Master Training Program on Water (Water Supply, In-house Processing, End-of-Pipe) in Textile and Garment factories

Promotion of Sustainability in the Textile and Garment Industry in Asia - FABRIC

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

FABRIC Asia

Day 2: Presentation 1

Process Optimisation – Cotton Knit Fabric dyeing

Outlines

Contents

Knit dyeing – Exhaust process

- ✓ Pretreatment (scouring, bleaching, singeing, biopolishing)
- ✓ Dyeing (reactive, direct, Vat etc.)
- ✓ Finishing (Compacting, stenter, drying etc.)

Understanding technology of dyeing machine for low water requirements

Process Modification

Advance Dye Chemistry

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Learning Outcomes

At the end of this module, you will be able to

- Understand the use of water cotton knit fabric batch dyeing
- differentiate requirements in reactive dyeing
- assess possible changes and impacts in process steps and production technologies
- apply process specific low water consumption technologies in selected production processes
- Use of green and advanced chemistry

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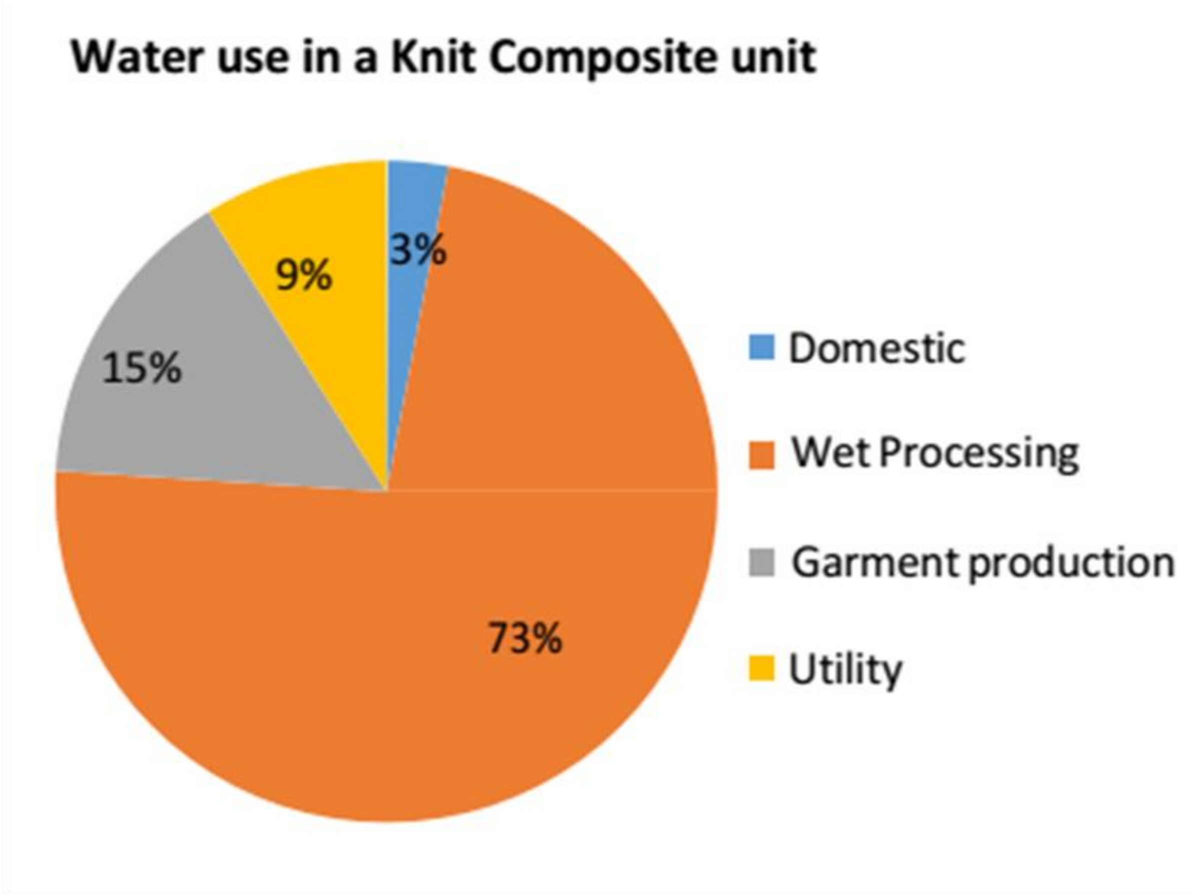
Water use in exhaust dyeing process

