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STRENGTHENING OF THE RAMIE TECHNOLOGY DEVELOPMENT CENTRE, CHANGSHA, HUNAN PROVINCE

DG/CPR/85/057 11-53/J13102

"Technology Package for the Dyeing and Finishing aspects of the Project"

Prepared for the Government of China by the
United Nations Development Organisation, acting
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Vienna

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* The document has not been edited.

DG/CPR/85/057 Strengthening the Ramie Technology Development Centre (RTDC), Changsha, Hunan Province

Technology Package for the **Dyeing and Finishing** aspects of Project DG/CPR/85/057

1. Singeing

The removal of hair from natural fibres is traditionally achieved by singeing or cropping the fabric; commonly, a gas-fired singeing unit is employed for this purpose. However, singeing alone of sized ramie fabric cannot, in the author's view, reduce the hairiness of the substrate; as the yarn is sized in order to smooth the fibre and thereby expedite weaving (in essence, sizing 'sticks' the surface hairs down), when singeing is carried out on sized ramie fabric in which the hairs are 'stuck' down on the yarn surface, the singeing process cannot adequately reduce the hairiness of the fabric. Furthermore, as itchiness can be considered to be caused predominantly by short hairs rather than long hairs, singeing and/or cropping may only reduce the length of the hairs and thus exacerbate the problem of itchiness rather than remove the rigid hairs which are the cause of itchiness. However, singeing of desized fabric may prove successful; in this context, progress may be achieved by undertaking singeing trials of desized ramie fabric in an attempt to determine the effects of flame setting, running speed, number of passes given, etc., on the hairiness and itchiness of the fabric.

2. Desizing

As incomplete removal of the PVA/CMC/Starch size from 100% ramie fabric was not achieved, even after the dyeing stage and, as it appears common for relatively high concentrations of size to be applied to the yarn, effort needs focusing on three aspects:

- ☐ more efficient removal of the PVA/CMC/Starch size;
- ☐ the use of modified starch formulations;
- ☐ the use of enzymatic desizing.

As residual size may impair the effectiveness of mercerising, the extent of size removal may be improved by giving the bleached fabric two treatments (rather than the one treatment currently carried out) with sodium hydroxide prior to mercerisation. Also, as residual size may impair both the handle and dyeability of the fabric, as discussed above, attempts should be made to remove **all** size from the fabric prior to dyeing.

3. Scouring

Although the scouring method employed appears satisfactory, as mentioned above, in order to enhance the effectiveness of the mercerisation stage, the extent of size removal may be improved by scouring the bleached fabric twice.

4. Bleaching

The bleaching method seems appropriate; however, to achieve the degree of quality control desired for the particular end use, it is, of course, necessary to evaluate the bleached fabric. Several tests are available, included amongst which are ***absorbency***, ***whiteness***, ***chemical damage*** and *inorganic/organic residue content*, all of which should, preferably, but not necessarily, be undertaken. All bleaching compounds must be removed from the fabric prior to dyeing.

5. Dyeing

(i) *General aspects*

The dyeing behaviour of all fresh dye samples must be assessed, using laboratory dyeings, prior to bulk usage; this is especially important in the case of reactive dyes. The fabric should be free of all peroxy/chlorine compounds as they may degrade the dye; the fabric should be of uniform pH (preferably 7) and free of all sizing materials. Electrolytes (eg NaCl, Na_2SO_4) should be free of Mg and Ca salts which can lead to reduced colour yields and impaired fastness properties; high concentrations of sequestering agents in the dyebath can result in de-metallisation of some metal-complex reactive and direct dyes leading to hue change and reduced light fastness. Obviously, in order to expedite rapid and uniform wetting in the case of continuous dyeing, the fabric should have good absorbency.

