For many years knitted cotton fabrics were predominantly used for underwear. Some degree of dimensional stability was specified, but other than that there were no special requirements. Today, because it is inexpensive to manufacture, and unsurpassed for comfort, knitted cotton underwear is still in high demand. However, in the last 25 years the growth in cotton used in knitted outerwear garments has completely changed the dyeing and finishing industry.

We only need to compare photographs of football crowds from 50 years ago with those of today to see the impact of knitted leisurewear.

The latest research report from ‘Textiles Intelligence’ predicts that the world’s knitted textiles and apparel output will increase 25% to over 21 million tons over the next ten years. Currently, over 17 million tons are produced each year, representing one third of the global textile market.

The study, ‘World Markets for Knitted Textiles and Apparel: Forecasts to 2010’, attributes the forecast to new fibres opening up new markets. For example, knitted textiles are no longer used solely for basic apparel items such as T-shirts, and high-tech fibres allow designers to create more sophisticated product ranges. New manufacturing technologies also give companies the opportunity to be more flexible and produce smaller quantities at lower prices.

The market for leisurewear places high demands on colour, form, and design, and the consumer is willing to pay higher prices than for similar underwear fabrics for quality in these areas. Specifications for knitted outerwear have required quality standards of the fabric appearance and its properties to be raised.

Dimensional stability of outerwear fabrics for leisurewear and sportswear must be better than for underwear, and to satisfy the requirements of the highly developed markets of Western Europe, USA and Japan this means stability in machine washing and tumble drying. One of the most attractive properties of knitted fabrics is their adaptation to the shape of the wearer. Unfortunately this characteristic also creates problems for the knitter and the dyer and finisher in that the fabrics may be subjected to tension and/or distortion in every stage of manufacture and processing, and yet the garments made from these fabrics are expected to retain their intended shape in subsequent laundering.

How can a dyer and finisher control the goods during processing so as to obtain acceptable end use properties?
In a comparison of 20 gauge cotton interlock fabrics and 14 gauge 1X1 rib fabrics dyed on winch machines and jet machines, it was observed that:

- The relaxed weights of the winch and jet dyed fabrics were similar, both lighter than the corresponding unfinished fabrics by approximately 7%. The reason lies in a reduction in the number of courses per unit length, and consequently in a permanent elongation of the fabric. The elongation is greater in all winch dyed fabrics.
- The jet dyed fabrics were about 5 to 7% wider than the corresponding winch dyed fabrics. If a winch dyed fabric were therefore finished to a width that results in a 10% residual shrinkage, a corresponding jet dyed fabric, finished to the same width, would shrink only 3 to 5%.

The improvement in stability, combined with the greater facility for automation and microprocessor control afforded by modern jet and overflow dyeing machines, has resulted in the change in appearance of the average knit goods dye house we have seen in the last 25 years.

A similar comparison of 100% cotton 28 gauge single jersey fabrics dyed to various shades from white to very dark shades on winch and jet machines showed that weight per square metre, and courses per 3 cm increase somewhat with increasing depth of shade, although width shrinkage decreases after scouring. This reveals higher length shrinkage with darker shades, where the length of the dyeing cycle is markedly longer than with white or pastel shades.

The conclusion, as every dyer realises without need for too much science, is that a higher quality fabric will result if the wet processing time can be minimised, whilst at the same time ensuring that the fabric is well prepared, levelly and reproducibly dyed, and efficiently washed-off.
Preparation of knitted cotton fabrics

Of course, the production of a top quality fabric starts with knitting a high quality yarn, but the influence that the dyer can exert on the quality of the finished fabric begins as soon as the fabric enters the dye house.

Ensuring that the fabric is well prepared involves removal of the natural and man-made impurities present in the greige fabric. In the case of cotton knitted fabrics, the soil to be removed comprises only those lubricants used in spinning the yarn, and on the knitting machine, in addition to the natural impurities of the cotton.

### Soil to be removed in preparation of Knitted Cotton

<table>
<thead>
<tr>
<th>Natural Impurities</th>
<th>Added Impurities</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Fats</td>
<td>- Paraffin Wax</td>
</tr>
<tr>
<td>- Waxes</td>
<td>- Spinning oils</td>
</tr>
<tr>
<td>- Hemicellulose</td>
<td>- Knitting oils</td>
</tr>
<tr>
<td>- Pectins</td>
<td></td>
</tr>
<tr>
<td>- Proteins</td>
<td></td>
</tr>
<tr>
<td>- Mineral matter</td>
<td></td>
</tr>
</tbody>
</table>

- **10-15 %**
- **0.5 - 2 %**

**Total Impurities: 10 - 17 %**

As spinning speeds have increased over the years, and speed and complexity of knitting machines has increased, so the lubricants used have changed, and every customer has experience of knitting oils which have been very difficult to remove in scouring and bleaching. Yarn spinning and knitted fabric manufacture has increasingly been resourced from countries offering lower labour costs, and, in general, these countries have more tropical climates than the traditional European manufacturing countries. Paraffin waxes with higher melting points have therefore been used on cotton yarns, making them more difficult to remove. The natural fats and waxes found in raw cotton are saturated and unsaturated fatty acids with carbon chain length C15 to C33, glycerol, and fatty alcohols with carbon chain length C24 to C34.
## Detectable wax acids and alcohols in cotton *(Ref 1)*

<table>
<thead>
<tr>
<th>Chemical Formula</th>
<th>Systematic name</th>
<th>Trivial Name</th>
<th>Melting Point deg C</th>
</tr>
</thead>
<tbody>
<tr>
<td>C15H31COOH</td>
<td>hexadecanoic acid</td>
<td>Palmitic acid</td>
<td>64</td>
</tr>
<tr>
<td>C17H35COOH</td>
<td>octadecanoic acid</td>
<td>Stearic acid</td>
<td>69</td>
</tr>
<tr>
<td>C19H39COOH</td>
<td>eicosanoic acid</td>
<td>Arachinic acid</td>
<td>76</td>
</tr>
<tr>
<td>C21H43COOH</td>
<td>docosanoic acid</td>
<td>Behenic acid</td>
<td>81</td>
</tr>
<tr>
<td>C23H47COOH</td>
<td>tetracosanoic acid</td>
<td>Lignoceric acid</td>
<td>81</td>
</tr>
<tr>
<td>C25H51COOH</td>
<td>hexacosanoic acid</td>
<td>Cerotic acid</td>
<td>88</td>
</tr>
<tr>
<td>C27H55COOH</td>
<td>octacosanoic acid</td>
<td>Montanic acid</td>
<td>91 - 93</td>
</tr>
<tr>
<td>C29H59COOH</td>
<td>triacontanoic acid</td>
<td>Mellissic acid</td>
<td>92</td>
</tr>
<tr>
<td>C31H63COOH</td>
<td>dotriacontanoic acid</td>
<td>Locca acid</td>
<td></td>
</tr>
<tr>
<td>C33H67COOH</td>
<td>tetratriacontanoic acid</td>
<td>Ghedda acid</td>
<td></td>
</tr>
<tr>
<td>C19H33COOH</td>
<td>octadecanoic-9-acid</td>
<td>Oleic acid</td>
<td>13</td>
</tr>
<tr>
<td>C19H37COOH</td>
<td>eicosanoic-9-acid</td>
<td>Gadoleic acid</td>
<td></td>
</tr>
<tr>
<td>C24H49OH</td>
<td>Tetracosanol</td>
<td>Lignoceryl alcohol</td>
<td>75 - 77</td>
</tr>
<tr>
<td>C26H53OH</td>
<td>Hexacosanol</td>
<td>Ceryl alcohol</td>
<td>79 - 81</td>
</tr>
<tr>
<td>C28H57OH</td>
<td>Octacosanol</td>
<td>Montanyl alcohol</td>
<td>83</td>
</tr>
<tr>
<td>C30H61OH</td>
<td>Triacantanol</td>
<td>Gossypyl alcohol</td>
<td></td>
</tr>
<tr>
<td>C32H65OH</td>
<td>Dotriacontanol</td>
<td></td>
<td>92</td>
</tr>
<tr>
<td>C34H69OH</td>
<td>Tetratriacontanol</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C30H60(OH)2</td>
<td>Tricontandiol</td>
<td>Coceryl alcohol</td>
<td></td>
</tr>
<tr>
<td>C3H5(OH)3</td>
<td>Propantriol</td>
<td>Glycerol</td>
<td>18</td>
</tr>
</tbody>
</table>

Achieving good absorbency necessitates the thorough removal of cotton wax, which is located mainly in the fibre surface, forming a very thin layer that prevents adequate wetting of the fibre surface. Finer cottons contain a higher proportion of wax by weight, the thickness of the wax layer not varying significantly among different cotton types.

The most common method of removing cotton wax uses hot aqueous alkali. It can be seen from the table above that the melting point of the constituent components of the wax is up to 92°C, and therefore aqueous scouring is preferably carried out at a temperature higher than 90°C.

The reduction of the amount of wax on the fibre is not in itself an indication of improvement in wetting properties. Experiments carried out by Kollman (1937) demonstrated that boiling cotton in 95% alcohol for 1 hour reduced the amount of cotton wax from 0.46% to 0.10%, but had no effect on the time required for wetting, while a normal scour in aqueous alkali at a temperature above 100°C reduced the wax content to 0.19% and the wetting time to less than 1 second.

It appears, therefore, that although aqueous cotton scouring cannot remove all the wax, it must remove most of it, leaving a discontinuous film. When caustic soda is used as the alkali, it is believed that the primary cell wall of the cotton fibre is broken to some extent, which also assists in the wetting process. When used at concentrations of about 0.7% to 1.5% w/v, at temperatures above the melting point of the cotton wax, some of the fatty acid part of the wax forms a soap with the caustic soda, the esters are saponified, and the products of the reactions emulsify the remaining constituents of the wax and help to suspend any impurities. Caustic soda therefore plays a very important role in cotton preparation.
The primary wall consists of a network of cellulose fibrils and is covered with an outer cuticle of pectin, fats and waxes, which renders the fibre impermeable to water. The secondary wall consists of cellulose fibres in a spiral arrangement around the fibre axis. The lumen is what remains of the central canal.

However, as can be seen from the table above, 50 - 63% of the cotton wax is non-saponifiable, and therefore the preparation treatment must employ substances that assist in wetting the textile, emulsification of the fatty substances removed from the cotton, and in dispersion of other substances, in other words – a detergent.

<table>
<thead>
<tr>
<th>Component</th>
<th>Content ( % )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wax ester</td>
<td>22</td>
</tr>
<tr>
<td>Phytosterols</td>
<td>12 - 14</td>
</tr>
<tr>
<td>Polyterpenes</td>
<td>1 - 4</td>
</tr>
<tr>
<td>Hydrocarbons</td>
<td>7 - 8</td>
</tr>
<tr>
<td>Free wax alcohols</td>
<td>42 - 46</td>
</tr>
<tr>
<td>Saponifiable</td>
<td>36 - 50</td>
</tr>
<tr>
<td>Non-saponifiable</td>
<td>50 - 63</td>
</tr>
<tr>
<td>Inert</td>
<td>0 - 3</td>
</tr>
</tbody>
</table>
Nearpon LF-JET
Perhaps the most important property in a detergent to be used in jet and overflow dyeing machines is low foaming whilst not compromising on cleaning, emulsifying and soil removing properties. Nearpon LF-JET satisfies all of these requirements.