Water consumption in Knit composite and RMG unit



Source: Reed Consultancy reference database 2016

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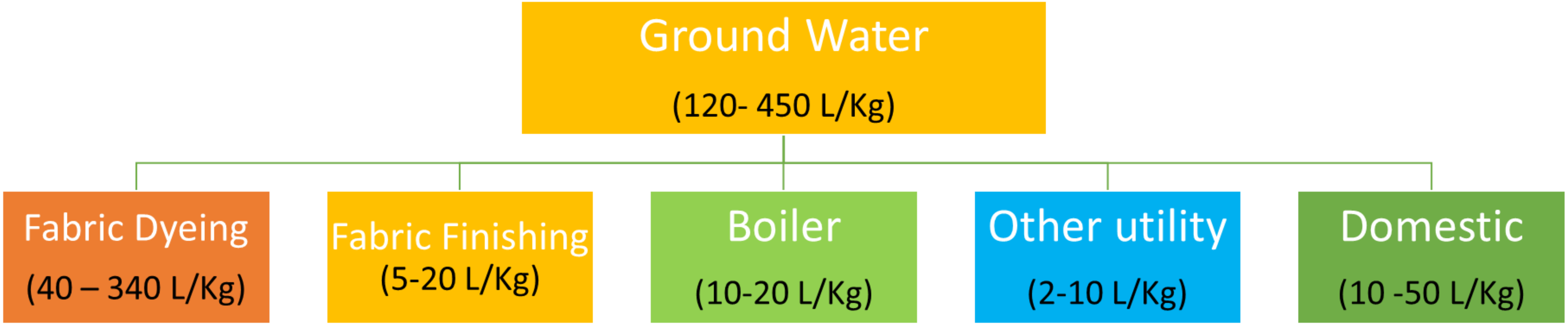
Water consumption in Knit composite and RMG unit



Source: Reed Consultancy reference database 2016

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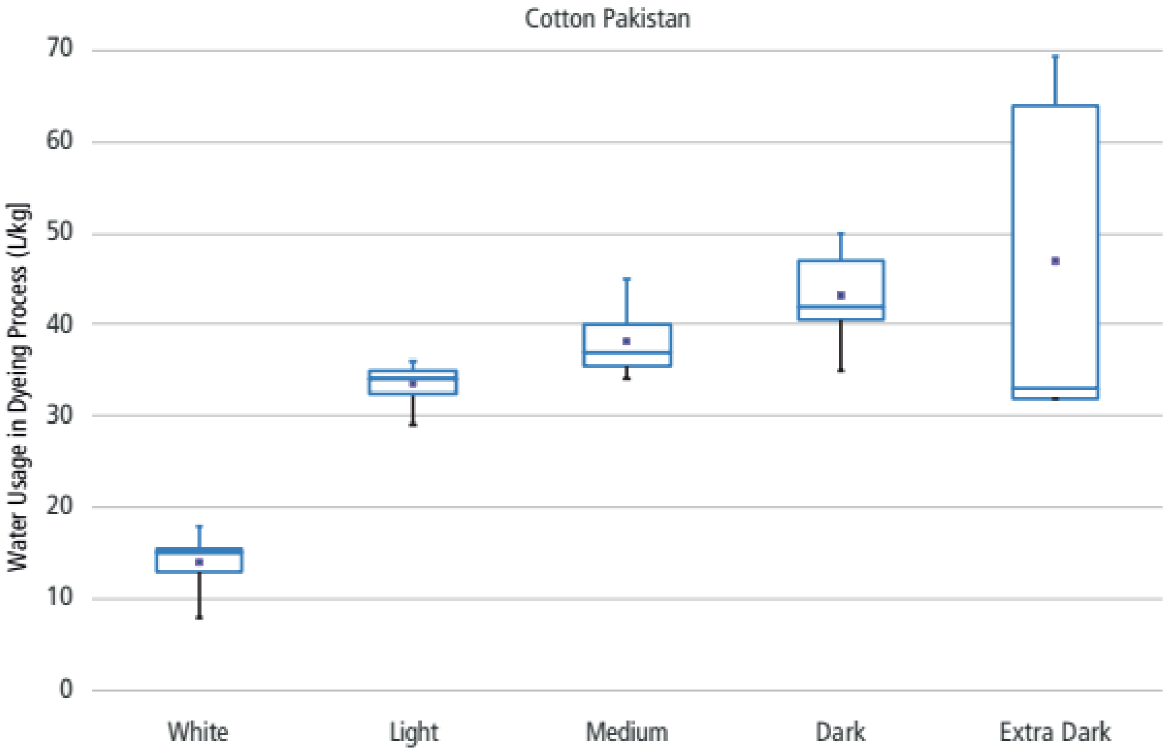
Water use in exhaust dyeing process