(ii) *Reactive dyes*

A comparison, by the author, of dyeings obtained using several Chinese reactive dyes and their Western counterparts on ramie and cotton confirmed that the colour yield achieved using the Chinese dyes were lower than that secured using their Western equivalents. This may be attributable to low dyebath exhaustion and/or the presence of hydrolysed dye in the Chinese dye samples used. In the latter context, it is important, with all types of reactive dye, to ensure that the dye is stored correctly (cool, dry storage in sealed containers) so as to minimise dye hydrolysis, old dye samples should preferably not be used and certainly not mixed with fresh samples (the dye maker will advise on the shelf-life of their products). As reactive dyes will react with most sizing materials it is very important to ensure 100% size removal prior to dyeing. Old samples of alkali (eg Na_2CO_3) should be avoided; $NaHCO_3$ should never be stored in warm, humid conditions. Wash-off after dyeing is of vital importance as, if it is not done correctly, the wet fastness of the dyeing will be reduced; the use of detergents is preferred to that of soap in wash-off. In Western Europe, there has recently been a move away from the use of detergent/detergent-alkali in wash-off to hot/cold water rinsing; dye makers should provide the preferred wash-off conditions for their dyes. In general, dyeings that were obtained using dyes that react with the fibre via nucleophilic substitution are prone to 'acid bleeding' (ie the dye-fibre bond is cleaved under aqueous acidic conditions) whilst dyes that react via nucleophilic addition are prone to 'alkali bleeding'; thus care should be exercised during wash-off and storage of the dyed fabric to ensure that the dyed fabric is adjusted to an appropriate pH value. Despite the finding (as detailed in the author's second report) that the approximate level of dye fixation could possibly be determined using visual assessment with the grey-scales, reflectance spectrophotometry would provide more accurate, more reliable and quicker results. The author considers that the RTDC could greatly benefit from the use of reflectance spectrophotometry, not only in terms of accurately determining reactive dye fixation, but also with respect to strengthening its role within the the ramie dyeing industry. Since reflectance spectrophotometry can, both rapidly and accurately, furnish a variety of information that is of great importance to dyers, namely, recipe match prediction, quality control. colour sorting and stock control and, as Mr He explained, that to his knowledge, no Mill processing ramie possessed this technology, then the RTDC may be able to offer the benefits of reflectance spectrophotmetry to the local ramie industry. However. the author feels that before considering the potential benefits that could accrue to the RTDC from the possession of reflectance spectrophotometry, the availability and cost of this technology in China must be ascertained.

(iii) *Vat dyes*

Although the continuous dyeing of ramie with vat dyes is relatively straight forward, care must be exercised to ensure that the pH and reducing agent concentration appropriate to the dyes are employed; obviously, air-free steam should be used in pad-steam application. It is recommended that a detergent is used rather than soap for the 'soaping' stage.

(iv) *Direct dyes*

Some azo dyes are prone to degradation during dyeing at the boil; in this context it is important to ensure that alkaline dyeing conditions are avoided. Some direct dyes can cause tendering of dyed cellulosic fibres. Recently introduced cationic fixing agents impart a level of wet fastness to direct dyes on cellulosic fibres that is equivalent to, or in some cases even superior to, that achieved for reactive dyes on the substrates; the availability of such 'new generation' cationic fixing agents in China should be determined.

(v) *Sulphur dyes*

Alternative reducing systems (eg glucose/NaOH) are more environmentally freindly than sulphide-based systems. 'soaping' should be effected using detergents rather than soap.

(vi) *Difference in colour between dyeings on cotton and ramie*

It is well known that ramie exhibits different dyeability than cotton in as much as. owing to the higher crystallinity of ramie. higher temperatures are generally employed in the dyeing of ramie. Also. it is well known that the colour of dyeings obtained using the same dye on ramie and cotton differ. this is not a unique situation as differences in colour occur when the same dye is used on cotton and other cellulosic fibres (eg viscose, Tencel) as well as for the same dye on different types of cotton.

Research work has shown that when cotton and ramie fabrics were dyed with reactive dyes, although the dyeings obtained on ramie were slightly paler and duller than those achieved on cotton, there was little difference in hue between the dyeings on the two fibres. This was attributed to the fact that reactive dyes differ to all other classes of dye used on cellulosic fibres in so far as a covalent dye-fibre bond is formed between the reactive system of the dye and the cellulosic macromolecule. Since, in such dyes, the reactive system is insulated chromophorically from the chromogen, the hue obtained for a given dye on different cellulosic fibres should be very similar as the chromogen is chemically linked to the substrate. Any differences in colour observed for the same reactive dye on different cellulosic substrates, such as the slight difference in brightness (dullness) found between dyeings on ramie and cotton, could be attributed to differences in the inherent colour of the undyed substrates.

