Dyeing applications with reactive dyes

History of reactive dyes

- Introduction of reactive dyes- such as Procion Yellow R, Brilliant Red 2B and Blue 3G by ICI in 1956 made its entry into the synthetic dyestuff market in a big way

- These dyes chemically reacted with the fibres with the formation of covalent bond between the dye and the fibre and therefore their name –REACTIVE Dye

Reactive dyes quality requirements

- Should be powder or liquid dyes
- Should have excellent stability
- Should have good solubility
- Low to medium substantivity
- Good compatibility
- Good diffusion and levelling properties
- Rapid fixation
- High degree of fixation
- Excellent washing fastness

Application of Reactive dyestuff

- Application of this dyestuff was due to the following facts:
- Physical adsorption of the water soluble dyestuffs from an aqueous medium by the fibre by reversible attachment to active sites present in the fibre
- Mechanical retention of the water insoluble dyes in the fibre by application involving temporary solubilization before applying
- Dissolution of the dyestuff in the fibre

Reactivity and affinity of this dye

- Reactivity of the dye is related to facts- if the reactivity of the dye is increased considerably, the rate of reaction with the fibre increases, dyeing rate is fast
- However, if the rate of hydrolysis of the dye increases, it leads to deactivation of a part of the dye, resulting in wastage of the dye
- If the reactivity of the dye is decreased, the extent of hydrolysis can be reduced considerably, but this would result in slow rate of reaction with the fibre
- However the ultimate objective of dyeing is to react as much o9f the dye as possible with the fibre and minimise the hydrolysis of the dye.

How it happens

This is achieved in practice in two stages-

1. dying should be started in neutral medium when the dye does not react either with the fibre of with water

2. Glauber’s salt or common salt should be added to exhaust the dye onto the fibre as much is possible

3. Then finally the fixing of the dye is done by the addition of the alkali(soda ash) as the dye is already exhausted into the fibre, will not be available for reacting with water

4. It is already known that the hydrolysed dye cannot further react with the fibre, but due to affinity forces, it is absorbed by the fibre and retained in it.

Stripping

During the subsequent washing or soaping the substantial hydrolysed dye gets stripped into the washing bath thus reducing the wash fastness of the dyed fibre.

If the affinity of the original dye is reduced to a very low value, this problem can be avoided, however if the affinity is too low, exhaustion of the dye prior to fixation cannot be achieved substantially.

If the dye affinity is high, then it is very difficult to remove the hydrolysed dye since it is absorbed and retained in the fibre by fairly strong affinity forces

Thus in actual practice low affinity dyes are selected

Process applied for dyeing

Dyeing can be carried out by 1.Batch dyeing processes

2. Continuous dyeing process

Batch dyeing processes keeping in mind the following points:

a) The pH of the dye bath

b) The temperature of the dyeing

c) The concentration of the electrolyte

d) The time of dyeing

e) The liquor ratio

2. Continuous dyeing processes

Reaction of dye with the fibre in the presence of water and alkali in a short time at elevated temperatures take place

The rate is further increased if the pH is high

This is the basis of continuous dyeing process to be possibly used with reactive dyes

Depending on the reactivity of the dye – two processes are possible-single padding and double padding

Single padding

- In single padding- the pad liquor contains the dye and the alkali, which does not hydrolyse the dye at room temperature
- For example- cold brand reactive dyes sodium bicarbonate is the preferred alkali, which on heating produces strong alkali- sodium carbonate
- Hot brand reactive dyes- sodium carbonate is added to the pad liquor- for pad bicarbonate in dry process
- Pad (alkali) dry steam process with bicarbonate or carbonate

Dye solubility in presence of Alkali

- Good solubility of the reactive dyes helps in preparation of highly stable and solvent free solutions of the dyestuff
- High solubility at room temperature
- No risk of dye being degraded
- Easy dyebath preparation

Double padding

- In this process the fabric is padded with the dye solution and re-padded (with or without intermediate drying) with an alkali solution containing a high concentration of salt to minimise bleeding of the dye from the cloth into alkali bath and then it is steamed

- The wastage of the residual liquor at the end of padding is low

Fiber reactive dyes

- **Fiber reactive dyes** are indisputably the best choice for dyeing any cellulose fiber including cotton, rayon, hemp and flax. They're simpler to use, more fade resistant and generally safer than direct dyes, vat dyes, napthol dyes and all purpose dyes

- Fiber Reactive dyes can also produce exceptional results on **silk** (when used properly) without the drawbacks of other dyes traditionally used on silk - including acid dyes, natural dyes and vat dyes.