- Exhaust method vs Padding methods
- Exhaust methods are water-intensive process due to use of high liquor ratio, meaning the amount of water require to dye a kg of textile substrate.
- The water requirement varies with
  - ✓ Fibre types and their combination
  - ✓ the depth of colour
  - ✓ Machinery types
  - ✓ Dyestuff chemistry



Source: Water as a Global Resource (GRoW) 2021

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Exhaust dyeing

- In exhaust dyeing a certain amount of textile material is loaded into a dyeing machine and brought to equilibrium with a solution containing the dye and the auxiliaries over a period of time.
- The dye liquor, with initial high dye contents, becomes **gradually exhausted** while the dye accumulates in the fiber.
- At the end of the process the material is washed or rinsed to remove the unfixed dye.

What is Exhaustion?

For a single dye, the exhaustion is defined as the mass of the dye taken up by the material divided by the total initial mass of dye in the bath, but for a bath of constant volume:

C_0 = concentration of dye initially solution
C_f= Concentration of dye in fiber after dyeing

C_S= Concentration of dye in solution after dyeing

Exhaustion % = C_f / C_0 x 100

or

$$\% \text{ Exhaustion} = \frac{C_0 - C_s}{C_0} \times 100$$

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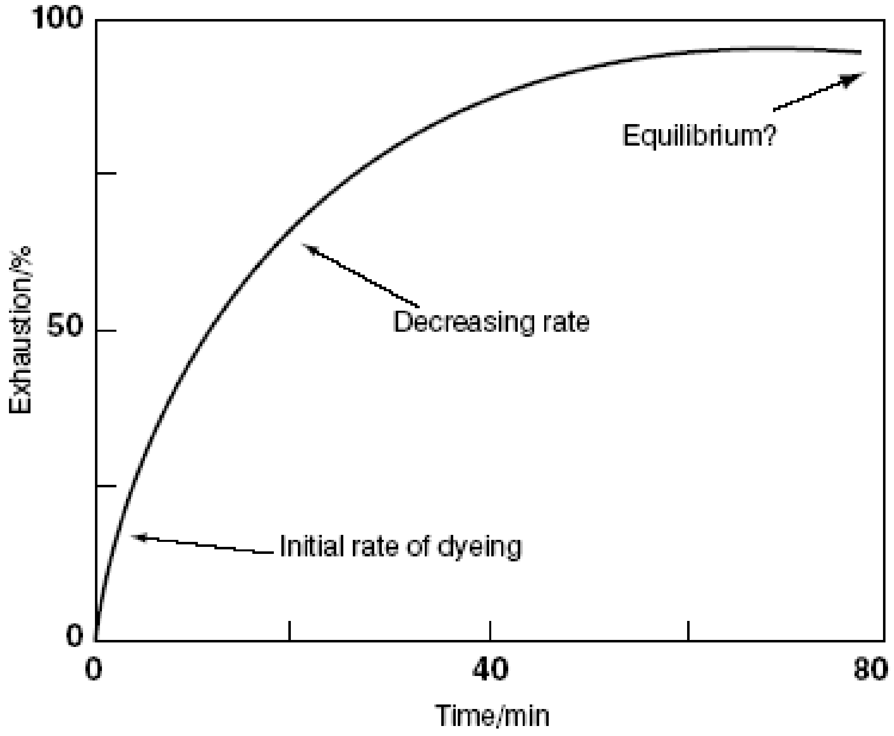
What is Exhaustion?

