Innovative Approaches for Polyamide Dyeing and Finishing

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Introduction

Polyamide is the first commercially successful synthetic polymer. It is a condensation co-polymer formed by reacting diamine and dicarboxylic acid. Polyamide is produced by melt spinning and available in staple, tow, monofilament, and multi-filament form.

The fibre has outstanding durability and excellent physical properties. The amide group forms hydrogen bonding between polyamide chains, imparting high strength at elevated temperatures. The features of polyamide fabric are: good strength, compact molecular structure, resistance to sunlight, softer hand, higher melting point, excellent abrasion resistance, elastic and creases/pleats can be heat-set at higher temperatures.

Polyamide fibres are used in manufacture of stockings, sport garments, undergarments parachutes and in the automobile industry.

Table 1: pH of Acidon PA at various temperatures (Initial pH 7.0)

Concentration	pH										
	Initial	40°C	50°C	60°C	70°C	80°C	90°C	90°C for 15min	90°C for 30min	90°C for 45min	90°C for 60min
0.1g/l Acidon PA	6.86	6.27	5.88	5.17	5.12	4.31	3.89	3.63	3.53	3.49	3.45
0.2g/l Acidon PA	6.71	5.93	5.22	4.38	4.35	3.83	3.45	3.37	3.3	3.27	3.22
0.25g/l Acidon PA	6.15	5.18	4.07	3.9	3.49	3.02	3.01	3	2.95	2.91	2.89

Dyeing of Polyamide

Dyeing efficiency of polyamide fibre is enhanced due to the presence of -COOH and -NH2 groups. Dye diffusion into the fibre depends on the rate of dyeing and the migration of the dye. Polyamide substrates are conventionally dyed with acid dyes, which are anionic in nature. At temperatures higher than glass-transition temperature the fibre matrix opens up, enabling negatively charged acid dyes to be attracted towards positive sites in the fibre and form an electrovalent bond.

In general, acid dyes have high affinity for protonated polyamide fabric, thereby it rushes and binds to the substrate, resulting in poor diffusion of dye. The high strike rate of dyes prevents even diffusion into polyamide and produces an uneven shade.

Polyamide substrates are dyed with acid dyes under carefully controlled conditions by which the rate of dye absorption is uniform. In particular, the temperature and the pH of the bath are usually monitored and regulated by constant pH process using a buffer or sliding pH system.

In the case of a sliding pH system for dyeing polyamides with acid dyes, the polyamide substrate is entered in a dye bath initially containing an acid dye, a levelling agent and an acid donor sufficient for dye exhaustion. When the dye-bath temperature is increased the pH gradually reduces and allows dye diffusion slowly into the substrate. The slow diffusion of dyes in such a system ensures uniform and reproducible shade, as against the rushing of dyes in a conventional system.

Sarex has developed a new-generation acid donor and dye-fixing agent – namely Acidon PA and Nylofix 993.

Acidon PA: A novel acid donor, based on the sliding pH principle. Acidic pH is achieved with increase in temperature, unlike a conventional buffer, which maintains pH irrespective of temperature.

Unique Features of Acidon PA

- Sliding pH system: pH decreases from alkaline/neutral bath to acidic pH with increase in temperature
- Controlled dye-bath exhaustion
- Applicable in soft flow/jet dyeing machine

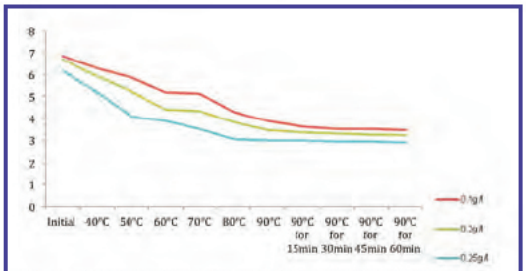


Fig. 1: Graphical representation of pH of Acidon PA at various temperatures (initial pH -7.0)

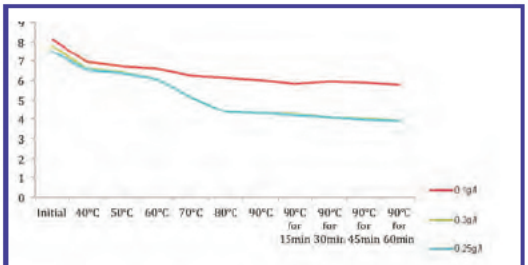


Fig. 2: Graphical representation of pH of Acidon PA at various temperatures (initial pH -8.5)

