

Dyeing of polyester and its blends

Dyeing of Hydrophobic fibres

- Dyeing of Hydrophobic fibres like polyester with disperse dyes is a completely different dye transfer system
- The process involves dye transfer from liquid (water) to a solid organic fibre and it takes as following:
 1. Dispersion of the dye in the solid phase into water by breaking up into molecules(dissolution of the dye)
 2. Adsorption of the dissolved dye from the solution onto the fibre surface
 3. Diffusion of the dye molecules from the fibre surface into the interior of the fibre

How does it happen

- The first step of dye dissolution in the dyebath depends on the dispersability and solubility of the dye with the help of dispersing agents
- The second step is the adsorption of the dye by the fibre which is turn is affected by solubility of the dye and fabric affinity
- The rate of diffusion of the dye into the fabric

Equilibrium in dyeing

- When equilibrium is reached in each of these steps , the dyeing actually takes place
- If the amount of dye present is not sufficient to saturate the fibre only the first two equilibria will be established
- If the fibre is saturated, the third equilibrium will be attained and dyeing will be completed
- Thus- Aqueous solubility of the dye and dye dye diffusion are the two main factors which govern the dyeing process

Impact of these factors

- The rate of dyeing
- The percentage of exhaustion of the dyebath
- The level dyeing characteristics of the disperse dye

For achieving good fastness

- Addition of small amounts of dispersing agents
- Leads to better exhaustion
- Longer dyeing period ensures better rubbing fastness
- Shorter dyeing times usually cause less level dyeing

Function of the Dispersing agent

- The dispersing agent performs many functions in dyeing
- It assists the process of particle size reduction of the dye
- They increase solubility of the disperse dye
- The choice of dispersing agent is specific for a dye

Dye	Solubility in water	A	B	C
1. Cibacet Orange 2RD	9.5	60	90	26
2. Dispersol Fast Orange A	0.5	46	140	17
3. Duranol Violet 2R	17.0	57	17	34

A- 0.5 %Sodium oleyl-p-anisidine sulphonate

B- 0.5% Castor oil ethylene oxide condensate

C- 0.5% Sodium oleate

Dye solubility only helpful to an extend

- Dye solubility only helpful to an extend, although dyeing rate increases with increasing solubility but upto a certain value and with further increase in solubility the dyeing rate actually decreases.
- Each dye has a favorable dispersing agent and is effective with that agent best

Fibre swelling

- Fibre swelling take place in hydrophilic fibres such as cotton with water molecules occupying the amorphous regions of the fibre
- This imbibed water help translocation to some extent of the absorbed dye
- However in the case of hydrophobic fibres like polyester the fibre structure is so compact that water is not able to swell fibres as a result minimal amount of water is imbibed in the fibre structure , so slow diffusion of dye takes place

Carriers

- The fibre structure may be opened up by the use of carrier or by thermal energy
- For dyeing polyester fibres at temperatures up to 100 degree without any carrier the diffusion of dye is affected
- Therefore use of carrier is recommended. This facilitates the diffusion of the dye molecules

Selection of carrier

While selecting a carrier for the use in polyester dyeing, the following factors should be considered

- 1.High carrier efficiency
- 2.Availability at low cost
- 3.Little or no effect on light fastness on the final dyed product
- 4.Absence of unpleasant odour
- 5.Non toxicity
- 6.Ease of removal after dyeing
- 7.No degradation or discoloration of the fibre

Continued

8. High stability under the dyeing conditions

9. Compatibility with the dyestuff

10. Low volatility

11. Ease of dispersion in the dyebath

12. Uniform adsorption by the fibre

These dye assistants alter the dispersion properties of the dyes and the physical properties of the fibre so that more dyestuff can be transferred from the dyebath to the fibres.

Mechanism of the role of the carriers

Carriers generally swell the fibres

Swollen fibres permit the large dye molecules to diffuse more rapidly

Some products having hydrophilic groups such as o-phenyl show rapid diffusion rate in polyester fibres

The diffusion rate is hindered by the affinity forces which bind the dye molecules on the walls of the fibre pores.

Good swelling agents

Phenol

O-phenyl phenol

P-phenyl phenol

Methyl salicylate,

Diphenyl

M-cresol are swelling agents for polyester fibres

However, Those with ionisable groups are less effective such as benzoic acid, beta-naphthol sulphonic acid,

Properties of carrier dyeing

1. Possibility of dyeing in machines operating at atmospheric pressure
2. Reduced dyeing cycle due to accelerated dyeing
3. Improved fastness properties due to increased penetration in the fibre
4. Increased levelling and hence a better coverage of dye on the surface of the fibre
5. Some carriers reduce the staining of wool while dyeing polyester/wool blends

Disadvantages with carrier

1. Increased cost
2. Decreased light fastness with some carrier
3. Toxicity of some carrier
4. Some have low emulsion stability and can cause carrier spots
5. Odour and air pollution
6. Some are dye specific having different efficiencies with different dyes

Actual dyeing machines used

In actual practice the polyester components are dyed by the carrier method in

1. Jiggers
2. Winch-beck

Where the dye used is the ones with high diffusion coefficients, dyes with low diffusion coefficients are less suitable

However uniform heating of the fabric presents difficulties in Jigger due to loss of heat in the open system even when it is heated to 100 degree the temperature available to the fabric is only 80-90 degree
The conditions with Winch-beck dyeing are more favorable

Role of Dyeing Auxiliaries

The role of dyeing auxiliaries such as carriers and levelling agents in the dyeing of polyester fibres with disperse dyes in high temperature dyeing machines is well known.