Exhaustion: as a function of time



.2 Dyebath exhaustion as a function of time

Typical Exhaustion level in Batch dyeing

Dye/Fibre combination	Exhaustion%
Acid/nylon	80 to 99%
Azoic/cotton	90 to 95%
Basic/acrylic	98 to 100%
Direct/Cotton	70 to 95%
Disperse/polyester	85 to 98%
Reactive/Cotton	**50 to 90%**
Sulfur/Cotton	60 to 90%
Vat/Cotton	80 to 95%

Group Task

How much dye will be exhausted for 1000 kg cotton fabric with 2% Shade?
The minimum – The maximum

What is Fixation?

Fixation is basically how much the dye reacts with the fabric. It depends on how much dye is fixed onto the fabric after considering all the washes.

Formula will be:

Fixation % = $[\{C_0-(C_1+CW_1+CW_2+.....)\}/C_0] \times 100$

C_0 = concentration of dye initially

C_1= Concentration of dye after dyeing

CW_1, CW_2 are concentrations of the dye in each wash.

Typical Fixation level in Batch dyeing

Dye/Fibre combination	Fixation%
Acid/nylon	80 to 95%
Basic/acrylic	95 to 100%
Direct/Cotton	70 to 95%
Disperse/polyester	80 to 90%
Reactive/Cotton	**50 to 90%**
Sulfur/Cotton	60 to 90%
Vat/Cotton	80 to 95%

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Group Task

How much dye will be fixed for 1000 kg cotton fabric from the exhausted dye before? The minimum – The maximum

Reactive Dye

A dye that, under suitable conditions, is capable of reacting chemically with a substrate to form a covalent dye-substrate linkage.

- Most popular dyestuff in the world.
- used on cellulosic fibers (cotton, rayon), protein fibers (wool, silk), and nylon.
- These dyes offer good color fastness and bright colors are possible.
- Widest and full color range from extremely bright to heavy dark shades.

Yellow 2GL	
Golden Yellow 2RL	
Orange 2R	
Scarlet	
Red BG (primary)	
Red 4B (bluish red)	
Red 8B (magenta)	
Rubinole 5B	
Brilliant Blue 2R	
Brilliant Blue BL	
Violet 2R	
Turquoise 2G	
Navy GRL	
Brown 2R	
Brilliant Green BL	
Black B (blue base)	
Black 2B (green base)	

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Reactive Dye

Why reactive dyes are so popular?

Reactive dyes are superior to direct dyes in the following aspects:

- Ability to produce bright shades of wide range.
- High leveling quality.
- Good washing fastness. (Rating 4)
- Very good light fastness. (Rating 5-6)

Again it is superior to vat dyes in the following aspects:

- Simple dyeing method.
- Low temperature dyeing (below 100^0c)
- Cheap.

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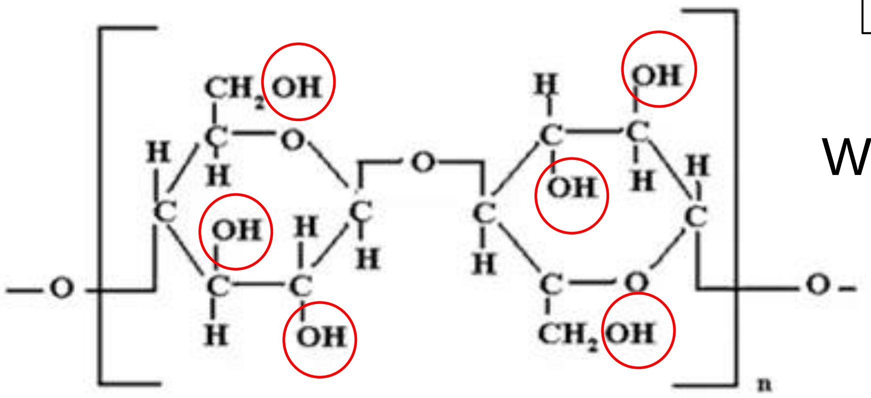
Reactive Dye