Experimental Methods Acidon PA

- pH of distilled maintained at 7.0+ 0.2 and 8.5 +0.2
- Concentrations of Acidon PA = 0.1%, 0.2%, 0.25%
- Initial pH was recorded
- The solution was treated at 40°C, 50°C, 60°C, 70°C, 80°C, 90°C and 90°C for 15, 30, 45 and 60min
- The bath was removed as soon as the temperature reached 40-90°C and then at 90°C after 15, 30, 45 and 60 min
- The solution was allowed to cool down to room temperature and pH was measured

Table 2: pH of Acidon PA at various temperatures (Initial pH 8.5)

Concentration	pH										
	Initial	40°C	50°C	60°C	70°C	80°C	90°C	90°C for 15min	90°C for 30min	90°C for 45min	90°C for 60min
0.1g/l Acidon PA	8.12	6.93	6.7	6.61	6.26	6.1	5.99	5.81	5.94	5.91	5.78
0.2g/l Acidon PA	7.78	6.6	6.39	6.09	5.11	4.35	4.3	4.23	4.07	4	3.91
0.25g/l Acidon PA	7.47	6.54	6.35	6.07	5.1	4.35	4.28	4.21	4.06	3.96	3.88

Results and Discussion

Table2 1 and 2 indicate that with increase in temperature there is a progressive decrease in pH with both systems, where starting pH was 7.0 and 8.5.

Also, with increase in concentration from 0.1 to 0.2, there is a sharp decrease in pH (Figs 1 & 2). Further, with increase in concentration of the product from 0.2 to 0.25% there is not much reduction in pH.

Dye Fixing Agent for Polyamide – Nylofix 993

It is essential to fix the dye of dyed polyamide to increase fastness characteristics. Sarex has a unique dye fixing agent, Nylofix 93, which improves fastness characteristics of treated fabric

Unique features of Nylofix 993

- Powder form
- Strong fibre affinity for acid and metal-complex dyes and good reserving agent for dyed polyamide/cellulosic blends
- Excellent colourfastness to washing and perspiration
- No influence on shade or handle of the fabric
- Light fastness of dye-fixed sample not affected
- Low foaming, hence can be used in soft-flow machine

Experimental Methods

Substrate: Dyed nylon yarns (red colour)

Application Conditions

- The dye fixing of yarn carried out with Nylofix 993 at pH-4.5-5.5 , Temp – 70°C, Time – 30min
- Concentration of Nylofix 993 = 0.4%,0.6% and 0.8%
- After dye fixing, washing fastness was studied as per ISO CO3

Results and Discussion

It can be seen from Fig. 3 that dyed yarn fixed with Nylofix 993 at various concentrations (0.4- 0.8%) shows slight to no staining on multifibre strip.

Finishing of Polyamide

Polyamide fibre has an inherent soft handle coupled with good tenacity and abrasion. Hence, finishing should be innovative and creative for value addition. We at Sarex have developed specialty finishes, viz. chlorine-fast; phenolic yellowing quencher; moisture management; and antimicrobial.

Chlorine Fast Finish: Saradye PLE

The skill of a dyer is in reproducing gradation of the colour as required by the customer. The art of a finisher is to fix or sustain it with a high level of fastness. Chlorox or regular-bleach disinfecting products help to keep microbes at bay. Chlorine bleach or Chlorox is used all around the world at places such as swimming pools, hospitals, hotels and houses, including bathrooms, kitchen and floors. Chlorox kills most of the microbes that cause illness, thus making homes cleaner and healthier. But accidental spillage and exposure to Chlorox or regular bleach on the surface of fabric, garments, towels and rugs lead to undesirable bleach spots or discolouration and fading. Chlorinated-pool water fastness is highly important in terry towels, swimwear and beachwear.

Sarex has a unique solution in the novel finishing agent Saradye PLE, which meets the requirement of customers. Fabrics, garments, home textiles and medical textiles finished with Saradye PLE exhibit excellent resistance to bleaching and fading due to contact with chlorine in water.