Calculated and optimal dosage and application of the auxiliaries were documented by calculating the acceleration factor =a

$a = \frac{\text{dye exhausted with auxiliary}}{\text{dye exhausted without auxiliary}}$

Levelling agents

Levelling agents act in a similar manner as the carriers with respect to the interaction with the dye, equilibrium effect and migration effect

They do not interact with the fibre, thus have no role in accelerating the dyeing process

They also have lower effect on migration as compared to carriers

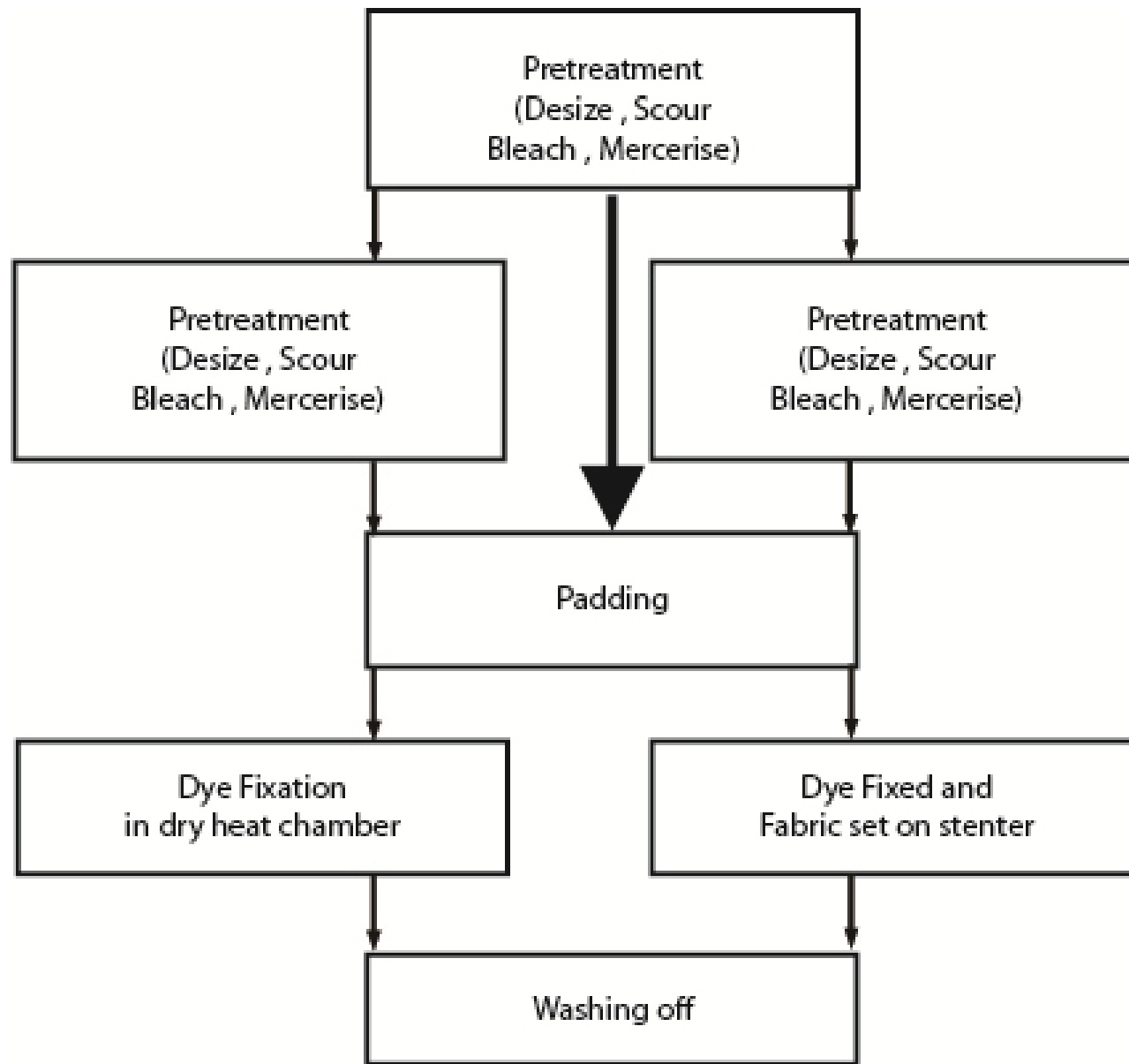
High temperature dyeing

Polyester fibres and their blends may be dyed under high temperature conditions above 125-130 degree. Above 100 degrees , the fibre swells to a great extend and hence there is rapid penetration of the dye molecules in the fibre structure

There is decresed resistance to the diffusion of the dye molecules at 130 degrees than at 100 degrees
Even the disperse dye is much more soluble in water at a higher temperature

Thermosol dyeing

- Du Pont introduced this dyeing method called Thermosol dyeing for nylon, polyester and orlon without the use of carrier
- Here the advantage taken is that synthetic fibres are considered to be thermoplastic and when these fibres are heated to a high temperature, they soften, their internal structure is opened up facilitating the entry of disperse dye in the fibre
- This plasticizing effect of heat on these fibres is responsible for rapid rate of diffusion of the dye, requiring only a few seconds to a few minutes



Factors that matter in polyester dyeing

1. Dye selection
2. Carrier selection
3. Dyeing temperature and time
4. Use of Glauber's salt
5. Pre scouring by anionic detergent or liquor ammonia
6. Dyeing
7. After scouring with non ionic detergents and acetic acid