

# COMPARISON OF NATURAL AND SYNTHETIC ANTI MIGRANTS IN CONTINUOUS DYEING OF 100% POLYESTER

Zulfiqar Ali Noonari<sup>1</sup>, Wazeer Hussain Solangi<sup>2</sup>, Asghar Ali Channa<sup>3</sup> and Arshad Hussain Memon<sup>4</sup>

<sup>1, 2, 3</sup> Pak-Korea Garment Technology Institute,

Karachi

<sup>4</sup>Environment Engg. & Management Institute MUET Jamshoro,  
Pakistan

**Abstract**— As we know polyester is a synthetic fiber and has more crystalline structure than natural fibers. In continuous dyeing of polyester by pad-Thermosol process, there are many advantages such as bulk production, low-cost, good efficiency etc.

But during dyeing process there is a severe problem occurs that is dye migration. In order to control the dye migration different migration inhibitors are used in this project. Both natural and synthetic migration inhibitors are applied on the 100% polyester fabric in order to compare that which migration inhibitor gives better results on the pad-Thermosol process.

After comparing the different properties of the both migration inhibitors the synthetic inhibitors found more efficient than the natural one. The following tests were conducted during project:

Migration test, tensile strength, color strength, bending length, light fastness.

Synthetic migration inhibitors gives better results for the tests which were conducted. But there is a problem that the synthetic migration inhibitors are not environmental friendly and they are costly than natural migration inhibitors.

**Index Terms**— Thermoelectric cooling, Vapour power refrigeration, Cooling rate.

## I. INTRODUCTION

### A. Background

During dyeing of polyester migration of dyes occurs which causes many problems during dyeing, usually this problem occurs in intermediate drying of padded fabric. Migration occurs due to the movement of dye particles. This movement of dye particles during the dyeing operation is generally termed "migration". Various types of faulty dyeing are occurring in practice due to migration. Cases of two-sided dyeing and listing are due to migration. Migration is influenced by air speed, temperature, humidity and dye constitution.

To counter this problem various migration inhibitors are being used (natural and synthetic) migration inhibitors.

In this project, different tests were conducted to evaluate the performance of the migration inhibitors.

### B. Area of research

Continuous dyeing of 100% polyester on pad-thermosol machine.

### C. Research problem

During dyeing the migration of the dye causes various problems such as:

- Shade change.
- Color strength loss.
- Change in tensile strength.
- Change in washing fastness.
- Rubbing fastness

All above mentioned problem were disused in this project.

### D. Significance of problem

During dyeing of polyester dye particles movement causes severe problems of shade variation. This cause's huge loss to industrialist's dyers uses migration inhibitors to overcome this problem. In this project different migration inhibitors were applied on fabric both natural and synthetic and evaluation was made to know which migration inhibitor works better.

## II. THEORY

### A. Polyester

In 1996, 24.1 million metric tons of manmade fibers were produced worldwide. The main volume gain took place in production of PET fibers (PET filament 9%, PET staple 4%) . The primary drive for this growth is demand for fiber and container resin. Seventy five percent of the entire PET production is directed toward fiber manufacturing. Hoechst, Dupont and Eastman are the three world largest polyester producers. The cost of polyester, with the combination of its superior strength and resilience, is lower than that of rayon. Polyester fibers are hydrophobic, which is desirable for lightweight facing fabrics used in the disposable industry. They provide a perceptible dry feel on the facing, even when the inner absorbent media is saturated. As new methods of processing and bonding of PET are developed, rayon is being replaced by polyester on the market. polyester has become the most widely used polymer in the nonwovens industry since 1995. The next most popular was polypropylene. But in 1996, poly-olefins, particularly polypropylene (PP) moved ahead of PET fibers. They had 46% market shares in fibers used for nonwovens, whereas, PET had a 45% share [1].

### B. Polyester fibers:

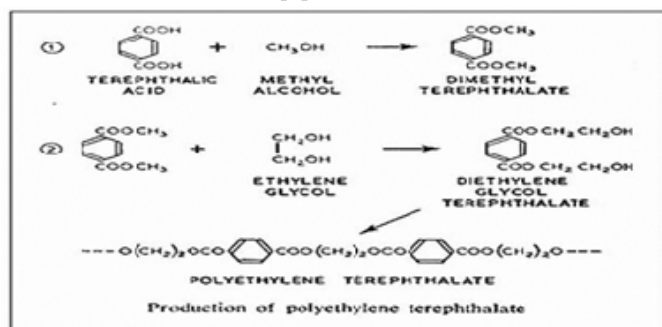
Polyester fiber is a "manufactured fiber in which the fiber forming substance is any long chain synthetic polymer composed at least 85% by weight of an ester of a dihydric alcohol (HOROH) and terephthalic acid (p-HOOC-C<sub>6</sub>H<sub>4</sub>COOH)" . The most widely used polyester fiber is made from the linear polymer poly (ethylene terephthalate), and this polyester class is generally referred to simply as PET. High strength, high modulus, low shrinkage, heat set stability, light fastness and chemical resistance account for the great versatility of PET.[1]

### C. Polymer formation:

Polyethylene Terephthalate (PET) is a condensation polymer and is industrially produced by either terephthalic acid or dimethyl terephthalate with ethylene glycol. Other polyester fibers of interest to the nonwovens field include:

- a) Terephthalic Acid (PTA), produced directly from p-xylene with bromide-controlled oxidation.

- b) Dimethyl Terephthalate (DMT), made in the early stages by esterification of terephthalic acid. However, a different process involving two oxidation and esterification stages now accounts for most DMT.
- c) Ethylene Glycol (EG) initially generated as an intermediate product by oxidation of ethylene. Further ethylene glycol is obtained by reaction of ethylene oxide with water.[1]



**Figure 1. 1 Production of Polyethylene Terephthalate**

#### D. The latest polyester production

Dr Boncella and Dr Wagner at The University of Florida are two scientists involved with the study to reveal a method for manufacturing polyester from two inexpensive gases: carbon monoxide and ethylene oxide. The polyester most commonly used today is referred to as PET or polyethylene terephthalate. Scientists have been successful in producing low molecular weight polyester using carbon monoxide and ethylene oxide, but researchers still lack the catalyst - a substance that speeds up chemical reactions - needed to make the reaction work more efficiently. They are looking for the chemical compound that will take molecules of low DP and create larger ones. Although they have had success in the research so far, they have yet to produce commercially useable polyester from the inexpensive gases. If this is successful, then these research findings can be used to replace the current polyester product, getting the same performance for a lower price. Finally, we all know that research requires patience and a long-term effort. [2]

#### E. General Polyester Fiber Characteristics

- Resistant to stretching and shrinking.
- Resistant to most chemicals.
- Quick drying.
- Crisp and resilient.
- Wrinkle resistant.
- Mildew resistant.
- Abrasion resistant.
- Retains heat-set pleats and crease.
- Easily washed.