Cleaning Ability
A number of competitors' low foam detergents were compared at equal concentrations of saleable product, in an identical scour-bleach recipe for cotton single jersey fabric. Into each bath, an equal weight of specially soiled fabric was introduced together with greige cotton knitted fabric. The whiteness of the knitted cotton was measured before and after scour/bleaching. The soil removed from the artificially soiled fabric was similarly determined spectrophotometrically. The cleaning properties of Nearpon LF-JET are clearly demonstrated.
Mineral matter
Metal impurities in the cotton must be removed during preparation in order to avoid problems in scouring or bleaching, and in subsequent dyeing procedures.

Disadvantages of alkaline earth impurities in textile processing

- Dust in singeing
- Insoluble white powder deposits of carbonates, hydroxides, phosphates formed in alkali
- Insoluble silicate deposits in bleaching
- Lime soap stains
- Build-up of deposits on machines
- Peroxide stabilisers blocked by excess calcium - Mg ions precipitated - poor peroxide stability
- Insoluble yellowish-green salts formed with FBA's
- Emulsions of oils and greases are split by Ca and Mg
- Solubility of dyes impaired
- Form spots and stains with dyes
- Cause changes in shade and reduced fastness
As can be seen from the table below, the content of mineral matter, metal impurities, in cotton is subject to considerable variation depending on local growing conditions, irrigation, and chemicals applied as fungicides, defoliants etc.

### Analysis of samples of cotton fibre of different provenance

<table>
<thead>
<tr>
<th>Provenance</th>
<th>Ca ppm</th>
<th>Mg ppm</th>
<th>Fe ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sendhwa India</td>
<td>1000</td>
<td>600</td>
<td>125</td>
</tr>
<tr>
<td>Bailhongal India</td>
<td>1030</td>
<td>845</td>
<td>115</td>
</tr>
<tr>
<td>Jepur India</td>
<td>580</td>
<td>585</td>
<td>84</td>
</tr>
<tr>
<td>Pandurna India</td>
<td>980</td>
<td>790</td>
<td>475</td>
</tr>
<tr>
<td>Izmir Turkey</td>
<td>905</td>
<td>890</td>
<td>22</td>
</tr>
<tr>
<td>Hatay Turkey</td>
<td>725</td>
<td>640</td>
<td>24</td>
</tr>
<tr>
<td>Urfa Turkey</td>
<td>6290</td>
<td>1190</td>
<td>63</td>
</tr>
<tr>
<td>Tarsus Turkey</td>
<td>985</td>
<td>620</td>
<td>29</td>
</tr>
<tr>
<td>Paranh Brazil</td>
<td>2711</td>
<td>1119</td>
<td>313</td>
</tr>
<tr>
<td>Sao Paulo Brazil</td>
<td>944</td>
<td>863</td>
<td>72</td>
</tr>
<tr>
<td>Peru</td>
<td>700</td>
<td>440</td>
<td>13</td>
</tr>
<tr>
<td>Texas USA</td>
<td>810</td>
<td>365</td>
<td>75</td>
</tr>
<tr>
<td>California USA</td>
<td>600</td>
<td>540</td>
<td>40</td>
</tr>
<tr>
<td>Russia</td>
<td>1320</td>
<td>567</td>
<td>112</td>
</tr>
</tbody>
</table>

Analysis of the blowroom waste from cotton spinning has established that the vegetable impurities in cotton contain extraordinarily high concentrations of metal impurities. If the dyer is faced with a knitted cotton fabric in which a lot of seed particles are present (showing as little black spots), it is almost certain that the fabric will also contain very high concentrations of metal impurities.

### Analysis of the metal content of vegetable impurities in cotton

<table>
<thead>
<tr>
<th></th>
<th>Ca</th>
<th>Mg</th>
<th>Fe</th>
<th>Al</th>
<th>Mn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seeds</td>
<td>25000</td>
<td>5500</td>
<td>600</td>
<td>1100</td>
<td>85</td>
</tr>
<tr>
<td>Stem particles</td>
<td>17500</td>
<td>7000</td>
<td>350</td>
<td>600</td>
<td>90</td>
</tr>
<tr>
<td>Bark particles</td>
<td>6500</td>
<td>550</td>
<td>500</td>
<td>1200</td>
<td>250</td>
</tr>
<tr>
<td>pure cotton fibre</td>
<td>540</td>
<td>490</td>
<td>27</td>
<td>8</td>
<td>&lt;1</td>
</tr>
</tbody>
</table>

It is evident that sequestering agents with a high complexing power for calcium and magnesium ions are necessary in cotton preparation if we are to avoid problems in subsequent processing. Sequestering agents and/or peroxide stabilising agents with high complexing power for Iron (Fe $$^{+++}$$) will be useful to prevent catalytic damage to the cellulose in peroxide bleaching.
Nearchel TMC

Nearchel TMC can be shown to be one of the most effective sequestering agents for Calcium and Magnesium under the strongly alkaline pH conditions usually used in cotton preparation.

Sequestration values for calcium at pH11

<table>
<thead>
<tr>
<th>Sequestering agent</th>
<th>mg CaCO3 / g (100%) at pH11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active agent of Nearchel TMC</td>
<td>1167</td>
</tr>
<tr>
<td>EDTMP Na salt</td>
<td>1135</td>
</tr>
<tr>
<td>Dequest 2086</td>
<td>927</td>
</tr>
<tr>
<td>HEDP Na salt</td>
<td>870</td>
</tr>
<tr>
<td>SPE 9402</td>
<td>865</td>
</tr>
<tr>
<td>ATMP Na salt</td>
<td>852</td>
</tr>
<tr>
<td>HDTMPA K salt</td>
<td>309</td>
</tr>
<tr>
<td>NTA Na salt</td>
<td>525</td>
</tr>
<tr>
<td>EDTA Na salt</td>
<td>467</td>
</tr>
<tr>
<td>DTPA Na salt</td>
<td>590</td>
</tr>
<tr>
<td>HEDTA Na salt</td>
<td>464</td>
</tr>
<tr>
<td>Citric acid</td>
<td>489</td>
</tr>
</tbody>
</table>

Because Nearchel TMC also exhibits good complexing properties for heavy metals like Iron, Copper and Manganese at alkaline pH, and those complexes are stable under hydrogen peroxide bleaching conditions, Nearchel TMC can also be used as an efficient stabiliser for hydrogen peroxide in batchwise bleaching.

In experiments to determine residual peroxide remaining in the bleaching bath as temperature is increased, 1 ppm Cu^{2+} copper and 2 ppm Fe^{3+} iron contaminants have been deliberately added to the bleaching bath.

Hydrogen peroxide stabilisation
Effect of Nearchel TMC

![Hydrogen peroxide stabilisation graph](image)
Wash-off and neutralisation after scouring or bleaching

It is well known that many reactive and direct dyes for cotton are sensitive to hydrogen peroxide carried over from the bleaching bath to the dye bath. The hydrogen peroxide can destroy the dye, or, at least, have a deleterious effect on batch-to-batch reproducibility. The excess hydrogen peroxide remaining in the bath at the end of the bleaching process must be very thoroughly rinsed away or reacted to effect neutralisation. This neutralisation can be done with reagents like Neareduxol PAB or Neareduxol EX, catalase enzyme.

What can happen if hydrogen peroxide is carried over into dyebath?

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1% Remazol Brilliant Blue R special</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1% Levaflx Brilliant Blue EFFF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1% Cibacron Blue F-4G</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1% Dimarone Brilliant Blue K-9L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1% Dimarone Blue X-3LR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1% Sunfast Supra Blue B-RF</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

It must be recognised that the reproducibility of the reactive dye recipe will be just as badly affected, if not more so, by a carry over of alkali from the bleach bath to the dye bath. Caustic soda, in particular, is very substantive to cellulose, and is not easy to wash-off and neutralise especially at low temperatures. It is quite possible to have a cotton yarn or fabric with caustic soda penetrated deep into the interstices of the fibre, circulating in a bath containing acetic acid at room temperature. The dyer believes that the cotton has been effectively neutralised, but it is only later when the cotton is dried, or dyed in a bath of hot water, that the caustic soda migrates to the fibre surface and may cause a problem. Effective neutralisation of a cotton fibre containing caustic soda is only possible in a short time in an acid bath at a temperature of at least 60°C.

Enzymes are available which will digest hydrogen peroxide, eliminating the peroxide from the cotton in a rinsing bath, but such enzymes are not stable to wide variation in pH or temperature. Therefore in order to be sure that the caustic soda used in bleaching is well neutralised, the bleached fabric must be rinsed in hot acid as well as a rinse in enzyme. If a hot acid rinse is to be used to neutralise the alkali, the same bath could be used with Neareduxol PAB to neutralise the hydrogen peroxide. The dyer should not make the mistake of believing that the bleached fabric has been effectively neutralised by only using an enzyme peroxide killer at low temperature and neutral pH.
Anticrease and dyebath lubricant

We have stated that the consumer is willing to pay higher prices for knitted fabrics for quality in the areas of fabric appearance, colour, form, and design. The dyer and finisher must therefore strive to produce fabrics free from creasing or abrasion marks, with a clean, non-hairy, non-fibrillated surface appearance. Obviously mechanical handling plays a major role in achieving these objectives. Because jet and overflow dyeing machines transport the fabric in rope form, creases are inevitable, but if the creases are rapidly and continuously moved they do not become permanent. When dyeing at longer liquor ratios this shifting in position of the folds is easier than under short liquor ratio processing conditions. Inside the jet nozzle the surface of the fabric becomes subject to stress and friction between fabric and fabric or between fabric and metal, resulting in a more fibrillated surface, abrasion marks, or permanent fibre damage.

Abrasion and chafing marks may result from:
- too high a machine speed;
- stationary fabric in a running machine, caused by poor wetting, knots and tangles in the fabric, poor operating practice e.g. whilst sewing ends;
- overloading leading to mechanical friction;
- rough patches in the machine.

Such chafe marks may exaggerate creasing, by dyeing a different shade on the abraded edge of the crease. Creasing may result from:
- an inadequate prepare (relaxation/bulking of fabric may not be complete or may have occurred too quickly);
- quality of goods (a tight construction, high twist yarns, dense weight per sq.m.);
- poor suitability of dyeing machine (folds not moved);
- too heavy a batch of fabric;
- incorrect loading (twisted rope, knotted or poorly sewn ends with no opportunity to balloon);
- incorrect dyeing process (heating, cooling rates too rapid);
- lustre - stationary fabric sitting on hot metal of machine under pressure giving a glazed mark.

To avoid fabric creasing the first steps should be to follow some simple rules to avoid the above problems and then an anti-crease lubricant should be used to influence the fibre-to-fibre friction, and fibre-to-metal friction only as an extra insurance against creasing and abrasion faults, not as the first resort.