General Features of a Reactive Dye Molecule

OH-Cellulose



Cellulose unit

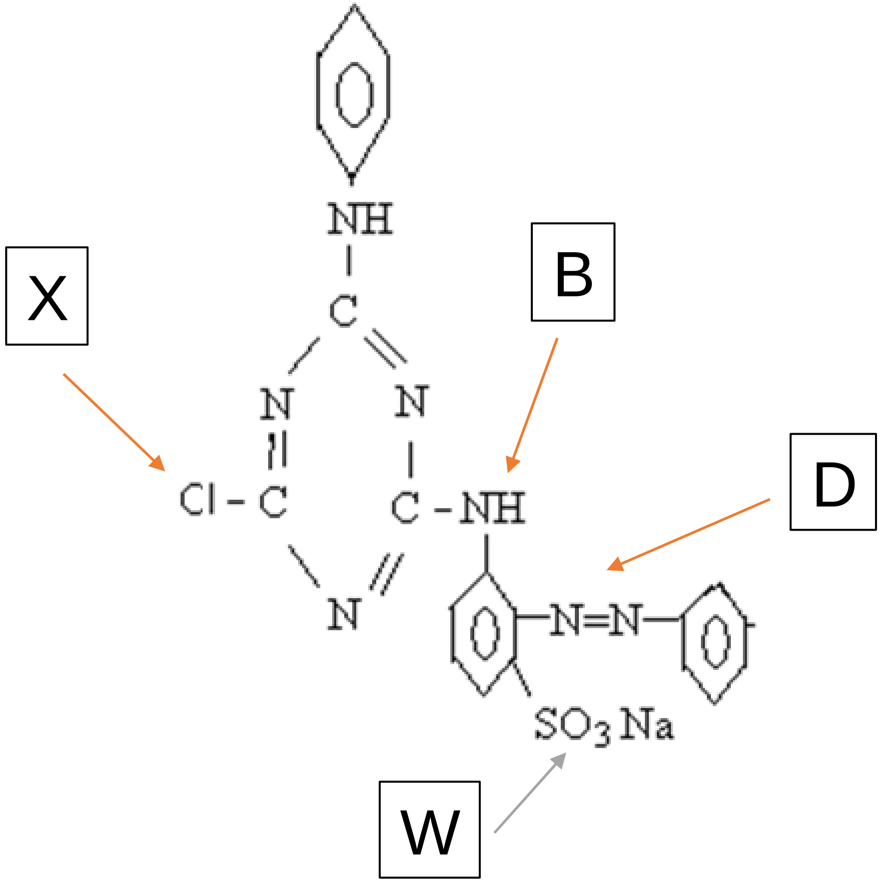
W — D — B — X

W = Water solubilising group