#### F. Mechanical properties

As the degree of fiber stretch is increased (yielding higher crystallinity and molecular orientation), so are properties such as tensile strength and initial Young's modulus. At the same time, ultimate extensibility, i.e., elongation is usually reduced. An increase of molecular weight further increases the tensile properties, modulus, and elongation.[2]

#### G. Physical properties

- Polyesters are thermo-plastics in nature and melts at a temperature of 258-260 oC, they are relatively strong

fibers and there is no significance change in strength while wet.

- Due to their high elasticity and complete recovery at an elongation of 5-6% owing to which their goods have anti-creasing properties.
- Glass transition temperature is approximately 68 oC.
- Usually density of polyester fiber is 1.38-1.5
- Softening point is 230-250 oC
- Their abrasion resistance is superior to that of all other natural and man-made fibers with the exception of polyamide.
- They are resistance to influence of sun, heat, and weather.
- They are resistant to moth and bacteria.
- They are difficult to ignite and once the flame is removed, they do not continue to burn. The fiber forms melt globules on heating.
- Clothes made of polyester retain their original shape.[3]

#### H. Chemical properties

Polyester fibers have good resistance to weak mineral acids, even at boiling temperature, and to most strong acids at room temperature, but are dissolved with partial decomposition by concentrated sulfuric acid. Hydrolysis is highly dependent on temperature. Thus conventional PET fibers soaked in water at 70oC for several weeks do not show a measurable loss in strength, but after one week at 100oC, the strength is reduced by approximately 20%.

Polyesters are highly sensitive to bases such as sodium hydroxide and methylamine, which serve as catalysts in the hydrolysis reaction. Methylamine penetrates the structure initially through noncrystalline regions, causing the degradation of the ester linkages and, thereby, loss in physical properties. This susceptibility to alkaline attack is sometimes used to modify the fabric aesthetics during the finishing process. The porous structures produced on the fiber surface by this technique contribute to higher wet ability and better wear properties.

Polyester displays excellent resistance to oxidizing agents, such as conventional textile bleaches, and is resistant to cleaning solvents and surfactants. Also, PET is insoluble in most solvents except for some polyhalogenated acetic acids and phenols. Concentrated solutions of benzoic acid and o-phenyl phenol have a swelling effect.

PET is both hydrophobic and oleophilic. The hydrophobic nature imparts water repellency and rapid drying. But because of the oleophilic property, removal of oil stains is difficult. Under normal conditions, polyester fibers have a low moisture regain of around 0.4%, which contributes to good electrical insulating properties even at high temperatures. The tensile properties of the wet fiber are similar to those of dry fiber. The low moisture content, however, can lead to static problems that affect fabric processing and soiling.[3]

#### I. Optical properties

PET has optical characteristics of many thermoplastics, providing bright, shiny effects desirable for some end uses, such as silk-like apparel. Recently developed polyester microfiber with a linear density of less than 1.0 denier per filament (dpf), achieves the feel and luster of natural silk.[3]

### J. Dyeing properties

Because of its rigid structure, well-developed crystallinity and lack of reactive dye sites, PET absorbs very little dye in conventional dye systems. This is particularly true for the highly crystalline (highly drawn), high tenacity-high modulus fibers. Polyester fibers are therefore dyed almost exclusively with disperse dyes. A considerable amount of research work has been done to improve the dye ability of PET fibers. Polymerizing a third monomer, such as dimethyl ester, has successfully produced a cationic dye able polyester fiber into the macro-molecular chain. This third monomer has introduced functional groups as the sites to which the cationic dyes can be attached. The third monomer also contributes to disturbing the regularity of PET polymer chains, so as to make the structure of cationic dye able polyester less compact than that of normal PET fibers. The disturbed structure is good for the penetration of dyes into the fiber. The disadvantage of adding a third monomer is the decrease of the tensile strength.

### III. POLYESTER DYEING TECHNOLOGY

Among man-made fibers dyed with disperse dyes, polyester fibers is the one with the most compact and crystalline structure, and due to its transition temperature point 70-80 oC, it must be dyed at high temperature that can reach at 140 oC in order to have an appreciate rate of dyeing, or otherwise carriers must be used at boiling temperature. As this fiber has two excellent properties and can be mixed with other fibers, both man-made and natural, the technology to dye it has been developed considerably, and there are, in fact, methods suitable for all types, ranging from traditional exhaustion to continue methods such as pad-thermosol process.[5]

#### A. Polyester dyeing at temperature of 100 oC with no carriers

This method is not used very often, it is only used when very pale shades are required and the dye diffuses very quickly. The fastness to sublimation is poor, because dye has little penetration. Usually this type of dye exhaustion before reaching 100 oC, however, it is better to reach this temperature to have a decent penetration. If this is not respected, the subsequent temperature could result in uneven dyeing. As the dyes are not characterized by the exhaustion, the liquor ratio is a rather conditioning factor; in fact, it is possible to have a difference of up to 20% in exhaustion when the liquor ratio varies from 1/2 to 1/20. The dyeing method consists in simply dispersing the dye with an anion-active agent at a concentration of x g/l and adjusting pH at 5.5 with acetic acid. Dyeing starts at 60c and the temperature is raised in 30/40 minutes to 100oC, which is held for 60-90 minutes in order to facilitate the dye diffusion, after this the goods are washed.[5]

#### B. Polyester dyeing with carriers

When the dyeing takes place in machines that cannot reach temperature over 100 oC a carrier must be used. Furthermore, when volatile carries such as chlorobenzene are used. The machinery must have a heater cover, or a device to let off the steam, so that the carriers do not condense on the walls or over the cover then drip into the dye bath, staining the textiles.

The dyeing process is follows as: a dye-bath is prepared with x g/l ammonium sulphate, formic acid up to a pH of 5-5.5 and a dispersing agent, but without adding the carrier or the dye.

When the liquor has reached a temperature of about 65 oC the goods are immersed in, and after ten minutes the carrier is added (once again adjusting the pH to 5-5.5 if necessary): after

another 10 minutes the dye is added. at this point the temperature is raised to 100 oC in 40 minutes and kept boiling for 90-120 minutes.[5]

#### C. Polyester dyeing with high temperature

With high temperature dyeing it is not necessary to use a catalyst. The main reason for this is because the rate of dyeing increases considerably with the temperature (the activation energy is 40kcal/mole). When the temperatures are low the dyeing is very slow, and not sufficiently quick when the temperature reaches 130 oC and 140 oC. The dyeing is carried out normally. the dye-bath is prepared with all the products except the dye. the goods are treated for 5 minutes at 50-60c, the dye is added well dispersed, the temperature is brought to 130 oC in 30-45 minutes and held for 1-2 hours according to the depth of the shade. finally it is cooled in order to be able to empty the machine and the goods undergo the subsequent reducing treatment.