The formation of creases and many other undesired phenomena can be avoided by reduction of friction.

The basic requirement of an anti-crease lubricant in wet processing is that it should form a thin, uniform protective coating around the fibre to lower the surface friction and flexural rigidity, thus minimising the formation of durable creases during high temperature wet processing.

Nearchimica S.p.A. offers different anticrease agents and wet processing lubricants for different applications.

Lubrifil LAF

Lubrifil LAF is an anionic anticrease lubricant especially recommended where high stability to electrolyte and to alkaline conditions is required. It is therefore particularly suitable for the preparation, and dyeing of cotton and viscose rayon, and their blends with polyester and polyamide. It is distinguished from other wet processing lubricants in having very useful emulsifying properties for oils and waxes which may be present on the fabric or on the walls of the machine. These properties help to avoid reprocessing as a result of spots and stains on the fabric, as well as reducing or eliminating creases and abrasion damage.
**Lubrifil LV**
Lubrifil LV is recommended for the wet processing of polyamide, wool and silk. The product gives a smooth handle and lower friction. But Lubrifil LV is not stable under alkaline conditions. Lubrifil LV is low foaming and has a foam breaking effect. So some customers are using Lubrifil LV as a dyebath foam controller, believing this product to be safer than silicone based defoamers.

**Lubrifil TFS**
Lubrifil TFS is based on an aqueous polymer dispersion, and is almost non-foaming when used in a high-speed machine or Ultra Low Liquor Ratio type machine. Lubrifil TFS is particularly recommended for synthetic fibres dyed under acid pH dyebath conditions.

Lubrifil LAF is a mixture of fatty acid phosphate esters, which probably attaches to the fabric surface as shown:

- **Surface**
  Some anti-crease lubricants attach themselves to fabric surfaces by what is called a “Loop – Tail – Train” surface science mechanism. In order to exhibit this form of attachment, the agent molecule will have adjacent hydrophobic and hydrophilic blocks.

  - Hydrophilic
  - Hydrophobic
  - Hydrophilic
  - Hydrophobic
  - Hydrophilic
  - Hydrophobic

  - Hydrophilic
  - Hydrophobic
  - Hydrophilic

- **Surface 1**
  Film exhibiting “Loop - Tail - Train” attachment

- **Surface 2**

  The hydrophobic portions of the molecule will be attracted to the substrate, and the hydrophilic portions project outwards into the application bath.

  The coefficient of friction between Surface 1 and Surface 2 is therefore lubricated by the presence of the loops of attaching films, and the lubricant further reduces the tendency of the two surfaces to adhere to one another.
**Scouring & Bleaching of Elastane blends**

Lubricant systems used on elastane fibres are based on low viscosity polydimethyl silicone fluids, and are notoriously difficult to remove, especially if the fabric is pre heat-set before preparation. **Nearpon KR** has been developed especially to assist in the removal of very obstinate oils such as the silicone oil used on elastane.

**Nearpon KR**

Nearpon KR is a mixture of a very efficient, biodegradable detergent, and an even more biodegradable, environmentally acceptable solvent. It is designed to remove very hydrophobic oils and difficult to remove sizes.

We can show that removal of silicone oil is more effective with Nearpon KR than with competitors' products.

It is very difficult to show silicone removal by extraction methods. Here secondary ion mass spectrometry has been used to identify residual silicone on a polyester/elastane fabric.

And in another comparison with competitors' products X-Ray fluorescence has been used to determine residual silicone remaining on a polyamide/elastane fabric after scouring with Nearpon KR.
Soil Removal
But it is not only silicone oil which is removed by Nearpon KR.
In our standard test for soil removal from a cotton fabric artificially soiled with graphite, mineral oil, paraffin wax etc., Nearpon KR gives the best performance of all these textile detergents.

Soil Removed from Standard Soiled Fabric Various Detergents
Nearpon KR shows excellent soil removal, soil suspending, as well as soil anti-redeposition properties. It is these anti-redeposition properties that often solve levelling problems in subsequent dyeing.

**Detergency testing carried out on standard soiled fabric at increasing temperature.**

<table>
<thead>
<tr>
<th>Temperature °C</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competition 1</td>
<td>![Image of Competition 1 at 60°C]</td>
<td>![Image of Competition 1 at 70°C]</td>
<td>![Image of Competition 1 at 80°C]</td>
<td>![Image of Competition 1 at 90°C]</td>
</tr>
<tr>
<td>Competition 2</td>
<td>![Image of Competition 2 at 60°C]</td>
<td>![Image of Competition 2 at 70°C]</td>
<td>![Image of Competition 2 at 80°C]</td>
<td>![Image of Competition 2 at 90°C]</td>
</tr>
<tr>
<td>Competition 3</td>
<td>![Image of Competition 3 at 60°C]</td>
<td>![Image of Competition 3 at 70°C]</td>
<td>![Image of Competition 3 at 80°C]</td>
<td>![Image of Competition 3 at 90°C]</td>
</tr>
<tr>
<td>Competition 4</td>
<td>![Image of Competition 4 at 60°C]</td>
<td>![Image of Competition 4 at 70°C]</td>
<td>![Image of Competition 4 at 80°C]</td>
<td>![Image of Competition 4 at 90°C]</td>
</tr>
<tr>
<td>Competition 5</td>
<td>![Image of Competition 5 at 60°C]</td>
<td>![Image of Competition 5 at 70°C]</td>
<td>![Image of Competition 5 at 80°C]</td>
<td>![Image of Competition 5 at 90°C]</td>
</tr>
<tr>
<td>Competition 6</td>
<td>![Image of Competition 6 at 60°C]</td>
<td>![Image of Competition 6 at 70°C]</td>
<td>![Image of Competition 6 at 80°C]</td>
<td>![Image of Competition 6 at 90°C]</td>
</tr>
<tr>
<td>Competition 7</td>
<td>![Image of Competition 7 at 60°C]</td>
<td>![Image of Competition 7 at 70°C]</td>
<td>![Image of Competition 7 at 80°C]</td>
<td>![Image of Competition 7 at 90°C]</td>
</tr>
</tbody>
</table>

The test ran for 30 minutes followed by a 50°C rinse lasting 5 minutes. The detergents were all used at 2g/l.

**Heat-setting of elastane blends before wet processing**

If the proportion of elastomeric fibre in a blended fabric is more than 5 or 6%, it is probably necessary to heat-set the fabric before wet processing in order to avoid creasing during batchwise dyeing, and in order to meet dimensional stability specifications for the final finished fabric. Without pre-setting the finished fabric will probably shrink more than 5% during domestic laundering.

A standard discontinuous process suitable for most stretch fabrics comprises:

- Relaxation
- Heat-setting
- Scouring
- Bleaching/dyeing/printing
- Finishing

Relaxation is necessary to relieve residual stresses in the fabric caused by tension of the elastane yarns during knitting. If these stresses are not relieved they can distort the structure, deform the design and cause puckering of the fabric. A stretch fabric is therefore relaxed as early as possible in wet processing by
  - Passing over a steam table
  - Steam framing in a steam box fitted at the inlet to the stenter
  - Solvent scouring
  - Hot water treatment on a washing or dyeing machine with little or no tension.
In heat-setting it must be remembered that it is the elastane fibre that is being set, and therefore dry heat in excess of 180°C will be needed to set fabrics for up to 60 seconds. Pre-setting conditions are usually 30 to 70 seconds at temperatures from 185°C to 195°C. If it is possible to pad impregnate a suitable auxiliary before heat-setting:
- oils and lubricants can be more easily removed subsequently;
- there is less risk of creasing in the dyeing machine;
- use of anti-oxidant can avoid undue yellowing and scorching;
- barré coverage of polyamide is improved -because amine end groups are undamaged;
- correct heat setting temperatures can be used giving improved stability.

Because Lubrifil LAF possesses good emulsifying properties for mineral oil and paraffin wax, we recommend pad application of 10 – 20 g/l Lubrifil LAF before heat-setting of grey fabric cotton/elastane or viscose/elastane blends. When the heat-set fabric is subsequently loaded into the dyeing machine, the Lubrifil LAF will assist with emulsification of spinning and knitting lubricants in scouring or bleaching, and will act as a wet lubricant avoiding abrasion marks and helping to eliminate creasing.
Dyeing of knitted cotton fabrics

The requirements of the dyer are:

- Levelness
- Reproducibility
- Good fastness — especially where different coloured fabrics will be used in the same garment
- Minimal damage to delicate constructions during processing
- Good dimensional stability

The dyeing system selected should therefore provide:

(a) excellent level dyeing and penetration properties, particularly in difficult shades (pale, ternary, etc.) and on difficult substrates;
(b) compatibility of the dyes within that system throughout the shade gamut;
(c) excellent reproducibility of shade, particularly in more difficult ternary shades;
(d) facility for automation with minimal supervision — ideally an ‘all-in’ method;
(e) the possibility for shortened processing techniques;
(f) excellent washing-off properties.

It is not always possible to ensure all of these properties in every shade area that the dyer is required to produce. For example, it is not easy to produce a very bright emerald green, in a full depth of shade, with very good wet fastness, no creases or abrasion marks, and perfectly level. This is where auxiliary products can help.

Well-equipped dyehouses should rarely have problems of bad level dyeing. Use of automated atmospheric jet and overflow dyeing machines has largely eliminated the problems of patchy dyeings and rope marks that were once so common with winch machines. So if offered a “levelling agent” for reactive dyes, the dyer will probably say that he does not have unlevel dyeing problems and does not need such a product. However, most customers do have problems of “shade consistency”, problems of piece-to-piece shade variation, end-to-end, side-to-centre, or yarn package-to-package, and inside-to-outside shade variation.

This leads to complaints from the garment manufacturer about variation from one garment panel to another.

Neargal LU-SRV

Neargal LU-SRV is a Levelling agent, for Substantive (Direct), Reactive, and Vat dyes on cotton.

Neargal LU-SRV is an amphoteric surfactant

Amphoteric surfactants contain both negative and positive charges within the same molecule, although the particular ionic charge under given conditions will be influenced by the pH of the solution. Thus, under alkaline conditions the molecules act as anionic species, while under acidic conditions they behave as cationic species. Between these extremes of pH lies the isoelectric point, where the ionic charges are balanced and the molecule carries no charge. This means that Neargal LU-SRV is capable of interacting with anionic cotton dyes in the dyebath, thus slowing down their exhaustion, and is capable of adsorption onto the fibre, competing with the dye, and thereby equalising variations in affinity on the fibre.

Mechanism of NEARGAL LU-SRV

a) with reactive and direct dyes

In order to attempt to explain the mode of action of Neargal LU-SRV we need to consider the mechanism of dyeing with direct and reactive dyes and why electrolyte (salt) is necessary in discontinuous application.
The role of electrolyte in the dyeing of cotton with direct and reactive dyes.