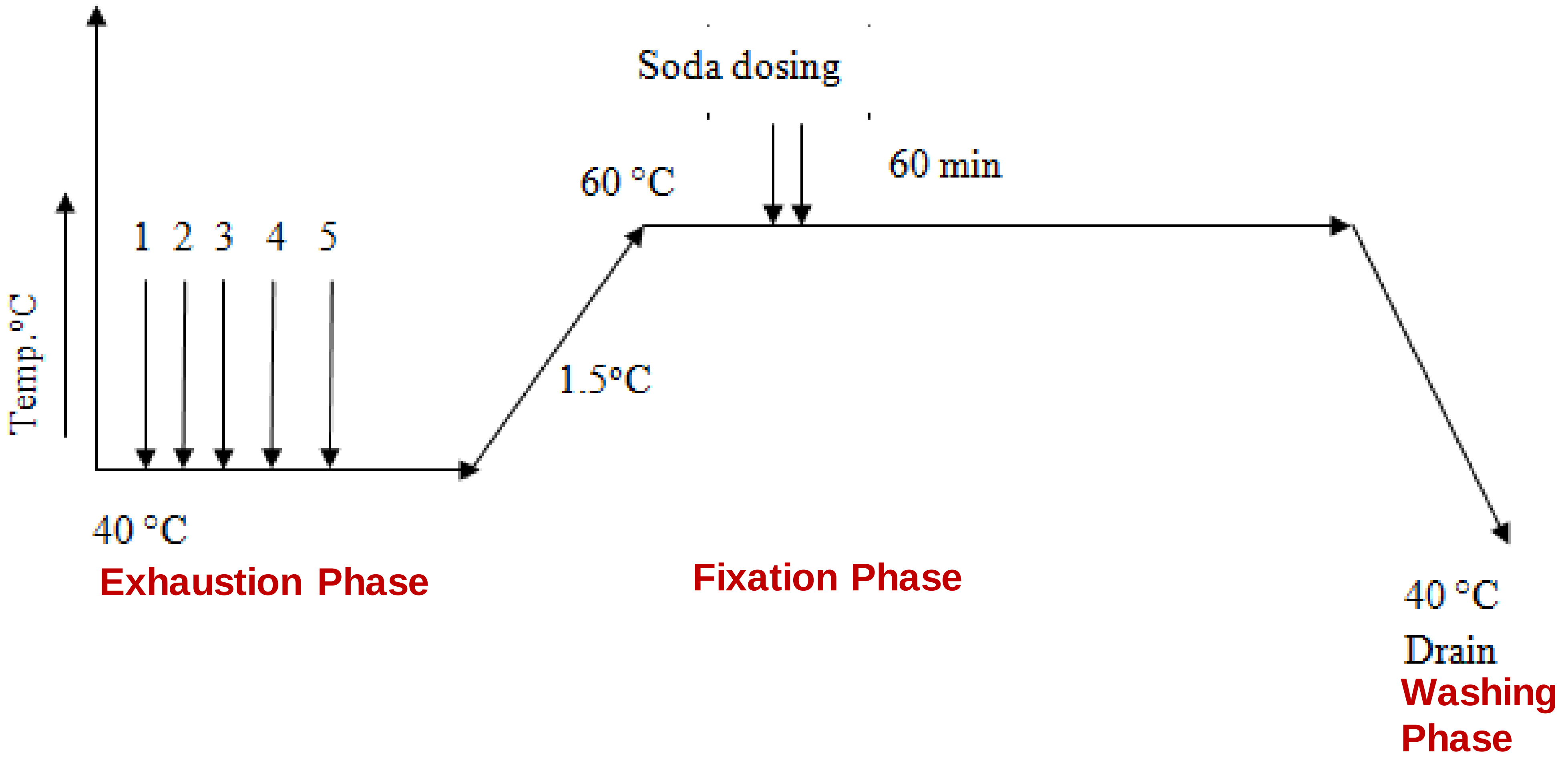
D = Chromophore

B = Bridging group

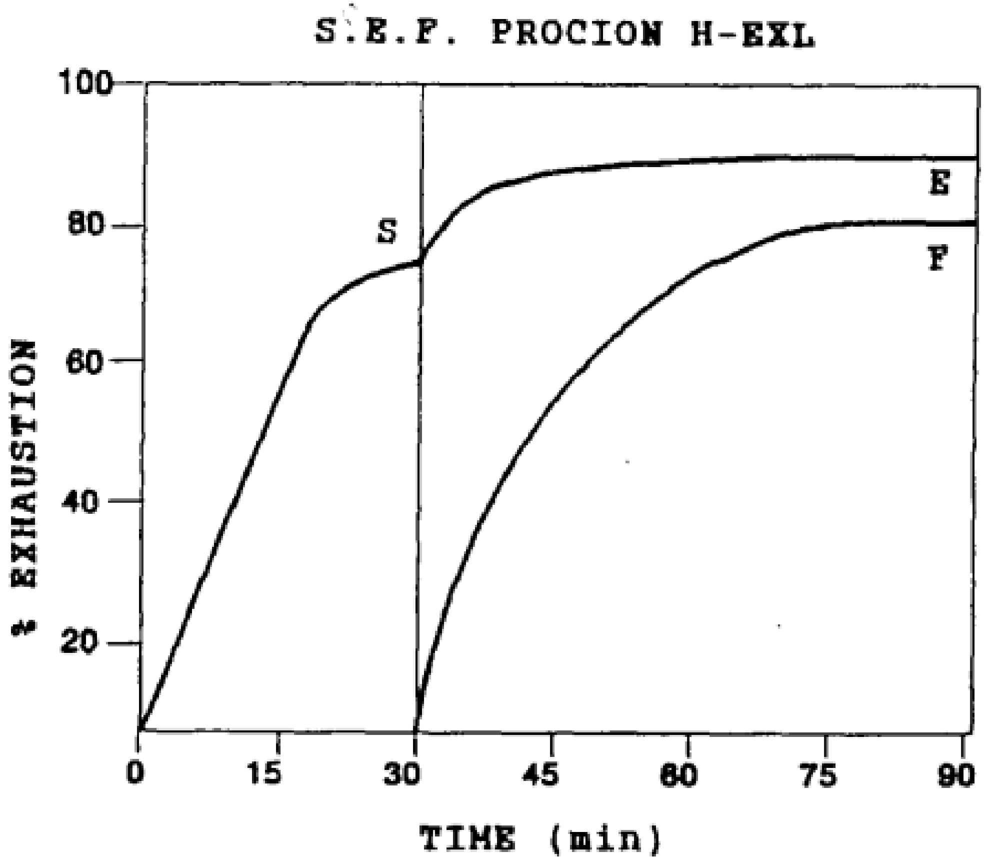
X = Reactive group



Dyeing Curve