The type of the machinery used depend upon the characteristics of the goods, usually for yarn pressure autoclaves are used, for the pieces pressure winches, jets, horizontal autoclaves etc, or mixed systems like the over flow.[5]

#### D. Polyester dyeing by Thermosol process

Among the continuous dyeing processes, the thermosol procedure is one of the most sophisticated. It consists in surrounding the polyester fiber with a layer of very fine disperse dye, then submitting it to high temperature (200 oC): with this method, the dye diffuses into the fiber at the rate that is one thousand times faster than at 100. The process has several stages, first there is foulard impregnation, followed by uniform squeezing, and the textile is then dried, usually in two stages. in the pre-drying stage about 30-40% of the water remains, while in the drying stage the moisture is eliminated completely. The water evaporation must be carried out without prejudicing in any way the even distribution of the dye.

##### 1) Textile preparation

As this is a very delicate process, the textile must be uniformly hydrophilic in order to submit it to the impregnation. The condition is carried out these treatments are: to work wide in order to avoid creases, use products with good soaking properties and make sure that the moisture content at the moment of the impregnation is uniform.

##### 2) Impregnation in dye-bath

The impregnation is always followed by foulard method, by which may be with 2 or 3 drums, the important factor is that the squeezing must be completely uniform over the entire textile width for this reason the drums must be slightly rounded, that is, with a certain central (swelling) so that, when under pressure squeezing is constant.

The dye-bath liquor should contain a disperse dye, anti-migrating agent, pH stabilizer and if necessary absorption accelerators agents.

The disperse dye is mostly used in the form of the liquid or granular brands which have better dispersing properties than ordinary brands, and give better penetration and even dyeing.

An anti-migrating agent is used in liquor so that during drying the dye does not move towards the wet zone. These bonding agents must prevent the migration without increasing the padding liquor viscosity too much. among the recommended thickeners we should indicate sodium alginate,

carboxymethylcellulose, polyacrylic acid derivatives or other already prepared products, such as solidokoll.

### 3) Drying

There are three ways of the drying,

- 1) infra-red pre-drying and drum drying
- 2) Infra-red pre-drying and hot flue drying
- 3) Hot-flue pre-drying and drying.

During pre-drying about 60-80% moisture is removed and in drying 20-40% moisture is removed.

### 4) Thermo-fixation

In this operation, as the dye is absorbed by the fiber, it diffuses very quickly towards the fiber inside. There are three basic stages.

- 1) Heating period
- 2) Dye absorption period.
- 3) Dye diffusion period.

## IV. HEAT SETTING

Dimensionally stability of synthetic fibers and blends is known as heat setting of the fabric. Heat setting fixes the position of the fibers and it becomes difficult for the fiber to move out.

### A. Advantages

- Heat setting imparts better shape and dimensional stability to the fabrics.
- Reduces the tendency of pilling.
- Modify the dyeing properties of polyester.
- Avoid the development of pebbles.

### B. Methods

- In hot water, at 100 oC for 100-120 minutes.
- In saturated steam ,at 120-140 oC for 10-30sec
- Dry heat setting, at 190-230 oC for 3-15 sec.

In case of heat setting, time depends on the to be heat set.

- Light weight goods =3-5 seconds
- Medium weight goods =5-8seconds
- Heavy weight goods for 10-15 seconds.

### C. Machines

- Setting in liq.medium (jig,crabbing,decatizing)
- Setting with saturated steam(vacuum and pressure)
- Setting with dry heat

## V. DYE MIGRATION

The movement of dye particles during intermediate drying after padding is known as migration.

### A. Phenomenon

The phenomenon of dye migration on the polyester fabrics is classified in two phenomenon's, first, the movement of the dye particles to the surface of fiber during the drying process, and second, the movement of the individuals dyes molecules into the interior of fiber during thermo soling process.

Relation between drying mechanism after padding of the dye solution and the phenomenon of migration of dye particles to the surface of fabric is considered as the following:

- First, the water evaporates from the surface of the fabric by the thermal energy from heat source and the water content decreases on the surface of the fabric.
- The difference of the water content between the surface of the fabric and the interior causes the water movement from the interior of fabrics to the surface by the capillary action, dye particles move with the movement of water.

- The water begins to evaporate when reaching the surface but the dye particle moving along with remain and accumulate on the surface, the cycle keeps repeating itself.
- Some of the vapors produced near the surface of the fabric begin to evaporate as result of the difference in vapor pressure, the rest of the vapors move into the interior of the fabric and the transmission of the heat quick inside of fabric.
- The vapors moving into the interior of the surface of the fabric-evaporation return to the interior of the fabric repeatedly.
- After drying the movement of water from the interior of fabric to the surface eventually ends, the vapour pressure on the surface begin to drop, the transmission of the heat to the interior now depends upon the fiber itself instead of the vapours and the temperature of interior of the fabric tends to to decrease. to reach this condition the temperature of the surface of the fabric then increases rapidly and accomplishes drying.[8]

### 1) Factors affecting migration

#### a) Air speed

In hot air drying, air speed provides the most prominent influence on the rate of the drying and simultaneously influence upon migration.

The absolute degree of the migration decrease as the air speed on the surface of the fabric becomes lower. The difference of the air speed shows considerable influence on migration by causing listing and poor reproducibility of the dyeing.

The migration generally reaches constant at air speed during 4-5m/sec .no further change in migration is observed at the higher speed and then difference in air speed does not significantly effect on migration but tends to Detrioter the appearance of the dyeing.

As the air speed of the hot-flue dryer applied in the factory is generally at over 15m/sec., on the hand, the air speed of drying equipment in a laboratory is from 0-4m/sec.

It may cause problems over reproducibility between laboratory production and bulk production and eventually effect shade, dyeing strength and appearance of the dyeing.

In order to improve reproducibility between laboratory and factory, air speed in laboratory by selecting a range with the least degree of migration, that is, 4-5m/sec should be selected.

#### b) Temperature

The temperature of the hot air drying is not so effective on the migration as air speed.

The migration becomes smaller as lower temperature, but the difference of temperature largely affects migration .in contrast, the influence of the temperature difference on migration becomes lower as the increasing temperature. in general, the effect of temperature difference on migration decrease considerably at temperature higher than 100° C.

#### c) Humidity

Humidity has practically on influence on migration .on the other hand ,moisture in hot air is liable to lower drying efficiency by lowering the drying speed and simultaneously create a difference in concentration between the surface and the backside of the dyeing. Consequently, drying should be carried out under low humidity as much as possible.[9]

#### d) Infra-red drying

In hot flue drying, the temperature of padded fabric cannot reach over 50-60c on wet bulb until the water completely evaporates from the padded fabric. in the infra-red drying, on the other hand, the temperature of the padded fabric can be increase to the boiling point e.g. 100c under atmospheric pressure by heat energy of the infra-red ray. by this infra-red radiation, the fibers are swelled and the penetration of dyes into the interior of the fiber is improved, moreover since the bound water in cellulosic becomes larger by increasing temperature, the volume of the free water in fiber decrease and migration becomes smaller. However, an excessive radiation of infra-red ray will result in drying in under boiling condition. By which the drying is accelerated and simultaneously migration become larger.