When cotton and ramie fabrics were dyed using direct dyes, it was found, as with the reactive dyeings, that the ramie dyeings were paler and duller than the cotton dyeings; however, unlike the reactive dyeings, there was a marked difference in hue between the dyed ramie and cotton samples. In a similar manner, in the case of vat dyes, the dyed ramie samples were markedly paler and duller than the corresponding dyed cotton samples and there was a large difference in hue between the dyed ramie and cotton samples. The marked different shade obtained for the vat and direct dyes on cotton and ramie can be attributed to the difference in physical structure of the two fibres. The adsorption of both vat and direct dyes on to cellulosic substrates occurs predominantly by virtue of dispersion forces and hydrogen bonding operating between the linear, co-planar dye molecules and the co-planar cellulosic substrate; this adsorption is considered to result in the formation of dye multilayers within the substrate. Thus, since the adsorption of both vat and direct dyes on to cotton and ramie arises from physical interactions between the dye and substrate, this adsorption will be greatly influenced by the nature of the adsorbent, namely the fibre. Furthermore, the hue of such dyeings is also influenced by the physical nature of the dye within the fibre, notably the physical disposition of the aggregates of dye within the fibre. Consequently, since ramie and cotton differ considerably in physical structure, it seems reasonable to propose that although the mechanism of dye adsorption will be identical for both fibres (ie via the operation of dispersion forces and hydrogen bonds), the physical disposition and thus hue of the dyeings on the two fibres will differ, as indeed was found for the vat and direct dyeings. Support for this proposal accrues from the previous finding that the hue of dyeings on ramie and cotton obtained using the same reactive dye was virtually identical, since reactive dyes bind covalently with the cellulosic substrates, physical interactions contributing little, if at all, to the final state and thus hue of the dye in the fibre and, since chemically, cotton and ramie are identical (ie are composed of cellulose), then it is not surprising that virtually identical hues were obtained for the same reactive dye on the two different substrates.

Hence these results appear to provide an explanation for the difference in colour that is often observed between dyeings on ramie and cotton and, also, that this particular problem is less significant in the case of reactive dyes.

(vii) *Enhancement of dye uptake*

Although ramie fibres and its blends are usually dyed using reactive dyes, it is difficult to achieve good wash fastness and high fixation efficiency. Also, many problems arise from the use of reactive dyes;

☐ high sodium chloride (or sodium sulphate) concentrations are required which pose environmental problems and operating difficulties;

☐ at the end of the dyeing process, unfixed or hydrolysed dye must be removed by boiling in detergent solution to ensure good wash fastness performance of the dyed textiles;

☐ when dyeing polyester/ramie blends by a one-bath/one-step method, the high electrolyte concentration required for the reactive dyes can cause particles of disperse dye used for the polyester component, to aggregate; an additional problem that can sometimes be experienced is the hue change that occurs on dyed polyester under alkaline conditions.

Many studies have been devoted to improving the substantivity of reactive dyes for cotton. One approach is to reduce the amount of salt required, or to eliminate salt altogether, and to increase the efficiency of the dye-fibre covalent bonding reaction by using various types of cationic compounds. Recent work has shown that pretreating cotton with a polyamide-epichlorohydrin resin (*Hercosett 125*) by a pad-bake procedure markedly improved the dyeability of the cotton with reactive dyes, improving the fixation efficiency of the dyeing process in the absence of salt. The effectiveness of this technique in enhancing the dyeability of ramie with reactive, direct and sulphur dyes was explored (report of Mr Luo's visit to Leeds); a summary of the experimental materials and procedures used is given below.

Fabric

Scoured and bleached plain weave ramie (36N x 36N) fabric as well as scoured and bleached cotton fabric were used.

Polymer

Hercosett 125, supplied as an aqueous solution containing 12.5% solids was used.

Dyes and auxiliaries

Commercial samples of Procion MX (ICI) and Sumifix Supra (Sumitomo) dyes, which correspond, respectively, to the M and K types of Chinese reactive dye, as well as Kayacelon React (Nippon Kayaku) and Drimarene K (Sandoz) reactive dyes were used. A range of Solophenyl (Ciba-Geigy) direct dyes and a range of Sulphosol (J Robinson Ltd) CI Solubilised Sulphur dyes were also used. Sandozin NIE was obtained from Sandoz and Leucad 71 from J Robinson Ltd.

