high quality tannic acid. We found that when using the traditional amount of tartar emetic (2% owf), 44 ppm antimony was left in the bath, while with 0.3% owf, only 4 ppm of antimony remained in the residual bath (Table VII). The washfastness of both samples was the same. The same situation was observed with all four dyes tested as shown in Table VIII.

The amount of antimony consumed is a function of the amount of tannic acid used. As shown in Table VII, the saturation point has not been reached at 2% of tartar emetic applied. It is evident that 0.3 parts of tartar emetic were sufficient to insolubilize 2 parts of tannic acid on dyed nylon.

We wanted to find whether tartar emetic can be sprayed onto dyed and tannic acid treated nylon to avoid any

Table IX. Continuous Application of Tartar Emetic to 2% owf Acid Red 151 Dyed Nylon and Treated with 2% owf Tannic Acid

Sample	AATCC IIA Wash, Stain on Nylon[a]
Dyed Only	1
Dyed and Tannic Acid Treated	2-3
Dyed and Tannic Acid Treated, Sprayed with 0.5% owf Tartar Emetic and Dried at 225F	4-5

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[a]AATCC Test Method 61-1986.

ITPC Box Score

ON THE BASIS of 1 point for each entry in the ITPC since 1940, 2 points for each third place finish, 3 points for each second place finish and 4 points for each winning entry, the Rhode Island Section leads all other sections with 75 points. Point totals for some sections have been distorted over the years by the changing of section boundaries; i.e., the splitting of the original Piedmont Section into the Piedmont, Palmetto and Northern Piedmont Sections, and the dissolution of the Washington Section.

Section	No. of Entries	Firsts	Seconds	Thirds	Fourths	Total Points
Rhode Island	28	12	3	5	8	75
Metropolitan	26	8	4	6	8	64
Piedmont	29	6	5	5	13	62
Delaware	30	2	8	12	9	65
Southeastern	30	4	5	6	15	59
Northern New England	23	3	6	2	12	46
Northern Piedmont	17	7	2	2	6	44
Palmetto	15	2	8	3	2	40
Gulf Coast	14	1	4	4	5	29
South Central	17	3	—	—	14	26
Midwest	16	—	1	2	13	20
Hudson-Mohawk	4	—	1	2	1	8
Pacific	2	—	—	—	2	2
Western New England	1	—	—	—	1	1

The Quebec Section of the Canadian Association of Textile Colourists and Chemists won first place in 1968 and 1986; CATCC's Ontario Section placed second in 1976 and third in 1961. The Washington Section had a total of 12 points in the competition when the section was dissolved.

effluent contamination with antimony. This technique was successful and is summarized in Table IX.

Conclusions

Direct dyes on cotton can be aftertreated with much lower amounts of copper sulfate than used in normal practice. Reductions of applied copper sulfate by four times did not reduce the fastness properties of dyed cotton and resulted in reducing the amount of copper in the effluent by about 3.5 to seven times, depending on the dye and its level of application.

It was also found that copper sulfate can be applied to dyed cotton by continuous methods, among which spraying generates no copper-containing effluent.

The amount of tartar emetic used to insolubilize tannic acid on dyed nylon can be reduced by over 6.5 times without affecting the washfastness of the dyed fabrics. This resulted in a reduction of antimony in the effluent by 11 times.

The feasibility of applying tartar emetic solutions to dyed and tannic acid treated nylon by the continuous spraying method was demonstrated. The procedure generates no antimony in the effluent.

Committee Members

Alex Kirjanov of Crompton & Knowles Corp. and Joseph Rivlin of Philadelphia College of Textiles and Science were co-chairmen for the Delaware Valley Section's 1989 ITPC research committee. Others on the committee were Roy J. Bamford of Schuylkill Haven Bleach & Dye Works, Paul Buerkle of G. J. Littlewood & Son, Janet Bulan-Brady and Gultekin Celikiz of Philadelphia College of Textiles and Science, and Carl D. Sickerott of Anchor Dyeing and Finishing Co. The paper was presented by Janet Bulan-Brady.