The most effective drying method generally follows' this sequence, 20-30% water of pick-up ratio of the padded fabric is generally dried by the radiations of the infra-red ray and simultaneously increase the temperature of the fabric to improve penetration of the dyes into fibers and to increase bound water and resulted in reduction of the free water, after inhibitive effects of the migration is obtained, the hot-flue drying is finally applied.

The most suitable conditions of the drying at each stage should be determined by the sorts of the materials, characters of the materials, the composition of the padded solution and the end-use of the finished products.[9]

e) Pick-up

Migration is increased at relatively high water content. In this stage, free water constantly moves from the interior of the fabric to the surface and the dyes migrate to the surface with water on the fabric.

It is possible to control the dye migration without trouble in practical application by keeping the percentage of the pick-up under 40% in order to control free water ratio in padding process.

However, besides adding a migration inhibitor to the padding solution, it is necessary to determine the optimum condition for pick-up according to the sort of fiber and its properties etc. [9]

f) Migration inhibitors

The migration property of dyes is largely influenced by the type of the migration inhibitor and by the amount applied. As common migration inhibitors, sodium alginate and synthetic thickening type agents of vinyl acetate or the acrylic acid types are used for the migration inhibitors, synthetic thickening type agents are inferior to sodium alginate in migration inhibiting effects but, on the other hand, they generally show favorable results in the appearance of dyeing because of their better adhesive effect of dyes on polyester fibers. [10]

VI. THE MIGRATION INHIBITORS MUST POSSESS THE FOLLOWING PROPERTIES

- Cold water solubility.
- Free from foreign matters
- Compatibility with dyes and chemicals
- Viscosity stability in different Ph
- Good penetration
- Produce smooth and even dye application
- Ability to control migration
- Obtain optimum color yield
- Easy removal

- Easy to handle[10]

A. Influence of migration behavior

- Dye constitution
- Dye formulation
- Physical factors
- Substrate
- Pad liquor additions[10]

1) Natural migration inhibitors

Natural migration inhibitor used in the industry:

- Sodium alginate
- Guar gum
- Carboxymethyl cellulose (cmc)

But the most commonly used is sodium alginate.

VII. SODIUM ALGINATE

The chemical compound sodium alginate is the sodium salt of alginic acid. Its empirical formula is  $\text{NaC}_6\text{H}_7\text{O}_6$ . Sodium alginate is a gum, extracted from the cell walls of brown algae. A major application for sodium alginate is in reactive dye printing, as thickener for reactive dyestuffs (such as the procion cotton-reactive dyes) in textile screen-printing and carpet jet-printing. Alginates do not react with these dyes and wash out easily, unlike starch-based thickeners.

The uses of alginates are based on three main properties. The first is their ability, when dissolved in water, to thicken the resulting solution (more technically described as their ability to increase the viscosity of aqueous solutions). The second is their ability to form gels; gels form when a calcium salt is added to a solution of sodium alginate in water. The gel forms by chemical reaction, the calcium displaces the sodium from the alginate, holds the long alginate molecules together and a gel is the result. No heat is required and the gels do not melt when heated. This is in contrast to the agar gels where the water must be heated to about 80°C to dissolve the agar and the gel forms when cooled below about 40°C. The third property of alginates is the ability to form films of sodium or calcium alginate and fibers of calcium alginates.



Figure 1. 3 Sodium Alginate Molecular Structure

A. In Textile Printing and dyeing Industry,

- It acts as a thickening agent for Printing Paste.
- It also acts as a Emulsifying agent.
- It also acts as a Stabilizer.
- It also acts as an Gelling agent in Textile Industry.[11]

VIII. GUAR GUM

Guar gum is a natural hydrocolloid that is obtained from the ground endosperm of the guar plant. This plant is basically an annual plant that grows in huge number in the arid regions. Guar gum is basically a polysaccharide (a long chain of sugars) made of the sugars, galactose and mannose. Guar gum is white to off white powder and odorless.

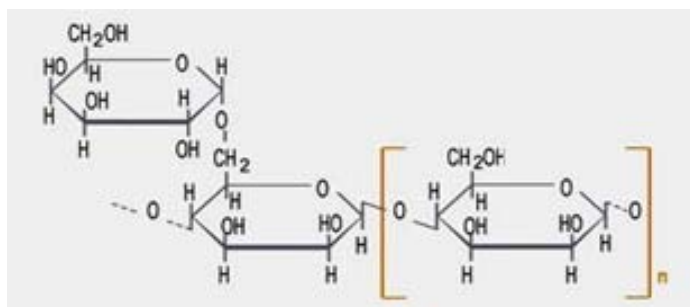


Figure 1. 4 Structure of guar gum

Guar Gum mainly consists of hydrocolloid polysaccharide with a high molecular weight, which consists of galactopyranose- and mannopyranose- units in glycoside linkage which can be chemically described as galactomannan. The most important property of guar gum is its ability to hydrate rapidly in cold water to attain uniform and very high viscosity at relatively low concentrations. Another advantage associated with guar gum is that it is soluble in hot & cold water and provides full viscosity in even cold water. Apart from being the most cost-effective stabilizer and emulsifier it provides texture improvement, and water-binding; enhances mouth feel; and controls crystal formation. It is inert in nature. It is resistant to oil, greases, and solvents.[12]

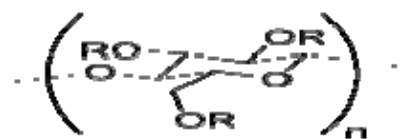
A. The main properties of Guar gum are

- Guar Gum gives excellent film forming and thickening properties when used for textile sizing, finishing and printing.
- It reduces warp breakage, reduces dusting while sizing and gives better efficiency in production.
- It is soluble in hot & cold water but insoluble in most organic solvents.
- It has strong hydrogen bonding properties.
- It has excellent thickening, Emulsion, Stabilizing and film forming properties.
- At very low concentration, Guar gum has excellent settling (Flocculation) properties and it acts as a filter aid.
- It is non ionic and maintains a constant high viscosity over a broad range of ph.
- It is compatible with a variety of inorganic and organic substances including certain dyes and various constituents of food.
- The viscosity of Guar gum solution increase gradually with increasing concentration of Guar gum in water.
- The viscosity of Guar gum is influenced by temperature, ph, presence of salts and other solids.
- It has excellent ability to control rheology by economic water phase management.
- It forms highly viscous colloidal dispersions when hydrated in cold water. The time required for complete hydration in water and to achieve maximum viscosities depends on various factors i.e. the ph; temperature; grade of powder used; Equipment etc.[12]

#### IX. CARBOXYMETHYL CELLULOSE

Carboxymethyl cellulose (CMC) or cellulose gum is a cellulose derivative with carboxymethyl groups (-CH<sub>2</sub>-COOH) bound to some of the hydroxyl groups of the glucopyranose monomers that make up the cellulose backbone.

It is often used as its sodium salt, sodium carboxymethyl cellulose.