Pretreatment with Hercosett 125

Ramie fabric was impregnated using the padding liquor trough formed between the bowls and side plates of a Benninger laboratory mangle; the pressure on the mangle was adjusted to give 80% pickup (2kg/cm²). After predrying, the samples were then baked for 3 minutes at 100°C using a Werner Mathis AG steamer/baker unit. Various concentrations of Hercosett 125 were applied to the fabric; for each concentration of the polymer used, 10 gl^{-1} Sandozin NIE were included in the pad liquor.

Dyeing

In the case of the reactive and direct dyes, this was carried out in glass dye pots housed in a Zeltex laboratory-scale dyeing machine, using a liquor ratio of 20:1 and a dye concentration of 1% owf; in the case of the sulphur dyes, a 1% omf shade was applied using a 7:1 liquor ratio. The particular dyeing method used for each dye was that recommended by the respective dye maker. At the end of dyeing, the dyed sample was removed and cut into two portions; one portion was allowed to dry in the open air and the other portion treated in a solution containing 10 gl^{-1} Sandozin NIE and 2 gl^{-1} sodium carbonate at the boil for 15 minutes using a liquor ratio of 50:1.

Wash Fastness testing

The reactive dyed fabrics were submitted to the ISO C04 wash test.

In the case of the four types of reactive dye used, pretreatment with 100 gl^{-1} Hercosett 125 yielded optimum results and dyeing at pH 7 gave greatest dye uptake. For all of the reactive dyes employed, pretreatment with the cationic resin enabled dyeing to be achieved in the absence of both salt and alkali, the resulting dyeings exhibiting improved colour yield and fixation efficiency as well as excellent fastness to the ISO C04 wash test. These findings offer the following potential benefits to the reactive dyeing of ramie:

- the high fixation efficiency secured will reduce the amount of coloured (dye) effluent produced thereby reducing both the environmental and financial costs associated with conventional reactive dyeing of the fibre,
- the ability to dye polyester/ramie blends in the absence of NaCl or Na_2SO_4 may alleviate the problem of the aggregation of disperse dye particles that is encountered

during the conventional reactive dyeing of polyester/ramie blends by a one-bath/one-step method;

- the ability to dye polyester/ramie blends under neutral pH conditions may alleviate the problem of hue change that occurs on dyed polyester during conventional alkaline reactive dyeing.

In the cases of the four direct dyes and two CI Solubilised Sulphur dyes used, a concentration of 50 gl^{-1} Hercosett 125 was employed and dyeing was carried out in the presence of NaCl. As ramie exhibits lower dyeability than cotton, it was not surprising to initially find that for each of the direct and sulphur dyes used, the colour strength secured for the dyeings of unmodified ramie were lower than those on cotton. However, pretreatment of ramie with Hercosett 125 resulted in enhanced colour yield being obtained for each dye; indeed, the colour yield of the pretreated ramie was, for each direct and each sulphur dye used, greater than that of the respective cotton dyeing.

It is evident from this work that the pretreatment of ramie fabric with the cationic polymer Hercosett 125 markedly enhances the dyeability of the substrate with reactive, direct and sulphur dyes; furthermore, Mrs Li of the RTDC has shown that the pretreatment of ramie fabrics with Glytac A markedly enhances the dyeability of the substrate towards both reactive and direct dyes. Although further studies need to be carried out, from the findings obtained, potential benefits may accrue to the RTDC and the Chinese ramie dyeing industry in terms of the enhanced colour yield, increased dyeing efficiency and reduced environmental problems that may be secured by the use of pretreatment of ramie with a suitable cationic agent. Since several such agents have been shown to enhance the dyeability of cotton with reactive dyes, further work would have to be undertaken in China to determine the most appropriate cationic agent and pretreatment conditions required.

6. Softening

Results obtained in Leeds (report of Mr He's first visit to Leeds) showed that four proprietary softening agents, each intended for use on cotton, were found to enhance the handle of ramie fabric; bending length was employed as a means of quantifying the softening action imparted to the fabric. A summary of the experimental materials and procedures used is given below.

Fabric

Scoured and bleached plain weave ramie (36N x 36N) fabric was used.