- Fiber reactive dyes offer superior ease of use and vivid, permanent colors yet they still clean up easily with water. All while being non-toxic, safe for home use and actually fun to work with.

How much reactive dyes are fixed

- Mono reactive dye- Dye fixation is 75% and dye hydrolysis is 25 %
- CIBACRON DYES- Pad batch 90-99%
- Pad dry- pad steam- 85-95%
- Pad thermofix- 82-92%
- Pad humidity fix- 82-92%
- Pad steam -70-90%

How important is affinity factor

- If the reactive dye chosen has low /medium affinity, it will show the following:

1. Good penetration and levelling
2. Excellent wash off and wet fastness properties
3. Low risk of tailing

Pad batch dyeing

Merits

- Modest investment layout
- Suitable for small and fairly large batches
- Very simple working conditions, Limited manpower required
- Low energy consumption
- Lower water consumption than exhaust dyeing
- Good penetration and level dyeing, Good reproducibility
- Suitable for dyeing knit goods

Demerits

- Batch process
- Higher dye consumption than pad-dry-pad-steam
- Moderate coverage of dead and immature cotton

Continuous method(Pad – steam)

Continuous method mainly used for dyeing fabrics with high liquor retention, such corduroy, because no intermediated drying is required

Merits

- No migration problems
- Reduced energy costs
- Good appearance of the dyedfabrics
- No detrimental influence onfastness
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Demerits

- Higher amounts of dye are required to produce deep shades compared to the pad-batch or pad-dry-pad-steam processes
- Worthwhile for dyeing deep shades when the higher dye costs are at least balanced by savings in energy and gains in productivity

Pad dry- pad steam process

Merits

- Economical process for large production runs
- Still economical for fairly small runs (>5000m) on modern equipment
- High colour yield
- Very good appearance of the dyed fabric
- Good reproducibility
- No detrimental influence on light and/or chlorine fastness

Demerits

- Shade changes are time consuming
- Less suitable for dyeing fabrics prone to migration problems or difficult to dry(pile fabrics)

Pad Thermofix process

Merits

- Good colour yield on fabric and coverage of dead fabric
- Very good lab to bulk reproducibility
- Good batch to batch reproducibility
- Moderate soiling of machinery
- No need for a chemical pad liquor

Demerits

- Not recommended for dyeing regenerated cellulose
- Possible specky appearance of the dyed fabric
- A negative influence on the fabric handle is possible
- Danger of yellowing of the substrate
- Lower light / chlorine fastness level
- The process requires urea

Cotton dyeing with Reactive dyes

- **Cotton fabric** after pre-treatments e.g desizing, scouring & bleaching can be dyed using the following recipe:

- Reactive Dyes————————–X%
  Sequestering agent————–0.5 G/L
  Wetting agent————————–0.1-0.5 G/L
  Ant-creasing agent————–0.5-2.0G/L
  Salt————————————10-80 G/L
  Soda————————————–2-20G/L
  Temperature ————————-60-80 Degree
  Dyeing time————————- 60 minute.

- When the cotton fabric dyeing is complete, the dye liquor is drain-off. The fabric is washed with hot water at 40 degree c & then with cold water. Again wash the dyed fabric with 1-3 G/L soap or detergent at 60 degree – 80 degree c for at least 10 minutes. Then drain –off the washing liquor. Again wash the dyed fabric with hot water & then with cold water.
  Finally, the dyed fabrics is taken out from the machine, hydroextuct the fabric and dry the fabric passing through any other drying machine.