R - H or CH<sub>2</sub>CO<sub>2</sub>H  
Figure 1. 5 Structure of CMC

CMC is used as a highly effective additive to improve the product and processing properties in various fields of application - from foodstuffs, cosmetics and pharmaceuticals to products for the paper and textile industries. Building material additives, printing inks, coatings, pharmaceuticals, food, cosmetics, paper or textiles – there's a long and growing list of applications.[13]

#### X. SYNTHETIC MIGRATION INHIBITORS

Synthetic migration inhibitors have mostly chemical constitution of acrylic copolymer. Their ionic character is anionic. They wash off easily hence no harshening of handle. They are present in both colored and colorless forms but mostly yellowish in color. Stable in hard water and to acids, alkalis and electrolytes in the usual amounts. They are stable at 20°C and can be kept for a year or more then year but they should be tightly reclosed after each withdrawal. The required amount of migration inhibitor depends on dyestuff concentration. They reduce cleaning time hence shortened downtime and increased productivity. They are applied in the continuous process and their application is in the following processes:[14]

- Pad-dry-cure
- Thermosol process
- Wet-in-wet dyeing
- Pad thermosol pad steam process

A. Synthetic migration inhibitors to be used in the experiment are

- Thermacol MIN
- Primasol FFAM
- Thermacol MP

Property	Thermacol MIN	Primasol FFAM	Thermacol MP
Chemical constitution	Aqueous solution of an acrylic polymer	Acrylic Copolymer.	Aqueous solution of an acrylic polymer
Ionic character	Anionic	Anionic	Anionic
Physical form	Colorless liquid	Yellowish viscous liquid.	Colorless liquid
Specific gravity	approx. 0.9	Approx.0.9	approx. 1
General stability	stable to hard water and pH values between 4 and 10	Stable in hard water at pH:- 6.5 - 7.5	Stable in hard water and to acids, alkalis and electrolytes in the usual amounts.
Storage stability	Store at 20c more than one year	can be store at 5-25 for 1 year	Store at 20c more than one year
Compatibility	compatible with anionic and nonionic auxiliaries	Freely miscible with water	Compatible with anionic and nonionic auxiliaries.
Ecology/ Toxicology		Note hygienic	Note Hygienic

Table 1. 1 Synthetic Migration Inhibitors

#### XI. OBJECTIVES OF THE EXPERIMENT

Main objective of the project is to compare the main properties of the synthetic and natural migration inhibitors, such as

- Color depth
- Bending length
- Wash fastness
- Rubbing fastness
- Tensile strength

## XII. EXPERIMENTAL WORK

### A. Material and equipment

The materials and equipment used for the completion of the project are as follows:

- Fabric
- Chemicals
- Equipment

### B. Fabric specification

100 % polyester fabric warp was 161.6's and weft was 96.6's and ends per inch were 140 and picks per inch were 64.

### C. Chemicals

Serial #	Chemicals	Commercial name	manufacturer
1	Migration inhibitor	Thermacol MIN	CIBA
2	Migration inhibitor	Thermacol MP	CIBA
3	Migration inhibitor	Primaol FFAM	BASF
4	Migration inhibitor	Sodium alginate	N/A
5	Migration inhibitor	Guar gum	N/A
6	Migration inhibitor	CMC	N/A
7	Disperse dye	Navy blue	CIBA
8	Acetic acid	N/A	N/A

Table 2. 1 Chemicals

### D. Equipment's and its application

Following machines are used for the completion of the project

Machine Name	Model Number	Manufacturer Name
Stenter Frame	OPT-1	Tsuji Japan
Thermosol Padder	M/C MH-1	Tsuji Japan

Table 2. 2 Mostly Used Machines

### E. Testing Equipment

Serial #	Test performed	Instrument used	Manufacturer	Standard
1	Migration test	Transparent glass and watch glass	Self made	AATCC Test Method 140-2001
2	Light fastness	Xenon arc lamp	Shimadzu, corporation	NA
3	Tensile strength	Tensile tester	Daie kagaku seiki seikugho ltd.	ASTM 14-32
4	Bending length	Centi lever	NA	NA
5	Color strength	Spectrophotometer	Color eye gretamacbeth	
6	Crocking fastness	Crock meter	Shirley development Manchester UK	ISO105*12

Table 2. 3 Testing Equipment

## XIII. APPLICATION METHOD:

First of all 100% polyester fabric was heat set at, at 190-230 oC for 3-15 sec. polyester fabric was dyed with navy blue disperse dye. Then laboratory pad-thermosol machine was used and method of dyeing was pad-dry-cure.

Padding was done in padder. then drying and curing was done in thermosol-drying temperature was 120 oC for 1 minute. And curing temperature was 210 oC for 60 sec.

### A. Recipe

Disperse dye	10g/l
Buffer(monosodium phosphate)	1g/l
Acetic acid	2 drops
Migration inhibitor	10g/1.20g/1,30g/1

Table 2. 4 Recipe

### B. Testing Methods

#### 1) Tensile Strength (ASTM D 5043-9)

- Tensile Strength Tester was checked and calibrated for zero error
- The jaws of the tester were tightened for proper use
- This test work on the Grab principle
- Fabric sample was cut to 6 inch x 2.5 inch
- Machine was switched on the fabric was placed between the upper and lower jaw of tester
- The lever was pressed down and the fabric will start to elongate and then will rip
- Press lever up again when the fabric start ripping and note the value
- This will give us the desired value of tensile strength of the fabric
- This cannot be used for a knitwear fabric.[22]



Figure 1. Tensile strength tester

#### 2) Light Fastness

- The test was performed according to AATCC test method 16
- The fabric was cut into 2.75 in x 4.75 in
- The fabric samples were then placed in a holder and placed into the light fastness tester
- Turn on the tester and 24 hours were given to the samples
- After 24 hours, remove the samples and compare with the Blue Scale of light fastness measurement
- Readings were taken after comparison [23]



Figure 2. Light fastness tester [24]

### 3) Rubbing Fastness

- The test was performed according to the AATCC test method 8
- The test of rubbing fastness can be performed in two ways:
  - a) Dry Rubbing Fastness
  - b) Wet Rubbing Fastness

#### Dry Rubbing Fastness

- Place a test specimen on the base of the Crock meter resting flat on the abrasive cloth with its long dimension in the direction of rubbing
- Place specimen holder over specimen as an added means to prevent slippage
- Mount a white test cloth square, the weave parallel with the direction of rubbing, over the end of the finger which projects downward from the weighted sliding arm. Use the special spiral wire clip to hold the test square in place. Position the clip with loops upward. If the loops point downward they can drag against the test specimen
- Lower the covered finger onto the test specimen. Beginning with the finger positioned at the front end, crank the meter handle 10 complete turns at the rate of one turn per second to slide the covered finger back and forth 20 times. Set and run the motorized tester for 10 complete turns.
- Remove the white cloth and compare it with the grey scale to get the value of rubbing fastness