Softening agents

Four proprietary softening agents, namely Alcosoft NBS (non-ionic emulsion of a modified aminosilicone), Alcolube CRT conc 40 (non-ionic polyethylene emulsion), *Alcamine CWS (quaternary ammonium compound) and Alcamine LNS (non-ionic, substituted amine), each obtained from Allied Colloids Plc, were employed.*

Treatment with softening agents

Ramie fabric was impregnated with an aqueous (20 gl^{-1}) solution of each softener using the padding liquor trough formed between the bowls and side plates of a Benninger laboratory mangle; the pressure on the mangle was adjusted to give 80% pickup (2kg/cm^2). The impregnated sample was then baked for 3 minutes at 100°C using a Werner Mathis AG steamer/baker unit.

Bending length determination

This was carried out on samples measuring 4 x 12 cm using the FAST testing system.

Each of the four softening agents reduced the bending length of the fabric, thus demonstrating that each agent softened the substrate; of the four softening agents used, Alcosoft NBS *(non-ionic emulsion of a modified aminosilicone)* imparted the greatest reduction in bending length and, thus, can be considered to have imparted greatest softening action to the fabric. However, although bending length determination is less subjective than manual inspection, since the perception of 'softness' by an individual involves both the pliability and the inherent greasiness of the fabric, whilst bending length offers a means of objectively quantifying the softness imparted to the fabric, manual assessment may represent a more realistic judgement of softness.

The extent of enhanced softness (as given by reduction in bending length) imparted by Alcosoft NBS was found to be very similar to that imparted by treatment with 0.5% omf *Cellusoft L* enzyme (see section 7). This particular finding implies that the joint use of enzyme treatment and a softener would enable a reduction to be made in the concentration of enzyme required to achieve softening; this, in turn, would then reduce the extents of mass loss, strength loss and reduction in dyeability that accompanied enzyme treatment (section 7).

7. Enzyme treatment

A preferred alternative to the use of singeing/cropping to reduce the hairiness of ramie fabric appears to lie in the treatment of the fabric with enzymes. The treatment (report of Mr He's first visit to Leeds), with *Cellusoft L*, of ramie fabric:

- ☐ enhanced its softness,
- ☐ decreased its bending length;
- ☐ reduced its mass;
- ☐ decreased its strength;
- ☐ increased its drapeability;

☐ reduced its dyeability with reactive dyes.

A summary of the experimental materials and procedures used is provided below.

Fabric

Scoured and bleached plain weave ramie (36N x 36N) fabric was used.

Enzyme

Cellusoft L (Novo Nordisk) was employed.

Dyes and auxiliaries

A commercial sample of Drimarene Brilliant Red K-4BL (Sandoz), was employed; Sandozin NIE was also obtained from Sandoz.

Treatment with Cellusoft L

A 10 g sample of ramie fabric was treated using a range of concentrations of the enzyme (0.2 to 5% omf) using a liquor ratio of 20:1, for two hours at 50°C at pH 5 (0.5 gl^{-1} CH$_3$COOH (96%) and 0.5 gl^{-1} CH$_3$COONa buffer) in sealed dyepots housed in a Zeltex Polycolor laboratory-scale dyeing machine. At the end of treatment, 0.2 g of anhydrous Na$_2$CO$_3$ was added to raise the pH to between 9 and 10 and so terminate the enzymatic process. The ensuing fabric sample was thoroughly rinsed in running tap water and allowed to dry in the open air.

Bending length determination

This was carried out as described in section 6.

Tensile strength determination

This was carried out using an Instron 1026.

SEM Analysis

A Jeol JSN-820 scanning electron microscope was employed.

Dyeing

This was carried out in glass dye pots housed in a Zeltex laboratory-scale dyeing machine, using a liquor ratio of 20:1 and a dye concentration of 2% owf by the method recommended by Sandoz. At the end of dyeing, the dyed sample was removed and treated in a solution containing 10 gl^{-1} Sandozin NIE at the boil for 10 minutes using a liquor ratio of 50:1; the washed-off sample was then rinsed thoroughly in warm and then cold water and finally allowed to dry in the open air.