1. To create an electrical double layer on the cellulose

Reactive dyes and direct dyes for cotton are anionic, and in water the cotton will take on a small negative charge, so that the dye and the fibre will tend to repel each other. The addition of salt creates an electrical double layer which hides the electrostatic charge, allowing the dye to approach the fibre.

2. Solubility

If the salt is dissolved in the water, the dye / water equilibrium is disturbed and the dye is driven to the fibre.

3. Aggregation

Addition of electrolyte causes aggregation of the direct or reactive dye, clusters of dye molecules that have a higher affinity for the cellulose fibre.

Here we see the effect of adding salt to a solution of Congo Red. Aggregation of the dye molecules takes place with several molecules joined into an aggregate by hydrogen bonding. The aggregate forms a larger particle with greater substantivity for the fibre.
We see this also if we examine the UV-Vis spectrophotometer trace of a solution of reactive dye in water. Each reactive dye will show two peaks, one the monomeric form of the dye – the individual dye molecules, the other the n-mer form – the aggregated dye.

If we add salt (sodium chloride) to the dye solution we see relatively more of the aggregated form and less of the single molecules. If we add urea, as for example when making a print paste or padding liquor, we see less aggregation and more single molecules.

When we add NEARGAL LU-SRV to the dye solution we see a similar effect to that when adding urea, less aggregation, more single dye molecules. However, the effect with NEARGAL LU-SRV can only be temporary because, as we will see, there is no effect on the final yield of the dye.
Dye aggregates are too large to diffuse inside the fibre and only single molecules with sufficient kinetic energy can diffuse inside the fibre. Dye molecules or ions diffuse inside physical pores in the fibre surface, or have to wait until a temporary hole is created in the fibre surface by the co-operative movement apart of segments of polymer chain molecules of the fibre substance.

The dye molecules or ions then diffuse within the accessible amorphous regions of the fibre, which are the disordered or non-crystalline regions. The dye diffusion into the fibre occurs by a succession of diffusion jumps until the dye reaches a dye site to which it may be attracted, and to which it may ultimately be fixed by chemical bonding.

Continuous replacement of the dye molecules in the diffusional boundary layer by more dye molecules arriving at the fibre surface, continues the adsorption and diffusion processes at the fibre surface. Not all of the dye molecules that diffuse inside a fibre are immediately retained, because if a temporary hole is created in the fibre surface, some of the unfixed dye inside the fibre may then diffuse out and be readsorbed by other fibres. This, ultimately, will lead to every fibre being uniformly dyed to the same colour.

**Mechanism of Neargal LU-SRV**

b) with vat dyes

A yarn package composed of half undyed yarn and half cotton yarn dyed with vat dye was treated with:

(a) 25 ml/l caustic soda 38º Bé liq
25 g/l sodium hydrosulfite

(b) 25 ml/l caustic soda 38º Bé liq
25 g/l sodium hydrosulfite
4 g/l NEARGAL LU-SRV
for 60 minutes at 60º C.
Then oxidised and soaped as normal.

The packages in the second picture illustrate the migrating effect of NEARGAL LU-SRV.

A smaller concentration of NEARGAL LU-SRV (1 to 4%) would be recommended to ensure level dyeing when added to a new dyeing.
To return to our proposition of what the dyer needs, during the first part of the dyeing process, the substantivity of the dye causes its uptake by the fibre, where it is absorbed. This rate of exhaustion must be controlled if the distribution of the dye is to be uniform and homogeneous. It can be regulated by successive and progressive additions of electrolyte (portionwise addition of salt), but in today’s automated machine cycles this procedure is no longer practical.

The dyer wants to add all the electrolyte to the dyebath before the dye in a simple and time saving method. Many dyers follow this procedure already, but there may be a high risk of unlevelness in some dye combinations. In the presence of electrolyte the dye forms aggregates of greater or lesser size, as we have seen, whose affinity for cotton becomes higher.

This phenomenon retards diffusion of the dyes and their migration power, and may lead to unlevel dyeings from the start.

The use of NEARGAL LU-SRV makes possible “Salt-at-start”, “All-in” dyeing methods with reactive dyes with less risk of unlevel dyeing, thus:

- Simplified dyeing – only one method for each dye class regardless of shade and recipe;
- Dyeing programmes are easier to control
- The electrolyte can be added before the dye with improved safety.
- Shortened cycle times.

**Lubricants to avoid creasing and abrasion marks**

As stated earlier, the dyer and finisher must strive to produce fabrics free from creasing or abrasion marks, with a clean, non-hairy, non-fibrillated surface appearance. Because jet and overflow dyeing machines transport the fabric in rope form, creases are inevitable, but if the creases are rapidly and continuously moved they do not become permanent. Inside the jet nozzle the surface of the fabric becomes subject to stress and friction between fabric and fabric or between fabric and metal, resulting in a more fibrillated surface, abrasion marks, or permanent fibre damage.

Abrasion and chafing marks may result from:

- too high a machine speed;
- stationary fabric in a running machine, caused by poor wetting, knots and tangles in the fabric, poor operating practice e.g. whilst sewing ends;
- overloading leading to mechanical friction;
- rough patches in the machine.

Such chafe marks may exaggerate creasing, by dyeing a different shade on the abraded edge of the crease.

Making a scratch with something metal on a prepared cotton knitted fabric, and then dyeing with a reactive phthalocyanine turquoise and a yellow can demonstrate this.

The area on which the scratch was made will dye to a deeper, bluer shade than the rest of the fabric. This is because damaged cotton will dye darker with a phthalocyanine blue dye. This can clearly be seen under the microscope.

Addition of **Lubrifil LAF** into the dyebath is therefore just as important as in the preparation bath in order to provide fibre-metal and fibre-fibre lubrication, and avoid such abrasion damage, and the formation of permanent crease marks.
Washing-off reactive dyes

The first reactive dyes for cellulose were launched by ICI in 1956 under the trade name “Procion”. They resulted from the pioneering work of W.E.Stephen and I.D.Rattee, and the earliest examples employed the dichloro-s-triazinyl group in the molecule. The chlorine atoms are readily susceptible to nucleophilic displacement. The attacking nucleophile can be either a cellulosate anion or a hydroxide ion, so that the dye can covalently react at hydroxyl groups within the cellulose or with water, leading to hydrolysis of the dye and its loss from the dyeing process.

The hydrolysed dye has the same substantivity as the unhydrolysed dye and in order to achieve good wet fastness properties it must be efficiently removed. The first step in washing-off should always be to reduce the concentration of electrolyte (Common salt or Glauber’s salt). Until the salt is removed, effective removal of unfixed dye is restricted.

Exhaustion of 5% shade of reactive dyes at 5:1 liquor ratio as affected by salt

The graph shows how little salt is necessary to exhaust a reactive dye. By the same token, the salt concentration must be reduced to 1 g/l or less for efficient washing-off.

Indicates salt concentration which would apply after 1, 2, 3 and 4 rinses
The fastness tests above illustrate the importance of several rinses in water only, before any ‘soaping’ treatment. This is especially true in low liquor ratio machines where water held in the fabric or yarn will be carried over from one rinse bath to the next.

### Common salt dilution at L.R. 5:1
Nominal working liquor ratio 5:1
Effective liquor interchange 3:1 allowing for 200% liquor carry-over

<table>
<thead>
<tr>
<th>Original salt concentration</th>
<th>Rinse 1</th>
<th>Rinse 2</th>
<th>Rinse 3</th>
<th>Rinse 4</th>
<th>Rinse 5</th>
<th>Rinse 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 g/l</td>
<td>8.0</td>
<td>3.2</td>
<td>1.28</td>
<td>0.51</td>
<td>0.2</td>
<td>0.08</td>
</tr>
<tr>
<td>30 g/l</td>
<td>12.0</td>
<td>4.8</td>
<td>1.92</td>
<td>0.77</td>
<td>0.31</td>
<td>0.12</td>
</tr>
<tr>
<td>40 g/l</td>
<td>16.0</td>
<td>6.4</td>
<td>2.56</td>
<td>1.02</td>
<td>0.41</td>
<td>0.16</td>
</tr>
<tr>
<td>50 g/l</td>
<td>20.0</td>
<td>8.0</td>
<td>3.2</td>
<td>1.28</td>
<td>0.51</td>
<td>0.2</td>
</tr>
<tr>
<td>60 g/l</td>
<td>24.0</td>
<td>9.6</td>
<td>3.84</td>
<td>1.54</td>
<td>0.61</td>
<td>0.25</td>
</tr>
<tr>
<td>70 g/l</td>
<td>28.0</td>
<td>11.2</td>
<td>4.48</td>
<td>1.79</td>
<td>0.72</td>
<td>0.29</td>
</tr>
<tr>
<td>80 g/l</td>
<td>32.0</td>
<td>12.8</td>
<td>5.12</td>
<td>2.05</td>
<td>0.82</td>
<td>0.33</td>
</tr>
<tr>
<td>90 g/l</td>
<td>36.0</td>
<td>14.4</td>
<td>5.76</td>
<td>2.3</td>
<td>0.92</td>
<td>0.37</td>
</tr>
</tbody>
</table>

Residual salt concentration g/l
As an initial guideline, dye manufacturers recommend that salt concentration should be diluted to approximately 1 g/l remaining in the soaping bath.
Common salt dilution at L.R. 8:1

Nominal working liquor ratio 8:1
Effective liquor interchange 6:1 allowing for 200% liquor carry-over

<table>
<thead>
<tr>
<th>Original salt concentration</th>
<th>Rinse 1</th>
<th>Rinse 2</th>
<th>Rinse 3</th>
<th>Rinse 4</th>
<th>Rinse 5</th>
<th>Rinse 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 g/l</td>
<td>5.0</td>
<td>1.25</td>
<td>0.31</td>
<td>0.08</td>
<td>0.02</td>
<td>-</td>
</tr>
<tr>
<td>30 g/l</td>
<td>7.5</td>
<td>1.88</td>
<td>0.47</td>
<td>0.12</td>
<td>0.03</td>
<td>0.01</td>
</tr>
<tr>
<td>40 g/l</td>
<td>10.0</td>
<td>2.5</td>
<td>0.63</td>
<td>0.16</td>
<td>0.04</td>
<td>0.01</td>
</tr>
<tr>
<td>50 g/l</td>
<td>12.5</td>
<td>3.13</td>
<td>0.78</td>
<td>0.2</td>
<td>0.05</td>
<td>0.01</td>
</tr>
<tr>
<td>60 g/l</td>
<td>15.0</td>
<td>3.75</td>
<td>0.94</td>
<td>0.24</td>
<td>0.06</td>
<td>0.02</td>
</tr>
<tr>
<td>70 g/l</td>
<td>17.5</td>
<td>4.38</td>
<td>1.1</td>
<td>0.28</td>
<td>0.07</td>
<td>0.02</td>
</tr>
<tr>
<td>80 g/l</td>
<td>20.0</td>
<td>5.0</td>
<td>1.25</td>
<td>0.31</td>
<td>0.08</td>
<td>0.02</td>
</tr>
<tr>
<td>90 g/l</td>
<td>22.5</td>
<td>5.63</td>
<td>1.41</td>
<td>0.35</td>
<td>0.09</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Residual salt concentration g/l

Thus, for example, at a liquor ratio of 8:1, with an effective liquor interchange of 6:1, if the original concentration of salt = 90 g/l 3 rinses are required to reduce salt concentration to 0.35 g/l in the ensuing soaping bath.