#### Wet Rubbing Fastness

- Place a test specimen on the base of the Crock meter resting flat on the abrasive cloth with its long dimension in the direction of rubbing
- Place specimen holder over specimen as an added means to prevent slippage
- Mount a white test cloth square which is made by dipping in water, the weave parallel with the direction of rubbing, over the end of the finger which projects downward from the weighted sliding arm. Use the special spiral wire clip to hold the test square in place. Position the clip with loops upward.
- Lower the covered finger onto the test specimen. Beginning with the finger positioned at the front end, crank the meter handle 10 complete turns at the rate of one turn per second to slide the covered finger back and forth 20 times. Set and run the motorized tester for 10 complete turns. Refer to individual specifications for any other required number of turns
- Remove the white cloth and compare it with the grey scale to get the value of rubbing fastness [25]



Figure 3. Crock meter

### 4) Color Value

- 4" X 8-10" specimen
- Prepare the machine. Clamps should be set about 3 inches apart
- Select the force range of the testing machine for the break to occur between 10-90% of full scale force
- Set the testing machine for a loading rate of 12 in/minute (unless otherwise specified)
- If specimen clips in the jaws, or breaks at the edge or in the jaws or performs markedly below average for the set of specimens, discard the result and take another specimen [26].



Figure 4. Spectrophotometer

### 5) Migration test

#### a) Principle

Fabric impregnated with colorant, or with colorant and auxiliaries, is dried while partially covered with a watch glass permitting differential drying and therefore, migration to occur. The degree of migration is evaluated by visual, or by reflectance measurements of the covered and uncovered areas.

#### b) Procedure

- Prepare a pad bath appropriate to the colorant(s) with or without a migration inhibitor.

Drying in air at room temperature. Pad a 150 × 300 mm swatch of fabric at 20 °C (68 ± 4°F). Other padding temperatures may be used, but must then be stated in the report. Generally use a wet pickup of 60%, but adjust as necessary to simulate wet pickup of a particular fabric to be run on a particular range. Immediately after padding place the fabric on a flat glass plate. Place the watch glass on the fabric and leave the fabric to dry at room temperature. Record the room temperature and relative humidity during drying. Remove the watch glass.

Gray Scale for Color Change:

Grade 5.no migration

Grade 4.slight migration

Grade 3.medium migration

Grade 2.severe migration

Grade 1.very severe migration [27].



XIV. RESULTS AND DISCUSSION

A. The effect of migration inhibitors on cv-sum

S#	Migration inhibitor	Untreated on cv-sum	10g/l on cv-sum	20g/l on cv-sum	30g/l on cv-sum
1	Thermacol MIN	3.568	3.25	4.116	3.764
2	Themacol MP	3.568	3.675	4.747	4.762
3	Primasol FFAM	3.568	3.675	4.4745	4.364
4	Sodium alginate	3.568	4.657	4.864	4.091
5	CMC	3.568	3.870	3.567	3.870
6	Guar gum	3.568	3.920	3.464	3.172

Table #1

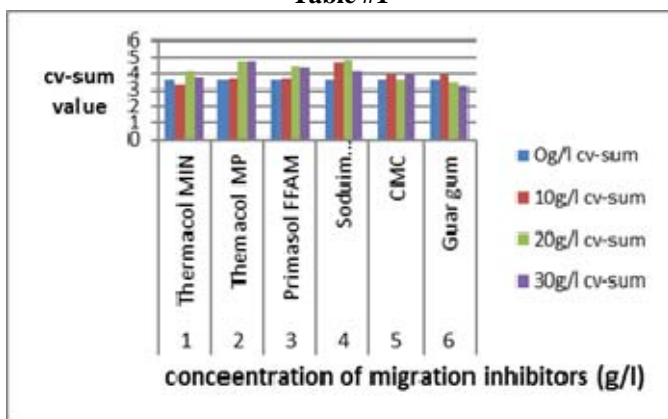


Figure #1

The graph shows that the synthetic migration inhibitor has more impact on cv-sum than natural migration inhibitors.

B. The effect of migration inhibitors on the %strength

S#	Migration inhibitor	Untreated on % strength	10g/l on % strength	20g/l on % strength	30g/l on % strength
1	Thermacol MIN	100	91.09	98.08	101.01
2	Themacol MP	100	136.33	133.07	133.47
3	Primasol FFAM	100	127.80	127.83	122.31
4	Sodium alginate	100	130	136	128
5	CMC	100	108.48	140.28	134.97
6	Guar gum	100	109.86	97.09	80.91

Table #2

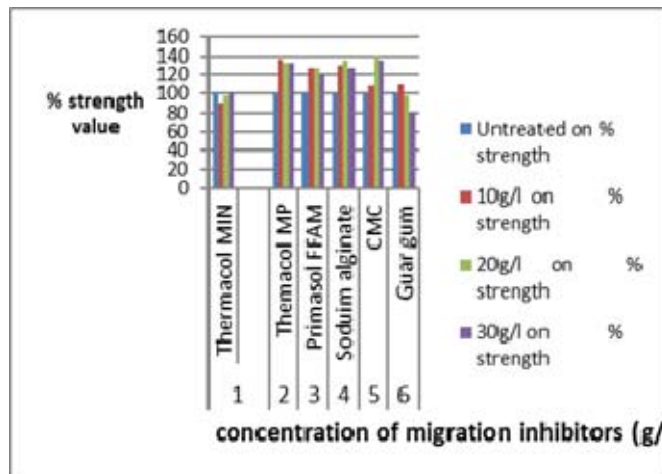


Figure #2

The graph shows that the synthetic migration inhibitors have impact on the % strength value than the natural migration inhibitors.

C. The effect of migration inhibitors on crocking fastness

S #	Migration inhibitor	Untreated on Rubbing fastness		10g/l on Rubbing fastness		20g/l on Rubbing fastness		30g/l on Rubbing fastness	
		DRY	Wet	dry)	Wet	dry	Wet	dry	Wet
1	Thermacol MIN	5	4	4.5	4	5	3.5	4.5	4
2	Themacol MP	5	4	3	3.	3.5	3	4	3.5
3	Primasol FFAM	5	4	4.5	3	4.5	3.5	4	3
4	Sodium alginate	5	4	4	3	4	3	5	3
5	CMC	5	4	4.5	3.5	4.5	3	4.5	3
6	Guar gum	5	4	3.5	3	4.5	3.5	4	3

Table #3

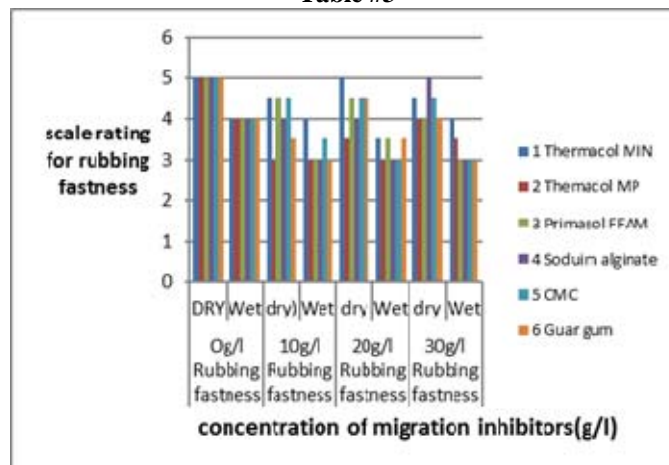


Figure #3

The graph and results shows that the migration inhibitors have not much effect on the crocking fastness ,however synthetic migration inhibitors have good crocking properties than natural migration inhibitors.