Unique Features of Saradye PLE

- Improves contact water fastness and chlorine fastness

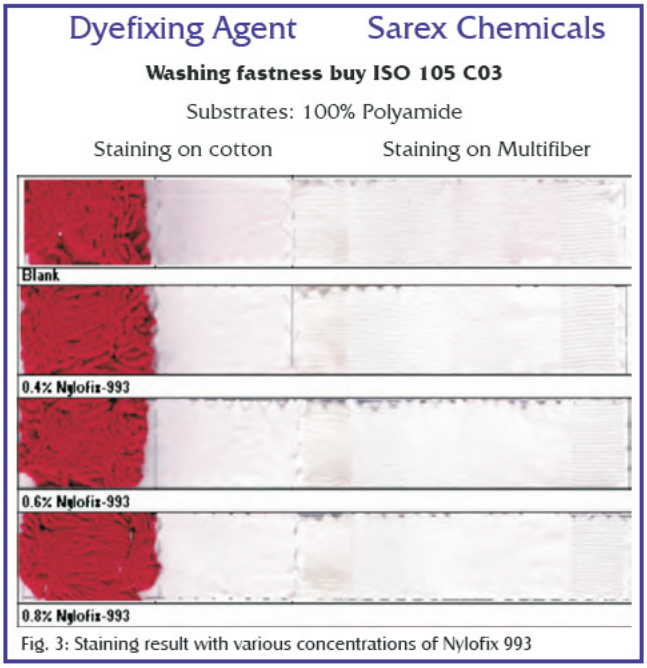


Fig. 3: Staining result with various concentrations of Nylofix 993

- Improves fastness to commercial laundering and domestic washing
- Minimum influence on the shade change and light fastness
- Does not affect handle and absorbency
- Saradye PLE is formaldehyde free and passes Oekotex Standard 100

Experimental Methods

Substrate: Dyed polyamide rug

Application Conditions

Padding:

30-50 g/l Saradye PLE, pH 5-6 and pad-dry at 140°-160°C.

Test Methods

Chlorine fastness testing to be carried out depending on the end use of the specimen by the following test method:

- **ISO 105/E03**

The test specimen is treated with 20 ppm, 35 ppm, 50 ppm and 100 ppm active chlorine for home textiles such as terry towels, at pH 7.5 for 1 hour at 27±2°C, in a launderometer (Fig. 4).

Results and Discussions

Figs. 4 and 5 indicate that the colour of a polyamide rug treated with Saradye PLE is not

affected up to 35ppm chlorine, as per ISO 105/E03 after 2 washes.

Phenolic Yellowing Quencher: Quench APY

Yellowing of textile fabrics may have various causes. Yellowing on whites, pastel shades or after-washed denims is a common feature. However, shade change noticed in dark-coloured fabrics can often be attributed to chemical change or degradation of the fibre, or to some chemical agent either applied to the fabric in finishing or absorbed by the fabric during storage and shipment.

Aromatic amines, antioxidants and stabilisers are generally used in packing materials. Butyl hydroxyl toluene (BHT) is one of the materials commonly as a packing material, which in the presence of NOX present in the atmosphere turns fabric yellow. See Illustrations 1 and 2.

Phenolic yellowing is perhaps the most common type of textile yellowing and is characterised by its bright-yellow colour. It has maximum absorption at 420- 450nm and is reversible in acid conditions.

Approaches to Overcoming Phenolic Yellowing

- Phenolic antioxidants and stabilisers in packaging materials to be avoided
- Fabric pH to be maintained slightly acidic
- Exposure of fabric to be avoided in the presence of NOX fumes
- Phenolic quencher types of auxiliary to be applied Sarex provides the solution to phenolic yellowing – Quench APY (Illustration 3).

Unique features of Quench APY

- Applicable to cotton/Lycra and polyamide fabrics
- Can be applied by pad as well as exhaust application
- Compatible with nonionic finishing agents

Experimental Methods

Substrate: Polyamide Nike woven fabric

Application Conditions:

For pad: 50-70 g/l, pH 4-4.5, pad with pick up of 60-65% dry at 160°C for 1min

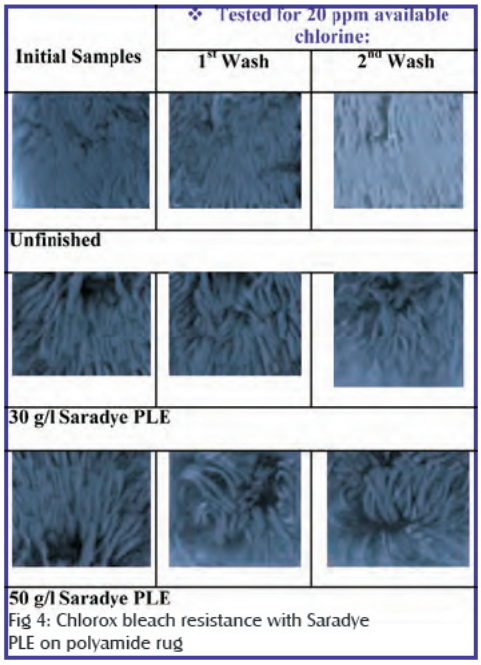


Fig 4: Chlorox bleach resistance with Saradye PLE on polyamide rug

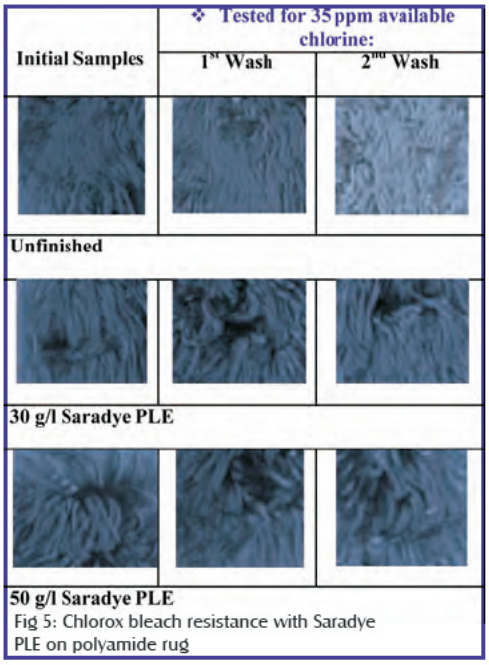


Fig 5: Chlorox bleach resistance with Saradye PLE on polyamide rug

For exhaust: 5-10%, pH 4-4.5, at 65-70 for 20-30min.

Test methods

Standard test methods for testing phenolic yellowing; elusive/reversible yellowing:

- Courtaulds Method: M&S C 20B
- ISO 105-X18:200

Fig. 6 shows test-specimen preparation.

From Fig. 7 it is clear that at 50g/l Quench APY-treated polyamide fabric in the presence of softener is non-yellowing.

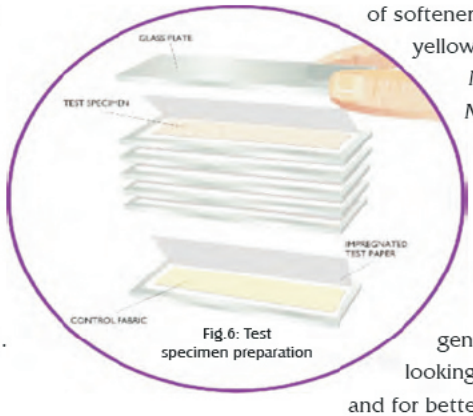


Fig.6: Test specimen preparation

Moisture Management Finishing Agents: Geotex HPA, Sarawick PSR and Moisture Guard

The new generation is looking for comfort, and for better appearance and feel of the fabric. In order to fulfil their requirements, innovative approaches are being adopted.

In view of this Sarex has developed Geotex HPA, Sarawick PSR and Moisture Guard to control moisture transport and add to the comfort of the wearer.

Our body is a perfect system, which reliably regulates body temperature to a constant 37°C, which is the optimum for maximum performance and comfort. An essential control mechanism of the body temperature to feel comfort is evaporation of the water from the surface of the skin,

Illustration 1

Illustration 2

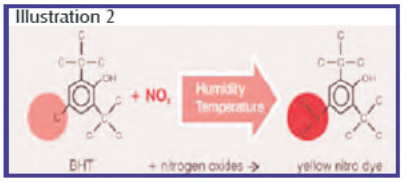
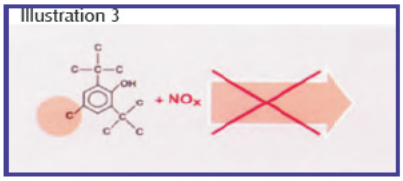


Illustration 3



generally called 'sweating'.

A textile worn next to the skin has to support this mechanism. Body moisture should be absorbed to a large extent by the textile to prevent body hyperthermia. Thus fabric should work similarly to the skin. The moisture-management finish helps to dissipate perspiration from the body, to keep the wearer cool and dry.

Mechanism of Moisture Management

Moisture management is the controlled

Table 3: Wicking height by Nike test

Recipe	Conc g/l	after 5 min.(cm)	after 10 min.(cm)	after 15 min.(cm)	after 30 min.(cm)	Time taken to pass Nike	after 5 min.(cm)	after 10 min.(cm)	after 15 min.(cm)	after 30 min.(cm)	Time taken to pass
Polyamide (Woven)											
Unfinished	-	2.5	6.2	8	10.6	Fail	2.7	6	8.6	11	Fail
Geotex - HPA	5	7.4	11.1	13.5	Passes	25.15	6.9	9.2	11.1	Passes	30
Sarawick - PSR	15	7.6	10.5	12.3	Passes	24.45	8.1	10.8	12.5	Passes	25.3
Moisture Guard	5	8.5	11.6	13.5	Passes	23.1	8.5	11.2	13.2	Passes	22.1