Some dyers believe that ‘soaping’ agents are unnecessary, and that the best way to wash-off cotton yarn or fabric dyed with reactive dyes is to use ‘hot, soft water and plenty of it’. On machines operating at 20:1 or 30:1 liquor ratios this may be true, but in many modern dyehouses the dyer does not have the luxury of plenty of hot, soft water.

Effect of calcium and magnesium on ISO Cold Water fastness of reactive dye

This illustration shows the effect on wet fastness of calcium and magnesium ions deliberately added to the dyebath, or to a boiling wash-off bath.
The addition to the ‘soaping’ bath of a sequestering agent effective in complexing calcium and magnesium is therefore clearly valuable in ensuring that the hydrolysed reactive dye is removed.

Nearcel TMC, as recommended in cotton preparation, could be used to assist in the ‘soaping’ bath. Nearpon DKS has been especially developed for this application.

Not only is Nearpon DKS an effective sequestering agent for calcium, magnesium, and heavy metals, but it also has a protective colloid function and prevents redeposition of the dye once it has been removed.

Washing fastness stain on adjacent cotton after using Nearpon DKS in soaping bath as part of wash-off procedure
Aftertreatments to improve the fastness of various dyes on cellulosic fibres

The effectiveness of the early aftertreatments based on cationic surfactants depended on the formation of surfactant-dye complexes of reduced aqueous solubility and thus higher wet fastness. But the improved fastness related only to non-detergent agencies such as perspiration and water. In a soap-based washing process the interaction between anionic soap and the cationic agent was stronger than that between dye and cationic agent, the latter complex therefore tended to cleave, so that after one wash the fastness was back to that of the untreated dyeing. Aftertreatment processes of this type function by the same principle, by creating a larger molecular complex with reduced solubility and therefore a lower rate of desorption, and the polymeric, non-formaldehyde, cationic surfactants in use as fixing agents today share the same principle.

For example, Nearfix RTS, has been developed to improve the wet fastness of direct dyes on cotton, and to provide an insurance in the processing of reactive dyes to safeguard against any unfixed, hydrolysed dye residues remaining in the fabric after ‘soaping’.

Ref 1 V.Hornuff and H.Richter, H Faserforschung und Textiltechnik, 15 (1964) 115
Ref 2 C.Zerbe, Mineraloele und Verwandte Produkte (Berlin: Springer Verlag, 1952)
Dyeing of knitted polyester fabrics

Although acid- and basic-dyeable variants of polyester have been developed, the majority of PET fibres are dyed using disperse dyes. It is generally accepted that the mechanism of the aqueous phase transfer of disperse dyes is identical for all hydrophobic fibres.

Mechanism of the aqueous phase transfer of disperse dyes in a polyester dyeing

While the greater proportion of the disperse dye is in dispersion in the dyebath, a small amount of disperse dye forms an aqueous solution. Monomolecular dye is adsorbed on to the surface of the fibre from the aqueous dye solution situated at the fibre surface. As dye molecules diffuse, monomolecularly, from the surface to the interior of the fibre, dye particles from the bulk dispersion dissolve in the depleted aqueous dye solution, which is thus replenished with monomolecular dye that can be further adsorbed on to the fibre surface. This process continues until either the dyebath is exhausted of dye or the fibre is saturated with dye.

The precise molecular state of the dye in both the dyebath and in the PET fibre remains a matter of debate, some researchers arguing that the dye is monomolecularly distributed in a solid solution, some argue that although a proportion of the adsorbed dye is monodisperse, the remainder is present in the fibre as very small aggregates.

Whatever the case, it is clear that the action of dispersing agents in reducing the propensity to aggregation and agglomeration of the disperse dye in the dyebath, plays a very important role in achieving a well-penetrated, uniform dyeing. Certainly it can be shown that the aqueous solubility of disperse dye particles in a dispersion increases with decreasing particle size. In a typical dispersion comprising a distribution of particle sizes, the greater solubility of the small particles may cause the solution to become supersaturated with respect to the larger particles with the result that dye crystallisation occurs on the surface of the large particles. Such crystal growth will reduce solubility with the result that dye uptake falls.
Dispersing agents used in polyester dyebaths are mainly of the naphthalene sulphonic acid condensate (NSC) type, but this type of dispersing agent was obviously developed (1913) long before the advent of disperse dyes or of polyester. They were used with vat dyes at low temperatures.

Polyester fibres are dyed under pressure, at temperatures typically up to 140°C. It has been found that under such conditions many dye dispersions dispersed with NSC type dispersing agents, break down in one way or another. Frequently aggregation, agglomeration, crystallisation or crystal growth takes place with consequent detriment to the dyeing.

**Neargal DN** yields dispersions of dyes which are more stable at high temperatures, and which show a reduced tendency to undergo aggregation, agglomeration, crystallisation or crystal growth at the high temperatures encountered in dyeing polyester.

In many cases dispersions made with **Neargal DN** also prevent, hinder or reduce crystallisation of the dye as the dyebath is cooled.

Since problems with cyclic trimers of polyester, polyester oligomers, also result when such oligomers crystallise in the cooling high temperature dyebath, **Neargal DN** similarly prevents or reduces problems caused by the deposition of such oligomers.

An experiment was done with oligomer taken from a production dyeing machine. The oligomer was milled to a fine particle size and then equal portions were added to each of three baths.

Bath 1 acted as control and contained no agent.
Bath 2 with 2 g/l **Neargal DN**.
Bath 3 with 4 g/l **Neargal DN**.
All three baths containing oligomer were heated to 130°C, maintained at 130°C for 30 minutes, cooled to 70°C, then filtered.

Much less oligomer is deposited on the filter when the dyebath contains **Neargal DN**.
The exhaust application of disperse dyes, either to 100% polyester, or to polyester/cellulose blends, accounts for more than 60% of the total disperse dye consumption. The ability of *Neargal DN* to maintain a stable dispersion of disperse dye in the presence of high concentrations of electrolyte e.g. 80g/l sodium sulphate, is therefore significant. This property differentiates *Neargal DN* from many competitors’ dispersing agents, making it suitable for dyeing blends of polyester and cellulose in one-bath dyeing techniques.

**IDEAL FOR 1-BATH BLEND DYEING**

- Equally good for dispersion in electrolyte
- Ideal for one bath dyeing of blends
- Disperse/reactive or disperse/direct

Disperse/reactive dye filtration tests after taking liquor through conventional disperse dyeing cycle

80 g/l Glauber’s Salt
No agent

80 g/l Glauber’s Salt
1 g/l *Neargal DN*

80 g/l Glauber’s Salt
1 g/l Competitor A

Commercial disperse dyes commonly contain from 20 to 60% dispersing agent in their formulation. Comparison of dispersing agents used in the dyebath is therefore difficult because of interference from the dispersing agent already present in the dye. To compare dyebath dispersing agents *Nearchimica* use a disperse dye which was originally formulated for transfer printing and which contains very little dispersing agent in the dye itself.
**Levelness of the polyester dyeing**

Level dyeing requires uniform distribution of disperse dye over the entire surface of the polyester substrate. This depends on:

- Stability of the dye dispersion
- Solubility of the dyes
- Contacts between the liquor and substrate
- Dyeing temperature
- Diffusion rate of the dye into the fibre

For many years the philosophy of Nearchimica was that the best way to ensure a level dyeing was to select compatible combinations of disperse dyes. Selection of disperse dyes with similar molecular size, similar diffusion properties, and similar thermal fixation properties (A,B,C,D classification) primarily required a stable dispersion for optimum results.

Today competition may force the dyer to choose dyes on price grounds rather than compatibility. Today, therefore, an auxiliary product may, more than ever before, be required to assist with levelling incompatible dye combinations.

**Dispersing Properties**

The high temperature efficiency of the Nearchimica dispersing agent, **Neargal DN**, and the advantages in dispersion stability conferred as compared to competitors’ dispersing agents, is well known. **Neargal HP-MF NEW** has been developed to show at least equivalent high temperature dispersing properties but **Neargal HP-MF NEW** has additional migration and levelling properties.

**Effect of levelling agents on dye adsorption**

Non-ionic levelling agents increase the solubility of the dye thereby lowering the initial strike and overall rate of dye uptake. This can also cause a restraining effect that results in a loss of colour yield. Non-ionic levelling agents, whose effects are highly dye specific, can also have a deleterious effect on the stability of dye dispersions. The solubility of the agents decrease with increasing temperature and, if the temperature of the dyebath is raised above the cloud point of the agent, then the dye dispersion breaks down resulting in dye aggregation and an unlevel dyeing.

Although some non-ionic levelling agents of high cloud point do not cause dye aggregation, they can show a significant restraining action with some dyes. This may sometimes be useful, especially in strip and redye situations.

Anionic levelling agents, like **Neargal HP-MF NEW** and **Neargal SD-PE**, exhibit little if any restraining effect on dye uptake, but can induce dye migration. They increase the solubility of the dye and thus retard dye uptake having increased the affinity of the dye for the aqueous phase.

Use of **Neargal HP-MF NEW** results in a more uniform dye uptake even with incompatible dyes.

**Neargal HP-MF NEW also improves migration of disperse dyes on polyester fibre.**

Even with notoriously difficult dyes, migration is improved by **Neargal HP-MF NEW**. **In extreme cases, Neargal HP-MF NEW, can be used to strip and redye faulty batches**. **Neargal HP-MF NEW** has been found particularly effective in levelling different shades to one uniform shade.
Neargal HP-MF NEW reduces deposition of oligomers

As well as forming conspicuous white deposits on yarn, fabrics and machinery, oligomer may impair the spinning characteristics of yarns and reduce liquor flow during package dyeing. The presence of oligomer deposits in high temperature dyeing of polyester may cause nucleation and growth of dye crystals or agglomeration of dye particles. Because Neargal HP-MF NEW retains its dispersing power at high temperatures, it is effective in dispersing polyester cyclic trimer in the cooling dyebath, thereby reducing recrystallisation on the fibre and on the walls of the dyeing vessel.
Preparation, dyeing and finishing of polyester, and especially polyester microfibres
Introduction

Fabric construction based on microfilament synthetic yarns are commonly referred to as:

MICROFIBRES in Europe and the USA
and SHIN GOSEN in Japan (meaning New Generation synthetics)

Fabrics from these sources use a combination of:

- conventional, fine and/or superfine filaments
- filaments of widely differing shrinkage characteristics
- very high and low twist yarns
- textured, air-textured and flat filament yarns
- variations in cross-sectional shape

to produce a very wide range of high density materials which have novel characteristics and properties which demand very specialised processing.

Effect fabrics available to date include:

- imitation silks
- peach skins
- suedes (light to heavyweight)
- air and moisture permeable waterproof fabrics
- staple blends and yarn mixtures with viscose, cotton and wool.