D. The effects of migration inhibitors on the bending length

S#	Migration inhibitor	untreated bending length(cm)	10g/l bending length(cm)	20g/l bending length(cm)	30g/l bending length(cm)
1	Thermacol MIN	3.5	3.1	2.9	2.5
2	Themacol MP	3.5	3.8	3.2	3.3
3	Primasol FFAM	3.5	2.3	2.7	2.9
4	Sodium alginate	3.5	3.7	3.4	3.1
5	CMC	3.5	3.9	3.6	3.5
6	Guar gum	3.5	3.1	3.8	3.5

Table #4

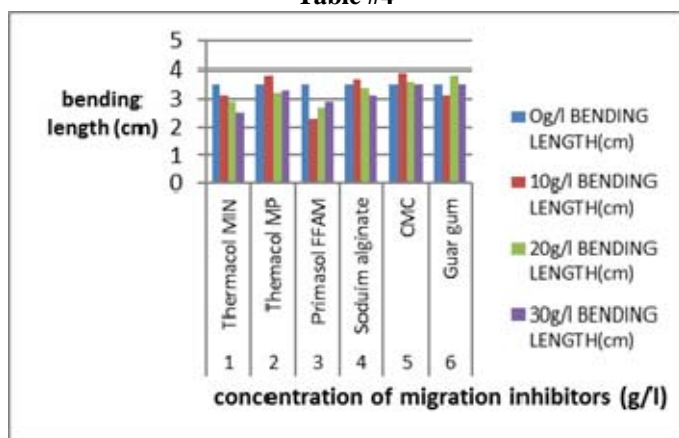


Figure #4

The effect of migration inhibitor from the graph show that the natural migration inhibitors have more bending length then the synthetic migration inhibitors because the synthetic migration inhibitor make the fabric more stiff.

E. The effect of migration inhibitors

S#	Migration inhibitor	Untreated g/l	10g/l	20g/l	30g/l
1	Thermacol MIN	2.5	3	3.5	4
2	Themacol MP	2.5	3.5	3	4
3	Primasol FFAM	2.5	4	3	3.5
4	Sodium alginate	2.5	2	2.5	3
5	CMC	2.5	2.5	2	3
6	Guar gum	2.5	2.5	2	3

Table #5

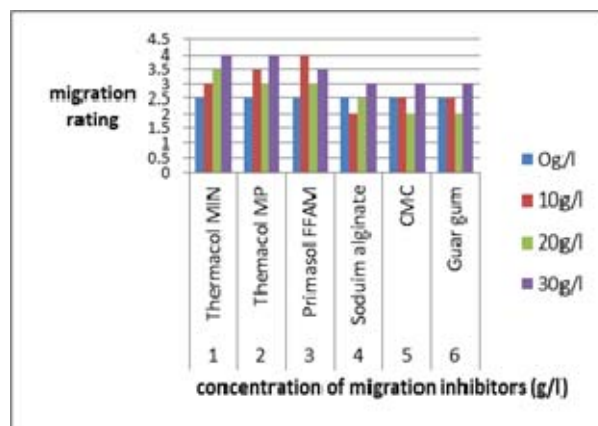


Figure #5

The graph shows that the synthetic migration inhibitors have better properties for controlling the dye migration the natural migration inhibitors. Synthetic migration inhibitors also reduce cleaning time hence increased productivity. In natural migration inhibitor, sodium alginate prevents dye migration better than other natural migration inhibitors, while in synthetic migration inhibitors Primasol FFAM and Themacol MP prevents better dye migration.

F. The effect on the tensile strength

S Migration #	inhibitor	Untreated on		10g/l on		20g/l on		30g/l on	
		tensile strength		tensile strength		tensile strength		tensile strength	
		Warp (kg)	Wef t (kg)	Warp (kg)	Wef t (kg)	Warp (kg)	Wef t (kg)	Warp (kg)	Wef t (kg)
1	Thermacol MIN	40	35	44	38	45	37	42	38
2	Themacol MP	40	35	49	41	53	47	51	43
3	Primasol FFAM	40	35	33	28	39	34	40	33
4	Sodium alginate	40	35	39	31	40	36	42	38
5	CMC	40	35	49	40	51	48	53	46
6	Guar gum	40	35	40	33	39	30	50	44

Table #6

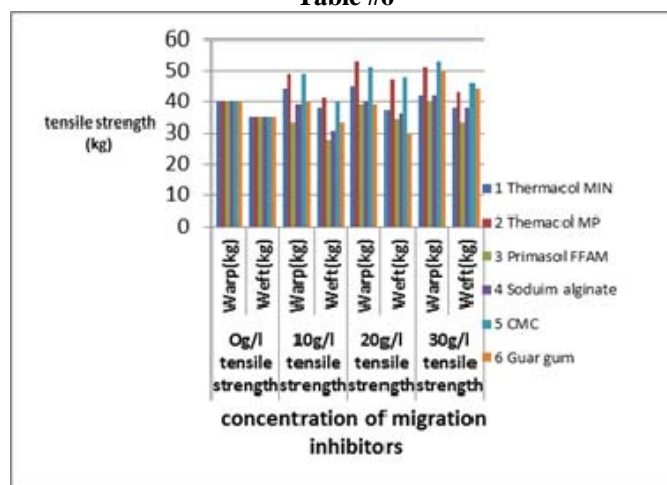


Figure #6

From the above graph it has been concluded that synthetic migration inhibitor have more affect on tensile strength then the natural inhibitors. More the concentration of the synthetic migration concentration more will be tensile strength.