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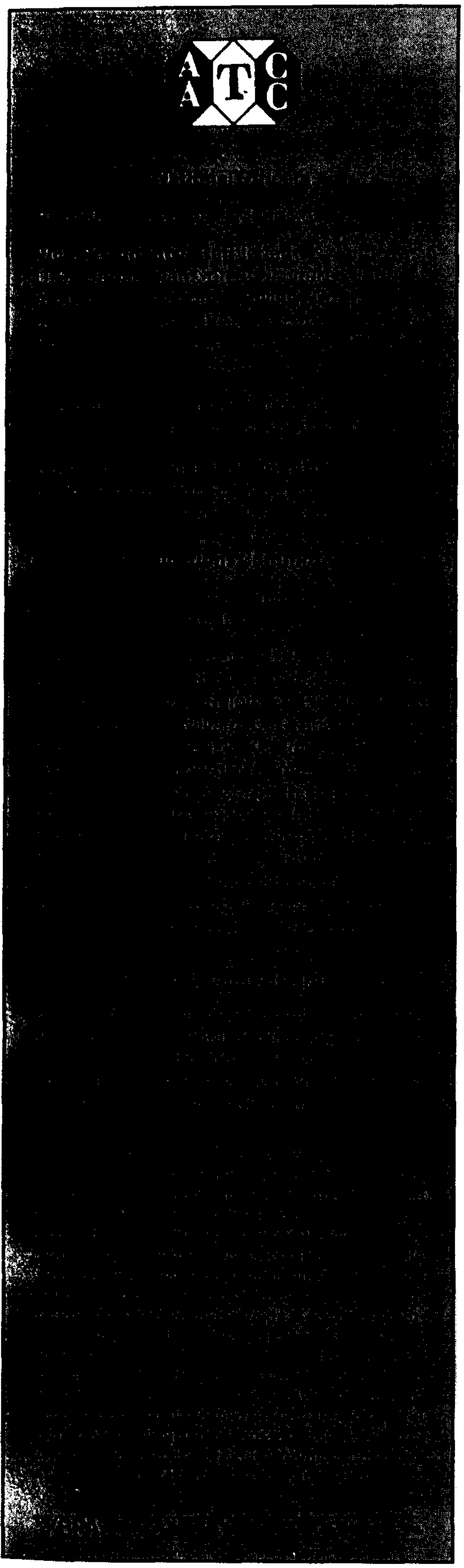

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Features

12 **AATCC Committees To Hold Their Winter Meetings February 13-15 at the University Hilton in Charlotte**

Meetings of some 65 research and administrative committees will conclude with a meeting of the AATCC Council.

13 **Awards: A Call for Nominations**

Nominations are being sought for this year's Olney Medal, Chapin Award and Millson Award for Invention.

17 **George J. Mandikos Re-Elected President of AATCC**

Five regional vice-presidents also named for 1990.

19 **ISO Subcommittee Meetings Hosted by the United States**

by Fernand Schlaeppi, Chairman, AATCC International Test Method Committee, and General Chairman, ISO Subcommittee Meetings

Fourteen countries sent delegates to meetings of ISO subcommittees held in August at Williamsburg, Va.

23 PRIZE WINNING RESEARCH

Use of Heavy Metals in Textile Wet Processing

The Delaware Valley Section was first runnerup in AATCC's 1989 Intersectional Technical Paper Competition at Philadelphia in October.

28 **AATCC Research Committee Activity**

Some 30 research committees met during the regular fall series of AATCC committee meetings held November 14-16 in New York.

35 **A Review of New Products for the Dyehouse and the Lab**

In case you missed any of them, here's a review of new products published in Textile Chemist and Colorist during 1989.

Departments

THE COVER: When the Georgia-Carolina Blood Center in Greenville, S. C., wanted to avoid a sterile hospital image to put donors more at ease, it turned to a series of tie dyeings by Robert W. Joerger, a retired textile chemist noted in the Greenville area for his tie dyeings and brush painting of fabrics. Each of the 42 × 38-inch dyeings were made on tissah silk with fiber reactive dyes. A past chairman of AATCC's Rhode Island Section, Joerger was with Franklin Process Co. and Indian Head Yarn Co. before his retirement in 1970. Now 85 years old, he still lives in Greenville.

IF YOU HAVE A PHOTO YOU THINK WOULD MAKE AN APPEALING COVER, PLEASE LET US HEAR FROM YOU