Popular outlets for these rapidly growing effect fabrics include:

- apparel    by virtue of very soft, silk-like handle
- sportswear and improved moisture absorbency
- leisurewear wicking and evaporation given by microfibres
- furnishings & upholstery fabrics
- lens wipes
Microfibre Definition

The fineness of a synthetic yarn is usually described in ‘decitex’ or ‘denier’.

- Decitex = the weight in grammes of 10,000 metres of yarn
- Denier = the weight in grammes of 9,000 metres of yarn

Hence a 167 decitex yarn can also be described as a 150 denier yarn.

NOTE – for simplicity, only the decitex description will be used here.

Decitex per filament (dtexpf)

Is described as the decitex of a yarn divided by the number of filaments within the yarn.

\[ \frac{1}{167} \text{ f200 yarn} \]

Thus this yarn has \( dtexpf = \frac{167}{200} = 0.835 \)

A “Microfibre” is widely described as a yarn which contains filaments of less than 1 decitex per filament.

- 2.0 - 6.0 dtexpf: Conventional filament
- 1.2 - 1.6 dtexpf: Weight reduced polyester silk
- 0.3 - 0.99 dtexpf: Microfibre
- < 0.5 dtexpf: Super Micro
Microfibre Production Methods

(1) CONJUGATE TECHNOLOGY
Developed by Kanebo Ltd. of Japan and involves spinning of bicomponent filaments comprising of a nylon 6 matrix with polyester fibrilles. Following the spinning and weaving stages, the fabric is subjected to a solvent swelling treatment. The poor cohesion in solvent of the polyester fibrilles and the nylon matrix causes the individual wedge-shaped polyester segments to move outwards. Each polyester segment then acts as an individual super-microfibre filament.

OTHER CONJUGATE DEVELOPMENTS

TORAY
solvent or alkali swelling

KURARAY
Solvent or alkali swelling

TEIJIN
mechanical brush/crush
Microfibre Production Methods

(2) SEA ISLAND TECHNOLOGY
Developed by TORAY INDUSTRIES of Japan and involves the spinning of ‘islands’ of polyester in a ‘sea’ of polystyrene. Following the spinning and weaving stages, the polystyrene is dissolved out using chlorinated hydrocarbon solvents to leave polyester super-microfibre filaments.

(3) DIRECT MELT SPINNING
Single component filaments are extruded through spinnerettes. Using conventional melt spinning technology, it is possible to produce microfibres down to 0.4 dtexpf. Developments by ASAHI KASEI and UNITIKA of Japan have enabled spun fibrils of 0.1 dtexpf to be produced.
The greater surface area of microfibres requires a greater addition of lubricants in spinning etc. These lubricants must be removed in pretreatment.

The very high surface area associated with closely packed microfibre filaments means that a greater proportion of incident light is reflected when compared with larger diameter filaments.

This results in a visually lighter appearance and necessitates higher percentages of dye needing to be applied to achieve the same relative visual strength as on coarser fabrics.

**More dye is required for any given shade – wet fastness will be lower on microfibres than on conventional fibres in the same shade.**
Microfibre Effects

The key effects achievable with Microfibres can be categorised as general and specific effects.

**General Effects**
- Softness from the low profile effect of the fibres.
- Absorbency from the capillary action of fine fibres.
- Dimensional stability like normal polyester *but unlike cotton*.

As 100% Polyester: compared to regular polyester
- Enhanced softness and absorbency.

As Microfibre in polyester/cotton; compared to regular polyester/cotton
- Greater durability and softness.
- Use of less cotton for the same absorbency.

**Special Effects**
- More rapid cooling through moisture transport.
- Excellent anti-creasing and stability properties.
- Special surface effects, such as peach or suedeing.
- Special feel like “Micropowder” or “Moist Touch”.
- Water Barrier effects while permeable to vapour.

These effects lead to:
- Improved comfort and desirability.
- Texture effects that are durable and dimensionally stable.
Whilst many of the recommendations for wet processing of microfibres will vary depending upon components, construction and end use, there are important factors in each of the three stages of wet processing, preparation, dyeing and finishing, which apply generally to microfibre-based fabrics.
# Microfibre Processing Flow Chart

## Lightweight Silks & Rayons

<table>
<thead>
<tr>
<th>MOST WIDELY USED</th>
<th>ALTERNATIVES</th>
<th>MOST WIDELY USED</th>
<th>ALTERNATIVES</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) DESIZE</td>
<td>EITHER</td>
<td>(ii) DESIZE</td>
<td>EITHER</td>
</tr>
<tr>
<td>(ii) SCOUR/RELAX</td>
<td></td>
<td>(iii) SCOUR/RELAX</td>
<td></td>
</tr>
<tr>
<td>(iii) PRESET</td>
<td></td>
<td>(iv) PRESET</td>
<td></td>
</tr>
<tr>
<td>(iv) CAUSTIC SODA</td>
<td></td>
<td>(v) CAUSTIC SODA</td>
<td></td>
</tr>
<tr>
<td>(v) WEIGHT REDUCE</td>
<td></td>
<td>(vi) WEIGHT REDUCE</td>
<td></td>
</tr>
<tr>
<td>(vii) DYE</td>
<td></td>
<td>(viii) DYE</td>
<td></td>
</tr>
<tr>
<td>(ix) DRY AND MILD</td>
<td></td>
<td>(x) DRY AND MILD</td>
<td></td>
</tr>
<tr>
<td>(xi) POST-STENTER</td>
<td></td>
<td>(xii) POST-STENTER</td>
<td></td>
</tr>
</tbody>
</table>

- **Alternatives**
  - **EITHER**
  - **OR**
  - **OR**
  - **OR**

### Process Stages

- **Lightweight Silks & Rayons**
  - Stages (i) and (ii) are reversed. This gives rise to fixing of fibre processing aids into fabrics which are subsequently difficult to remove.
  - Pre-setting at stage (ii) is omitted and incorporated into stage (v). This causes the fabric to stiffen with a resultant loss in silk-like aesthetics.

### Breathable/Moisture Permeable Waterproofed Effects

- Fluorocarbon Finish
- Polyurethane microporous coating

## Peach Skins & Suedes

<table>
<thead>
<tr>
<th>MOST WIDELY USED</th>
<th>ALTERNATIVES</th>
<th>MOST WIDELY USED</th>
<th>ALTERNATIVES</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) DESIZE</td>
<td>EITHER</td>
<td>(ii) DESIZE</td>
<td>EITHER</td>
</tr>
<tr>
<td>(ii) SCOUR/RELAX</td>
<td></td>
<td>(iii) SCOUR/RELAX</td>
<td></td>
</tr>
<tr>
<td>(iii) PRESET</td>
<td></td>
<td>(iv) PRESET</td>
<td></td>
</tr>
<tr>
<td>(iv) CAUSTIC SODA</td>
<td></td>
<td>(v) CAUSTIC SODA</td>
<td></td>
</tr>
<tr>
<td>(v) WEIGHT REDUCE</td>
<td></td>
<td>(vi) WEIGHT REDUCE</td>
<td></td>
</tr>
<tr>
<td>(vi) DYE</td>
<td></td>
<td>(vii) DYE</td>
<td></td>
</tr>
<tr>
<td>(vii) DRY</td>
<td></td>
<td>(viii) DRY</td>
<td></td>
</tr>
<tr>
<td>(viii) EMERISE</td>
<td></td>
<td>(ix) EMERISE</td>
<td></td>
</tr>
<tr>
<td>(ix) POST-SET</td>
<td></td>
<td>(x) POST-SET</td>
<td></td>
</tr>
<tr>
<td>(x) DYE</td>
<td></td>
<td>(xi) DYE</td>
<td></td>
</tr>
<tr>
<td>(xi) DRY, STENTER</td>
<td></td>
<td>(xii) DRY, STENTER</td>
<td></td>
</tr>
</tbody>
</table>

- **Alternatives**
  - **EITHER**
  - **OR**
  - **OR**

### Process Stages

- Stages (i) and (ii) are reversed. This gives rise to fixing of fibre processing aids into fabrics which are subsequently difficult to remove.
- Pre-setting at stage (ii) is omitted and incorporated into stage (v). This causes the fabric to stiffen with a resultant loss in silk-like aesthetics.

### Breathable/Moisture Permeable Waterproofed Effects

- Fluorocarbon Finish
- Polyurethane microporous coating

### Other Notes

- Emerising can be done after dyeing process but this may give rise to shade change problems.
- Emerising can be done on greige fabric but this can cause problems with residual processing aids in subsequent dyeing.
- Some of the alkali-splittable PES/PA conjugates are subjected to continuous pad-steam weight reduction which also acts to separate filaments.
Preparation

**DESIZE SCOUR/RELAX**

Woven polyester fabrics will often contain very high twist, high shrinkage yarns incorporated into the fabric. Microfibre based fabrics have a high bulk density and a particularly large surface area.

An efficient preparation stage thus becomes vital to:

- optimise removal of fibre processing aids
- whilst minimising creasing and maintaining the desired aesthetics

(i) **Optimising removal of processing aids**

As well as acrylate or polyester-based sizes, large amounts of oils and waxes are frequently applied to aid fibre processing and help protect delicate polyester microfibre fibrilles. Because of the very large surface area of microfibre-based fabrics, 2 to 5 times more fibre processing aids must be applied compared with conventional polyester based fabrics.

To avoid problems with levelling and coverage of the disperse dyes applied in dyeing, the size and fibre processing aids must be efficiently removed.

(ii) **minimising creasing and maintaining desired aesthetics**

Relaxation of the fabric must be under minimum tension to allow the controlled shrinkage during scouring.

Creasing and ‘crows feet marks’ will result if insufficient care is taken at this stage.

Shrinkage relaxation of microfibres starts at lower temperatures than conventional polyester filaments.

**SUMMARY**

- Controlled shrinkage under relaxed conditions is vital during preparation.
- Shrinkage commences at lower wet processing temperatures when fabrics contain microfibres.
- Microfibre containing fabrics have a much higher loading of fibre processing aids (sizes, waxes, oils).
- Waxes have a high melting point – inefficient removal in preparation can cause spots in dyeing.
- Fibre processing aids must be identified so removal can be optimised.
Preparation

(iii) Size identification
To establish whether the size used on woven polyester is polyester or polyacrylate based:

- Dip sample of unprepared fabric in solution of 0.5% C.I. Basic Red 22 (e.g. Astrazone Red F3BL).
- Wet out thoroughly
- Take out fabric and leave for 10 seconds in air
- Rinse in cold water

![Diagram showing dip and rinse procedure]

Light to dark red colour indicates presence of
- Polyacrylate size
- Polyester size
- Polyvinyl acetate size

Wash stained fabric in dichloromethane
- If stain is removed
  - Size is polyester based

Wash stained fabric in methanol
- If stain is removed
  - Size is polyacrylate based

(iv) Removal of size, oils and waxes
In addition to the removal of waxes and oils present on the fabric, the preparation conditions must be adapted to optimise removal of the particular size (identified as above).