G. The effect of migration inhibitors on the light fastness

	migration inhibitor	untreated on light fastness	10g/l on light fastness	20g/l on light fastness	30g/l on light fastness
1	Thermacol MIN	5	5	5	4.5
2	Themacol MP	5	4	4.5	6
3	Primasol FFAM	5	5.5	5	5
4	Sodium alginate	5	6	5.5	5
5	CMC	5	5	5.5	5
6	Guar gum	5	5	5.5	5.5

Table #7

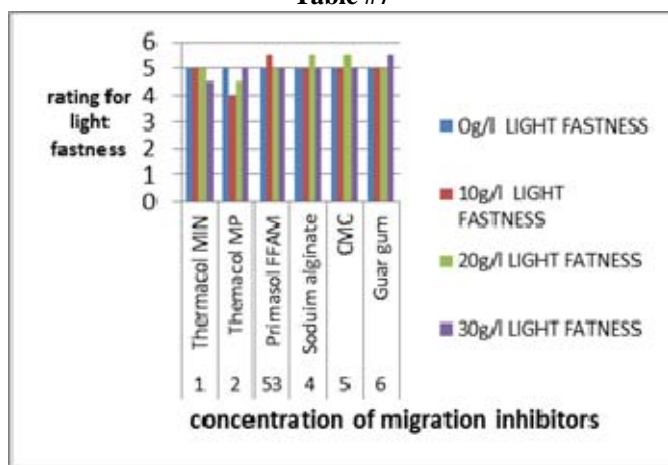


Figure #7

From the above graph it has been concluded that the migration inhibitors both natural and synthetic have not much effect on light fastness properties because there was no staining no little staining was observed on the fabric.

XV. CONCLUSION

Following conclusions are drawn after the project:

- Synthetic migration inhibitors efficiently restrict dye particle movement during drying but along with the environmental concern.
- Natural migration inhibitors are environmental friendly but do not restrict dye particles movement efficiently.
- Migration inhibitors have no any effect on wash fastness as they have no any role in dye fixation.
- Migration inhibitors also not have any impact on crock fastness properties of dyed fabric.
- Synthetic migration inhibitors do not cause stiffness in fabric while natural cause to little extent.
- Synthetic migration inhibitors also effect on Tensile/ Tear strength of fabric while natural migration inhibitors do not affect strength of fabric.
- CV-SUM and % strength of natural migration inhibitors is better then synthetic migration inhibitors because cellulosic component in natural migration inhibitors have more dye affinity then acrylic based synthetic migration inhibitors.

XVI. APPENDIX

**Absorbency:** The propensity of a material to take in and retain a liquid, usually water, in the pores and interstices of the material.

**Colorfastness:** The resistance of a material to change in any of its color characteristics, to transfer of its colorant(s) to adjacent materials, or both, as a result of the exposure of the material to any environment that might be encountered during the processing, testing, storage or use of the material.

**Crocking fastness:** A transfer of colorant from the surface of a colored yarn or fabric to another surface or to an adjacent area of the same fabric, principally by rubbing.

**Color change:** A change in color of any kind whether a change in lightness, hue or chroma or any combination of these, discernible by comparing the test specimen with a corresponding untested specimen.

**Colorant staining:** The unintended pickup of colorant by a substrate due to exposure to a colored or contaminated liquid medium, or direct contact with dyed or pigmented material, from which colorant transfers by sublimation or mechanical action (as in crocking)

**Gray Scale:** A scale consisting of pairs of standard gray chips, the pairs representing progressive differences in color or contrast corresponding to numerical colorfastness grades.

**Tearing strength:** In fabrics, the force required to propagate a tear after its initiation.

**Tensile Strength:** The resistance of a material to a force tending to tear it apart, measured as the maximum tension the material can withstand without tearing.

REFERENCES

- [1] Industrial dyes by Klaus Hunger, page 409-411
- [2] Ehow.[Online].-[http://www.ehow.com/about\\_5114277\\_polyester-cotton-blend.html](http://www.ehow.com/about_5114277_polyester-cotton-blend.html), October 17, 2010
- [3] Polyester Properties. [Online], -<http://www.tutorvista.com/content/chemistry/chemistry-ii/carbon-compounds/polyester.php>, October 17, 2010
- [4] Nishida, Morimoto, "The Dyeing Properties on Polyester Fiber Blends of Monoazo Reactive Disperse Dyes Containing a Vinylsulphonyl Group" Coloration Technology, Volume 94, Issue 2, pages 53-55, February 1978
- [5] Polyester dyeing [online], -<http://www.thesmarttime.com/processing/disperse-dyeing.htm> December 12,2010
- [6] Heat Setting. [Online], -<http://en.wikipedia.org/wiki/Heatsetting>, October 17, 2010
- [7] Disperse Dyes. [Online], -<http://www.pburch.net/dyeing/dispersedye.shtml>, November 20, 2010
- [8] Urbanik, Ethers, J.N, "Particulate migration during dyeing of fabric padded with dyestuff dispersion" Textile Research Journal, vol 43, 1973, Page 657-661
- [9] Ethers, J.N, "Evaluation of anti migrant" Am. Dyest. Rep 77 (4), page 13-18, 1988
- [10] De Boer, J.J., "The Determination of the degree of migration of easy care chemicals in polyester fabric", textile research journal, vol 53, page 624-631, 1983
- [11] Sodium Alginate. [Online], -<http://www.fao.org/docrep/w6355e/w6355e0x.htm>, October 20, 2010
- [12] Guar Gum. [Online], -[http://en.wikipedia.org/wiki/Guar\\_gum](http://en.wikipedia.org/wiki/Guar_gum), October 29, 2010

- [13] Carboxymethyl Cellulose. [Online], [http://en.wikipedia.org/wiki/Carboxymethyl\\_cellulose](http://en.wikipedia.org/wiki/Carboxymethyl_cellulose), November 9, 2010
- [14] Synthetic Migration Inhibitors. [Online] <http://www.ncbi.nlm.nih.gov/pubmed/12203736>, November 7, 2010
- [15] S.N PANDEY AND C.R. RAJE, "Migration of Crosslinking Reagents in Cotton/Terene blended fabric during resin finishing" Textile Research Journal, November 1985, Page 693-698
- [16] J.N Etters, "inducing and measuring particulate migration" Textile Research Journal, may 1987, page 275-278
- [17] J.N Etters, "Migration of particulate dye mixtures in textile capillary assemblies" Textile research journal, July 1991, page 397-401
- [18] P.BAJAJ, R.B CHAVAN, AND MANJEET BHATIA, " cross linked acrylic acid based thickeners: preparation and performance in reactive printing of cotton" textile research journal, January 1986, 63-66
- [19] NOELIE R.BERTONIERE, WALTER D.KING, AND STANLEY P.ROWLAND, "migration and location o reagents in polyester fabric" textile research journal, October 1983, page 624-630
- [20] ALLAN H.LAMBER T AND ROBERT J.HARPER, JR, "uses of cellulose ethers in migration control" textile research journal, October 1989, page 585-589
- [21] Tensile Strength By Grab Method (ASTM D 5043-9)
- [22] AATCC Manual. Test for Light Fastness AATCC-16
- [23] Light Fastness Tester, [Online]. <http://pub4.hi2000.com/upload/1007091118545044.jpg>, December 17, 2010
- [24] Colorfastness to Crocking: AATCC Crock meter Method. AATCC-08, AATCC Manual.2006, page 17-19
- [25] Spectrophotometer, [Online]. <http://2.imimg.com/data2/PC/SX/IMFCP-659792/spectroscan-250x250.jpg>, December 17, 2010
- [26] Dye and Pigment Migration in a Pad-Dry Process:: AATCC Test Method 140-2001, Manual 2006, page 240-242.