Table 4: Percentage rate of evaporation by M&S P -136A test and absorbency by AATCC-79

Recipe	Concentration (g/l)	Rate of Evaporation(%)	Absorbency(sec.)
		After 30 min	
Polyamide (Woven)			
Unfinished		39.4	>2min
Sarawick - PSR	15	52.2	3-4 sec

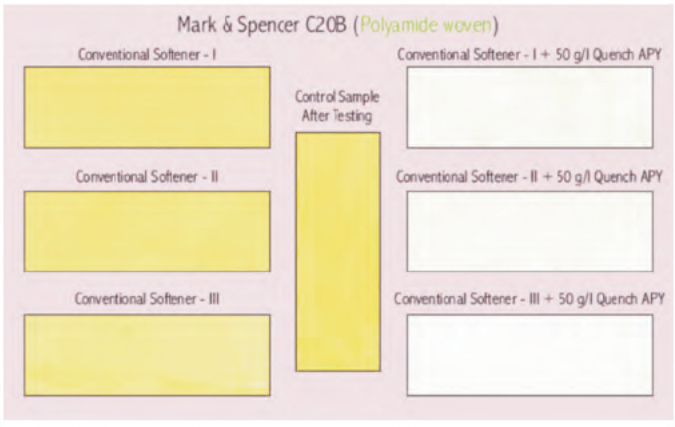


Fig. 7: Phenolic yellowing protection with Quench APY

movement of water (perspiration) from the surface of the skin to the atmosphere through the fabric. The cloth worn next to the skin should have two important properties:

- To transport the moisture from the skin to the fabric surface
- To assist in the evaporation of the moisture from the outer fabric surface

The moisture is transferred into the atmosphere by diffusion and wicking. The airflow through the fabric makes the moisture rapidly evaporate into the atmosphere through the capillary-action wicking behaviour of the fabric.

Unique features of Geotex HPA, Sarawick PSR and Moisture Guard

- Excellent wicking improver for polyamide and its blend: passes Nike test
- Applied by pad as well as exhaust application
- Imparts soft handle
- Durable to multiple home laundering

Experimental Methods

Substrate: Polyamide Nike fabric

Application Conditions

Fabric was padded with 70%, pH 5.0-6.0 and dried at 160°C for 2 mins.

Test Methods

Wicking Method: The finished substrates were evaluated for wicking by the Nike test.

Evaporation Test: Percentage rate of evaporation of finished substrate was measured by

M&S P 136 A, where fabric should show a 20% rate of evaporation in 30 mins.

Drop Test: This method was used to observe how quickly finished substrate can absorb a drop of water as per AATCC 79.

Results and Discussion

Tables 3 and 4 show the performance of Geotex HPA, Sarawick PSR and Moisture Guard according to wicking and evaporation tests.

Sarex has outstanding products for moisture-management finishing on polyamide, which meet the requirements of the Nike wicking test. Fabrics finished with Geotex HPA, Sarawick PSR and Moisture Guard exhibit comfort, breathability, softness, moisture transportation, and have a cool and pleasing handle.

Antimicrobial Finish – Saraguard AM (Conc)

The growth of microbes on textiles during use and storage negatively affects the wearer as well as the fabric. The detrimental effect can be controlled by a durable antimicrobial finishing agent.

Sarex has developed durable, concentrated Saraguard AM (Conc) antimicrobial agent.

Unique Features of Saraguard AM (Conc)

- Concentrated and easily dilutable
- Durable antimicrobial agent
- Can be applied by padding and exhaust
- Effective against broad spectrum microbes such as Klesbsiella pneumonaie, Staphylococcus Aureus and E. Coli
- Nontoxic and non skin sensitive
- It works by contact mechanism

Experimental Methods

Substrate: Polyamide

Application: pH 5.5–6, pad with 70% expression and dry at 160° for 2 min.

Test Methods

Finished fabric was studied for 50 washes durability as per AATCC 135.

The Antimicrobial test was evaluated as per AATCC 100.

Table 5 indicates that 40g/l Saraguard AM (Conc) + 30g/l Saralink ULF shows 94% reduction in bacteria after 50HL.

Table 5: Reduction of bacteria (Species – Klebsiella pneumonia) after 50 HL

Sample – 100% Nylon fabric	Before washing, %	After 50 HL, %
40g/l Saraguard AM (Conc) + 30g/l Saralink ULF	100%	93.57%