The enhanced softness imparted by enzyme treatment can be attributed to a reduction in the stiffness of the fibre; no evidence was secured of the enzyme having "polished" (smoothed) the fabric surface, in that the hairiness of enzyme treated fabric was not discernably different to that of untreated fabric as determined using SEM. Thus, it appears that enzyme treatment of ramie reduces the stiffness of the hairs in the yarn rather than reducing the extent of hairiness; nevertheless, enzyme treatment markedly enhances the softness of the fabric.

However, this enhancement of handle is accompanied by a relatively low reduction in mass of the fabric but, in contrast, a much larger loss in fabric strength as well as a reduction in the dyeability of the fabric with reactive dyes. Scanning Electron and optical microscopical examination of dyed, enzyme-treated fabric revealed that enzyme treatment removed much of the amorphous material that 'binds' together the crystalline, rectangular cells of the fibre as well as the cellulosic sheath that surrounds the whole fibre, thus enabling the rectangular cells to move apart. The removal of this cellulosic material can be considered to be responsible for the observed loss in mass that accompanied enzyme treatment and the reduction in tensile strength of the fabric imparted by the enzyme can be attributed to the rectangular-shaped cells being less firmly bound together. From the evidence obtained it can be concluded that the enhanced softness imparted to the fabric by enzyme treatment can be attributed to the breaking-up of the coarse fibres into much finer and less rigid fibres. The observed reduction in dyeability was very marked in that low concentrations of enzyme resulted in dramatic reductions in the colour yield of reactive-dyed fabric, this being attributable to the relatively small amount of amorphous material present in untreated fibre in which dye adsorption occurs, with the effect that only a small quantity of this material need be removed in order for a quite marked reduction in dyeability to be observed. In a similar manner, the extent of strength loss imparted by enzyme treatment was also very marked insofar as low concentrations of enzyme resulted in dramatic reductions in strength.

In the context of the strength loss that accompanies enzyme treatment, although the high strength of ramie, which is one of the substrate's famous characteristics, is important for some outlets, for many other end uses (eg shirting) this high inherent strength is not really necessary. Indeed, during discussions in Changsha, it was reported that preliminary findings within the local ramie industry had indicated that a loss in strength of up to 30% resulting from enzyme treatment may be acceptable; during discussions it was suggested that the extent of strength reduction imparted to ramie by enzyme treatment should be such that the strength of the enzyme-treated ramie was comparable to that of cotton. Such strength reductions seem reasonable in the context of outlets such as shirting; thus, whilst initially, the marked loss in strength that occurs as a result of enzyme treatment of ramie appears disconcerting, if the extent of this strength loss is controlled within pre-determined limits, it should be acceptable. It was also observed that the tear strength of ramie fabric which had been treated with 5% and also 15% omf enzyme was improved by treatment with 50 and also 100 $cm^3 l^{-1}$ *Hercosett 125* (see section 5). However, this enhancement of tear strength imparted by Hercosett 125 was accompanied by a reduction in the handle of the fabric; this finding was anticipated owing to the nature of the high M_r polymer. Thus, whilst several resins which are widely employed in cotton finishing could restore the strength loss that results from enzyme treatment of ramie, these resins may also impair the soft handle of the treated fabric and, thus, counteract the effect imparted by the enzyme; care will thus need to be exercised in selecting suitable resins to restore the strength of enzyme treated fabrics.

(i) *Effect of Hercosett 125 on the dyeability of enzyme treated fabric*

As discussed in section 5, pretreatment of ramie fabric with Hercosett 125 markedly enhanced the dyeability of the substrate with reactive, direct and sulphur dyes. As described above, whilst treatment of undyed ramie fabric with Cellusoft L enhanced the softness of the substrate, it also imparted to the substrate reduced dyeability towards reactive dyes and resulted in strength loss. Hence an examination was made (report of Mr He's first visit to Leeds) to determine whether treatment, with Hercosett 125, of ramie fabric which had been treated with 5% and 15% omf enzyme, would enhance the dyeability of the treated substrate towards reactive dyes. A summary of the experimental materials and procedures used is provided below.

Fabric

Scoured and bleached plain weave ramie (36N x 36N) fabric was used.

Polymer

Hercosett 125, supplied as an aqueous solution containing 12.5% solids was employed.

Enzyme

Cellusoft L (Novo Nordisk) was used.

Dyes and auxiliaries

A commercial sample of Drimarene Blue K-2RL was kindly supplied by Sandoz. Sandozin NIE was also obtained from Sandoz.