The type of size present determines the pH of the preparation bath:
- POLYESTER SIZE – usually pH 7 – 9 (with ± 0.2 g/l soda ash)
- POLYACRYLATE SIZE – pH 10 – 11 (with ± 3 g/l soda ash or NaOH)
Preparation

(v) Machinery and methods

The different process routes listed below decrease in their efficiency from A to D in terms of efficiency of removal of sizes, oils and waxes, as well as tensionless relaxation in preventing creasing and achieving the desired aesthetics.

**DECREASING EFFICIENCY**

<table>
<thead>
<tr>
<th>OPTION A</th>
<th>OPTION B</th>
<th>OPTION C</th>
<th>OPTION D</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAD</td>
<td>PAD</td>
<td>CONTINUOUS SCOUR/RELAX</td>
<td>JET SCOUR/RELAX</td>
</tr>
<tr>
<td>STENTER FIX</td>
<td>BATCH 3–12 HRS</td>
<td>EXTRA JET SCOUR</td>
<td>JET DYE</td>
</tr>
<tr>
<td>CONTINUOUS SCOUR/RELAX</td>
<td>CONTINUOUS SCOUR/RELAX</td>
<td>JET DYE</td>
<td>JET DYE</td>
</tr>
<tr>
<td>JET DYE</td>
<td>EXTRA JET SCOUR</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In Option A, 20 – 40 g/l Naistat 1350 can be applied by padding to take advantage of the excellent soil release properties conferred.

OR if a pre-setting route is unacceptable or not practicable, NAISTAT 1350 can be introduced to the first box in a continuous open width scour/relax unit.

For optimum results the first box should be at 80 – 85° C.
Problems with oligomer in dyeing polyester yarns and fabrics.

Typically polyester fibres contain between 1.5 and 3.5% by mass of low $M_r$ esters, the principal oligomer being cyclic tris(ethylene terephthalate) with smaller quantities of a dimer, pentamer as well as traces of other compounds.

Problems caused by oligomer deposits

- Spinning characteristics impaired
- Reduced liquor flow through package of yarn because spindle perforations become blocked, and deposits on pump cause improper pump pressure.
- Presence can cause nucleation and growth of dye crystals or agglomeration of dye particles and hence dye spots, unlevelness, and poor fastness.
- Deposits on machine guides at winding or twisting cause high tensions and increased friction on the yarn, leading to poor package build and end breaks.
- White powdery deposits cause dulling of the yarn/fabric especially in dark shades, black, navy etc.
- Variation in rate of temperature rise due to deposits on heat exchanger
- More frequent cleaning of dyeing and winding machines needed, hence increased down-time and lower efficiency.

In some markets we have recently seen evidence of rather higher concentrations of oligomer, particularly in yarn processing where the deposition of crystalline oligomers as a white powder on the fibre surface and on the mechanism of winding machinery causes problems.
Oligomers

Cyclic trimers migrate from PET fibre during dyeing and steam setting and, to a lesser extent, during dry heat setting. The amount of oligomer migrating to the fibre surface increases with increase in temperature, and with prolonged dyeing time, therefore the liberation of oligomers during dyeing can be minimised by lowering the dyeing temperature from $130^\circ$ to $120^\circ$ C and by using the shortest possible dyeing time.

We have found that there is no simple, one-step solution to the problem of oligomer deposits, but rather that a series of precautions can help

1. Preparation.
Often polyester yarn and fabric may be dyed with no preparation at all. However, when problems with oligomer deposits are being experienced we have found that a scouring treatment before dyeing can remove some oligomers from the outset.

Customers routinely preparing woven polyester fabric on an open width washing range, mainly to remove size, have noted also a marked reduction in oligomers present after scouring with a Nearchimica recipe.

Solvent extractions from polyester fabrics before and after scouring show the reduction in oligomer content after scouring with Nearpon TKR, Naistat 1350 and Nearchel TMC.

The table shows results from production on a Babcock washing range

<table>
<thead>
<tr>
<th>Fabric</th>
<th>Pet Ether extract</th>
<th>Methyl Ethyl Ketone extract</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% polyester</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 greige</td>
<td>0.85% ester lubricant</td>
<td>0.8% PES oligomer &amp; size</td>
<td>1.65%</td>
</tr>
<tr>
<td>1 scoured</td>
<td>0.2 %</td>
<td>0.35%</td>
<td>0.55%</td>
</tr>
<tr>
<td>2 greige</td>
<td>0.8% ester lubricant</td>
<td>1.2% PES oligomer &amp; size</td>
<td>2.0%</td>
</tr>
<tr>
<td>2 scoured</td>
<td>0.2 %</td>
<td>0.6%</td>
<td>0.8%</td>
</tr>
<tr>
<td>3 greige</td>
<td>0.75% ester lubricant</td>
<td>1.35% PES oligomer &amp; size</td>
<td>2.1%</td>
</tr>
<tr>
<td>3 scoured</td>
<td>0.3%</td>
<td>0.6%</td>
<td>0.9%</td>
</tr>
<tr>
<td>4 greige</td>
<td>0.95% fatty acid esters</td>
<td>0.85% PES oligomers</td>
<td>1.8%</td>
</tr>
<tr>
<td>4 scoured</td>
<td>0.25%</td>
<td>0.3 % includes surfactant</td>
<td>0.55%</td>
</tr>
<tr>
<td>5 greige</td>
<td>0.15% ester lubricant</td>
<td>1.15% PES oligomers</td>
<td>1.3%</td>
</tr>
<tr>
<td>5 scoured</td>
<td>zero</td>
<td>0.45% includes surfactant</td>
<td>0.45%</td>
</tr>
<tr>
<td>6 greige</td>
<td>0.1% synthetic esters</td>
<td>0.35% PES oligomers</td>
<td>0.45%</td>
</tr>
<tr>
<td>6 scoured</td>
<td>Zero</td>
<td>0.15%</td>
<td>0.15%</td>
</tr>
<tr>
<td>7 greige</td>
<td>0.9% esters &amp; silicone</td>
<td>0.67% oligomers &amp; acrylic</td>
<td>1.57%</td>
</tr>
<tr>
<td>7 scoured</td>
<td>0.06%</td>
<td>0.13% only trace acrylic size</td>
<td>0.19%</td>
</tr>
<tr>
<td>8 greige</td>
<td>0.8% natural esters</td>
<td>0.8% Polyester size &amp; olig</td>
<td>1.6%</td>
</tr>
<tr>
<td>8 scoured</td>
<td>0.08 %</td>
<td>0.26% size absent</td>
<td>0.34%</td>
</tr>
</tbody>
</table>
Oligomers - Preparation

Box 1
2 kg Nearpon TKR at 70°C

Box 2 & 3
8 kg Nearpon TKR
2 kg Naistat 1350
2 kg Nearchel TMC
20 litres Na₂CO₃ 1:20 solution at 90°C

Box 4 & 5
water only at 90°C
Speed 60 metres/min

Choice of detergent in the desize scour/relax can determine the extent to which the size, oil and waxes that are removed can redeposit onto the polyester fabric. This often results in dye spots and stains, or in a generally ‘cloudy’ appearance in dyeing. NEARPON TKR and NAISTAT 1350 give excellent removal of oligomer, size, oils and waxes and prevent redeposition.

Reduced concentrations of oligomer are also seen after batchwise scouring with a similar recipe:

Nearpon TKR 1g/l
Nearchel TMC 1g/l
Naistat 1350 3g/l

90°C for 20 minutes.
Rinse

(NAISTAT 1350 also makes the fabric sink instead of floating on the liquor surface, ensuring better running properties, and more level dyeing)
Untreated polyester yarn

After scouring it can clearly be seen that oligomer has migrated to the surface of the yarn.
Oligomers - Dyeing

We have found that after dyeing at 130°C much more oligomer is brought to the surface.

**High temperature dyeing with Neargal DN in the bath to disperse oligomers.**
Cyclic tris(ethylene terephthalate) is insoluble in water. Solubility is increased in the presence of carriers, particularly of the methyl salicylate, alkyl phthalate and benzyl benzoate types, and such compounds, present in some levelling agents, like Neargal HP-MF NEW, promote migration of the trimer to the surface of the fibre. But a dispersing agent should be present to try to prevent crystallisation and deposition of the oligomers. The longer the dyeing time the more oligomers will be released. Dark shades may produce more oligomer than paler shades because the dyeing time is longer.

**Neargal DN** is a dispersing agent which is very stable to high temperatures.

Many competitors’ dispersing agents are NOT stable to high temperature. Thus, when oligomers are released from the polyester fibre, after some time at 130°C, there will not be an efficient dispersing agent in the bath to prevent crystallization of the oligomers, and to prevent small particles of oligomers coming together to form larger agglomerates, and depositing on the yarn and the machine.

**Neargal DN** does not magically remove the oligomers., but it will maintain the oligomers in a fine dispersion so that when the machine is drained more oligomer goes down the drain.

Discharging the dyebath at high temperature, if this is possible, can also reduce oligomer deposition.

We recommend the following recipe in the dyebath:

Dyeing

**Neargal DN** 0.5 to 2g/l (with serious oligomer problems – try 2 g/l)
**Neargal HPMF New** 1g/l
**Nearchel TMC** 1g/l

pH buffer
130°C for 30 minutes

If we examine yarn under the scanning electron microscope after dyeing, we see that much more oligomer has been brought to the surface.

Now we recommend that a further dispersing agent is used during reduction clearing of the polyester yarn.
Oligomers – Reduction clearing

**Nearpon TO** is a combination of non-ionic and anionic dispersing agents which helps to remove more oligomers during the reduction clear process.

Sodium hydrosulphite reacts too quickly at 90° C, and the reducing power will be lost very quickly. **Riducente FBT** reacts more slowly at higher reduction clear temperatures, so that the clearing bath retains its reducing power for a longer time.

We recommend to reduction clear as follows:

Reduction clear  
caustic soda 36° Bé liquid \(5\)g/l  
**Riducente FBT** \(5\)g/l  
**Nearpon TO** \(2\)g/l  
90°C per 15 - 20 minutes  
2 rinses

---

**Oligomers – last rinse**

Application of an oligomer-binding agent to polyester yarn in the last rinse on the dyeing machine can reduce the build-up of white powder deposits on the winding machine mechanism with polyester containing high concentrations of oligomer.

We have recently done trials with Naistat 11009 and we see less build-up of white oligomer powder on the winding machinery.

Rinse in:

**Naistat 11009** \(1\) g/l  
This may be combined with the softener, lubricant or anti-static agent normally applied.
Neargal SD-PE - Levelling agent for polyester

- 0.5% C.I. Disperse Yellow 64
- 0.5% C.I. Disperse Blue 56
- 1 ml/l acetic acid

Original dyeing | Undyed polyester

Treated together at 130° C without levelling agent

Treated together at 130° C with 2 g/l Competition 1

Treated together at 130° C with 2 g/l Neargal SD-PE
Neargal SD-PE - Levelling agent for polyester

0.25% C.I. Disperse Yellow 64
0.25% C.I. Disperse Blue 56
1 ml/l acetic acid

Treated together at 130° C without levelling agent

Treated together at 130° C with 1 g/l Competition 2

Treated together at 130° C with 1 g/l Neargal SD-PE

Treated together at 130° C with 2 g/l Competition 2

Treated together at 130° C with 2 g/l Neargal SD-PE
0.25% C.I. Disperse Yellow 64
0.25% C.I. Disperse Blue 56
1 ml/l acetic acid

Treated together at 130° C with 1 g/l Competition 3

Treated together at 130° C with 0.7 g/l Neargal SD-PE

Treated together at 130° C with 0.8 g/l Neargal TDN

Treated together at 130° C with 1 g/l Competition 4

Treated together at 130° C with 1 g/l Competition 5
Fluorescent Whitening Agents for Polyester
Polyester fibres are treated with a spin finish which is usually a mixture of hydrocarbon oils, fatty acids, fatty esters and emulsifier. Woven polyester fabrics are often sized with acrylic or polyester size. Knitted fabrics will contain knitting oils and wax. The problem with preparation of all polyester fabrics is to prevent redeposition of impurities onto the very hydrophobic fibre.

Nearpon TKR is a special detergent developed specifically to remove oils, sizes and particulate soil, and avoid redeposition of the soil onto polyester. Use of Naistat 1350 in the scour makes polyester more hydrophilic and further helps to avoid redeposition of the soil and thus increases the whiteness of polyester-containing fabrics.

Usually, polyester fibres have very little inherent colour as supplied, and fibres to be optically whitened may only require a brief alkaline scour, but if a very high degree of whiteness is required the fibre can be chemically bleached with sodium chlorite. Polyester and polyester-cotton blends are often whitened by a pad-Thermosol process on the finishing stenter.
Suggested recipes - polyester

**Exhaust process**

*Nearoptic P-RG, Nearoptic P-RN* and *Nearoptic PSF* can be applied by the exhaust process from acid, neutral or alkaline baths as well as in the sodium chlorite and hydrogen peroxide bleach. *(Near optic PBN is a tinted product to give a more bluish shade, while Near optic PNV is a tinted product with a violet shade.)*

<table>
<thead>
<tr>
<th>Without chlorite</th>
<th>In the chlorite bleach</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3 – 0.6</td>
<td>0.3 - 0.6 % <em>Nearoptic P-RG, Nearoptic PRN</em> or <em>Nearoptic PSF</em></td>
</tr>
<tr>
<td>0.3 – 2.0</td>
<td>0.3 – 2.0 % <em>Nearoptic PSF</em></td>
</tr>
<tr>
<td>—</td>
<td>1 - 2 g/l <em>sodium chlorite 80 %</em></td>
</tr>
<tr>
<td>—</td>
<td>0.5 - 1 g/l <em>Nearstabil CL</em> (buffering salt)</td>
</tr>
<tr>
<td>—</td>
<td>1 - 3 g/l <em>sodium nitrate</em></td>
</tr>
<tr>
<td>0.5 - 2.0</td>
<td>0.5 - 2.0 g/l <em>Neargal HT</em></td>
</tr>
<tr>
<td>y</td>
<td>1 - 2 ml/l <em>formic acid 85 %</em></td>
</tr>
<tr>
<td>pH 5 – 7</td>
<td>pH 3 – 4</td>
</tr>
</tbody>
</table>

Liquor ratio 10 : 1 - 20 : 1

Heat-up time 30 - 40 min. Treat for 30 – 60 mins at 130° - 110° C.
The goods can be treated with suitable softening agents in the final rinse bath.

*Nearoptic P-RN, Nearoptic PBN* and *Nearoptic PSF* can also be applied continuously by the pad-bake process and pad-steam systems suitable for printing and bleaching.

**Continuous process**

**Pad-bake process**

5 - 10 g/l *Nearoptic P-RN, Nearoptic PBN* or *Nearoptic PSF*
1 – 3 g/l *Nearclear VL*
0.5 - 1 g/l *Nearfil FT-BS* padding liquor pick-up 40 - 80 %

Drying, followed by baking/developing 35 - 20 s at 185-210° C for P-RN, 180-210° C for PSF, 170 – 190° C for *Nearoptic PBN and Nearoptic PNV*

For articles like polyester net curtain fabrics, padding can be carried out with suitable soft handle, anti-static and non-slip finishing agents, such as *Nearsopht NI, Naistat 1350 and Noslip B.*
Finishing

Disperse dye on surface lowering wet fastness

Selecting an inappropriate softener can make fastness worse.

Dyed polyester

HEAT

softener

On 100% polyester drying is rapid and quantity of emulsifier distributed over whole fibre is limited

On polyester/cotton drying is slower because fabric is wetter. During longer drying process water migrates from wet cotton to dry polyester carrying with it emulsifier which is deposited on the polyester component

1. Emulsifier film with dissolved disperse dyes 100% polyester
2. Emulsifier film with dissolved disperse dyes PES/CO 67/33
3. Emulsifier film with dissolved disperse dyes PES/CO 50/50
Effect of softener on polyester/elastane
Washing fastness at 60° C (UNI EN ISO C06)

Heat set at 190° C for 60 seconds
Dyeing at 120° C for 45 minutes
3% Nearsper Black SR pdr
1% Neargal HP-MF New
1% Neargal DN
3% Neargal ER

Reduction Clear at 85° C for 30 minutes
3 g/l Nearclear PLY
3 g/l Riducente FBT
3 g/l caustic soda 36° Bé
Polyester / cellulose Production Methods

**Lubrifil LAF**

- Lubrifil LAF makes possible one-bath dyeing methods for polyester-cellulose.
- Polyester dyebath may be combined with polyester acid scour.
- Polyester disperse dyebath may be combined with cellulose reactive dyebath (“New Select” process)
Customer may be using a process with Alkaline Scour, 2 bath dye, Rinse, Fix

**Graph:**
- **Y-axis:** Temperature (°C)
- **X-axis:** Time in Minutes
- **Legend:**
  - Alkaline Scour or Bleach
  - 2 Bath Process – dye polyester, reduction clear – dye cotton
  - Rinsing & Soaping process for Reactive dyes

**Total dyeing time:**
- Minimum 9 hours 40 minutes
Customer's current process
Alkaline scour at boil. Dye polyester. Reduction Clear
Dye Cotton in 2nd bath. 2 hot rinses, boiling 'soap'.
Cationic fixing agent

<table>
<thead>
<tr>
<th>Customer’s process</th>
<th>Cost</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour</td>
<td>£36.27</td>
<td>14%</td>
</tr>
<tr>
<td>Effluent</td>
<td>£9.35</td>
<td>4%</td>
</tr>
<tr>
<td>Water</td>
<td>£22.21</td>
<td>8%</td>
</tr>
<tr>
<td>Steam</td>
<td>£30.34</td>
<td>12%</td>
</tr>
<tr>
<td>Dyes</td>
<td>£100.00</td>
<td>38%</td>
</tr>
<tr>
<td>Chemicals</td>
<td>£56.31</td>
<td>22%</td>
</tr>
<tr>
<td>Electricity</td>
<td>£7.17</td>
<td>3%</td>
</tr>
</tbody>
</table>

Process time, mins = 580

Batches per week = 11
Nearchimica Option 1 –
Combine Scour and Polyester Dye in one bath.
Dye Cotton.
Rinse and Fix

Combine Polyester scour and dye
Dye cotton with Reactive dyes – Isothermal process
Rinsing & Soaping of reactive dyes

Total dyeing time
minimum 7 hours 57 minutes
### Comparison of Process costs

<table>
<thead>
<tr>
<th></th>
<th>Customer’s process</th>
<th>Combine Scour &amp; PES Dye</th>
<th>SAVINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour</td>
<td>£36.27</td>
<td>£29.16</td>
<td>20%</td>
</tr>
<tr>
<td>Effluent</td>
<td>£9.35</td>
<td>£3.68</td>
<td>61%</td>
</tr>
<tr>
<td>Water</td>
<td>£22.21</td>
<td>£8.78</td>
<td>60%</td>
</tr>
<tr>
<td>Steam</td>
<td>£30.34</td>
<td>£18.43</td>
<td>39%</td>
</tr>
<tr>
<td>Dyes</td>
<td>£100.00</td>
<td>£100.00</td>
<td>0%</td>
</tr>
<tr>
<td>Chemicals</td>
<td>£56.31</td>
<td>£55.70</td>
<td>1%</td>
</tr>
<tr>
<td>Electricity</td>
<td>£7.17</td>
<td>£5.83</td>
<td>19%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TIME (mins)</th>
<th>BATCHES/week</th>
</tr>
</thead>
<tbody>
<tr>
<td>580</td>
<td>11</td>
</tr>
<tr>
<td>477</td>
<td>14</td>
</tr>
</tbody>
</table>

Combined Scour & PES Dye provides a 18% reduction in time.
MARGIN generated per Machine per week

Combine Scour & PES Dye
- Batches/week: 14
- Profit per week: £3,403

Customer’s 2 bath process
- Batches/week: 11
- Profit per week: £2,233

EXTRA
£ 1,170 Profit per week
Nearchimica Option 2 – 
Alkaline scour.
Dye Polyester and cotton in one-bath "New Select". 
Rinse, 'Soap', apply cationic fix.

**Total dyeing time**
**minimum 8 hours 21 minutes**
## Comparison of Process costs

<table>
<thead>
<tr>
<th></th>
<th>DEFAULT</th>
<th>&quot;New Select&quot; one-bath</th>
<th>SAVINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour</td>
<td>£36.27</td>
<td>£30.70</td>
<td>15%</td>
</tr>
<tr>
<td>Effluent</td>
<td>£9.35</td>
<td>£8.73</td>
<td>7%</td>
</tr>
<tr>
<td>Water</td>
<td>£22.21</td>
<td>£19.72</td>
<td>11%</td>
</tr>
<tr>
<td>Steam</td>
<td>£30.34</td>
<td>£28.21</td>
<td>7%</td>
</tr>
<tr>
<td>Dyes</td>
<td>£100.00</td>
<td>£100.00</td>
<td>0%</td>
</tr>
<tr>
<td>Chemicals</td>
<td>£56.31</td>
<td>£61.71</td>
<td>-10%</td>
</tr>
<tr>
<td>Electricity</td>
<td>£7.17</td>
<td>£6.02</td>
<td>16%</td>
</tr>
</tbody>
</table>

### Time (mins)

- DEFAULT: 580
- "New Select" one-bath: 501

### Batches/week

- DEFAULT: 11
- "New Select" one-bath: 13
MARGIN generated per Machine per week

"New Select" one-bath

Customer’s conventional process

<table>
<thead>
<tr>
<th>Process Type</th>
<th>Batches/week</th>
<th>Margin (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;New Select&quot; one-bath</td>
<td>13</td>
<td>£2,724</td>
</tr>
<tr>
<td>Customer’s conventional process</td>
<td>11</td>
<td>£2,233</td>
</tr>
</tbody>
</table>

EXTRA £491 profit