Treatment with Cellusoft L

A 10 g sample of ramie fabric was treated with the enzyme at both 5% and 15% omf as described in section 5 above.

Treatment with Hercosett 125

The sample of enzyme-treated ramie fabric was impregnated using the padding liquor trough formed between the bowls and side plates of a Benninger laboratory mangle; the pressure on the mangle was adjusted to give 80% pickup (2 kg/cm^2). After predrying, the sample was then baked for 3 minutes at 100°C using a Werner Mathis AG steamer/baker unit. The concentrations of Hercosett 125 that were applied to the fabric were 50 and 100 cm^{3}l^{-1}; for each concentration of the polymer used, 10 gl^{-1}

Sandozin NIE were included in the pad liquor.

Dyeing

This was carried out in glass dye pots housed in a Zeltex laboratory-scale dyeing machine, using a liquor ratio of 20:1 and a dye concentration of 2% owf by the method recommended by Sandoz. At the end of dyeing, the dyed sample was removed and treated in a solution containing 10 gl^{-1} Sandozin NIE at the boil for 10 minutes using a liquor ratio of 50:1; the washed-off sample was then rinsed thoroughly in warm and then cold water and finally allowed to dry in the open air.

Tensile strength determination

This was carried out as described above.

It was found that treatment with the cationic resin resulted in a dramatic increase in colour strength of the enzyme-treated substrate; indeed, the extent of dye uptake achieved for the two enzyme-treated samples was greater than that secured for an untreated ramie sample. This finding may be due to fact that enzyme treatment 'opens' the fibres, as a consequence of which, the extent of diffusion and thus uptake of the resin is enhanced; as a result, the colour strength of the enzyme-treated samples which had been treated with Hercosett was greater than that of the Hercosett-treated ramie which had not undergone enzyme-treatment.

Thus, this work demonstrated that treatment of enzyme-treated ramie with Hercosett 125 greatly improved the dyeability of the fabric with reactive dyes. As recounted in section 5, as Hercosett 125 pretreatment enhanced the dyeability of untreated ramie with direct and sulphur dyes as well as reactive dyes, such treatment of enzyme-treated fabric should also result in enhanced dyeability with direct and sulphur dyes as well as reactive dyes. Furthermore, in view of the findings by Mrs Li of the RTDC concerning the meritorious effect of Glytac A pretreatment on the dyeability of untreated ramie fabric with both reactive and direct dyes, it seems reasonable to suggest that treatment of enzyme-treated fabric with Glytac A would also impart enhanced dyeability towards each of these three classes of dye.

Clearly, enzyme treatment markedly enhances the softness of ramie fabric and, although such enhanced softness is accompanied by a dramatic reduction in the strength and dyeability of the substrate as well as a less marked reduction in the mass of the fibre, the treatment offers potential benefits to the RTDC and its clients.

8. **Quantification of itchiness**

'Wearer trials' have been undertaken at the RTDC that comprised some twenty persons wearing dyed ramie T-shirts of knitted ramie fabric, each wearer having rated the itchiness of the T-shirts on the scale:

1 extremely itchy;
2 very itchy;
3 itchy;
4 slightly itchy;
5 not itchy.

Although this method of assessing itchiness is subjective, it nevertheless appears to be successful and, therefore, should be employed as a suitable method for quantifying the itchiness of ramie fabrics.

9. Quantification of hairiness

As the hairiness of ramie fabric is of major importance with regard to the fabric's itchiness and, to the knowledge of the author, there is no known method for determining the hairiness of fabrics, several techniques were examined as to their ability to quantify this important parameter. Optical microscopy proved unsuitable for measuring the number and length of hairs present on the surface of ramie fabric. Although Scanning Electron Microscopy (SEM) also did not permit a direct measure to be made of the absolute hairiness of ramie fabric, this particular technique proved successful in enabling a comparison to be made of the relative hairiness of two samples of fabric. Also, SEM clearly revealed the effect of enzyme treatment on ramie fabric. Although, as mentioned above, the author is unaware of a method for quantifying the hairiness of fabrics, a comprehensive search of the relevant literature may identify a suitable method; in view of the importance of the hairiness of the fabric, future research effort should be directed towards developing an accurate and reproducible method for quantifying this characteristic.