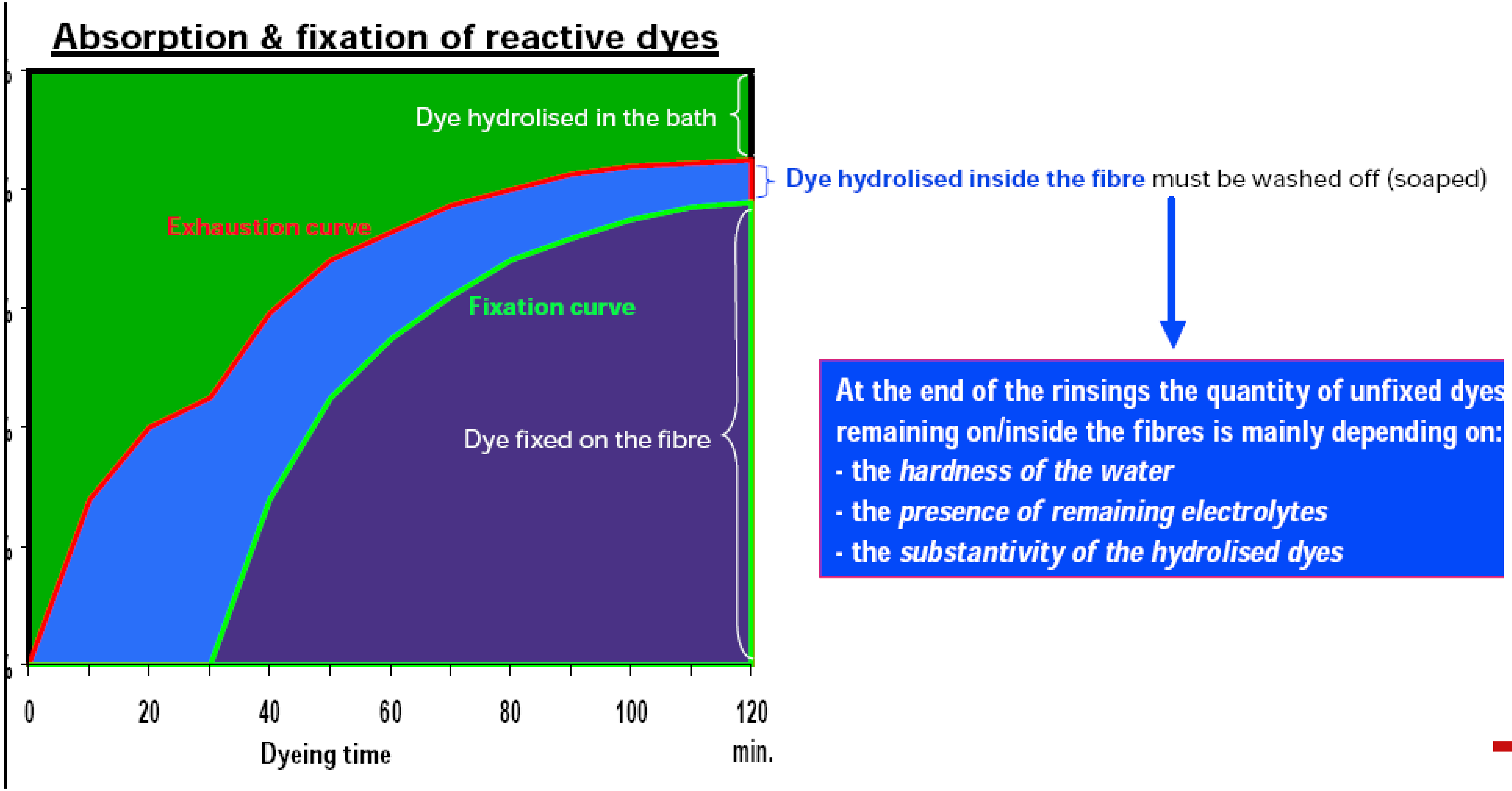


Reactive dyes



Reactive Dye

Dye Exhaustion and Fixation



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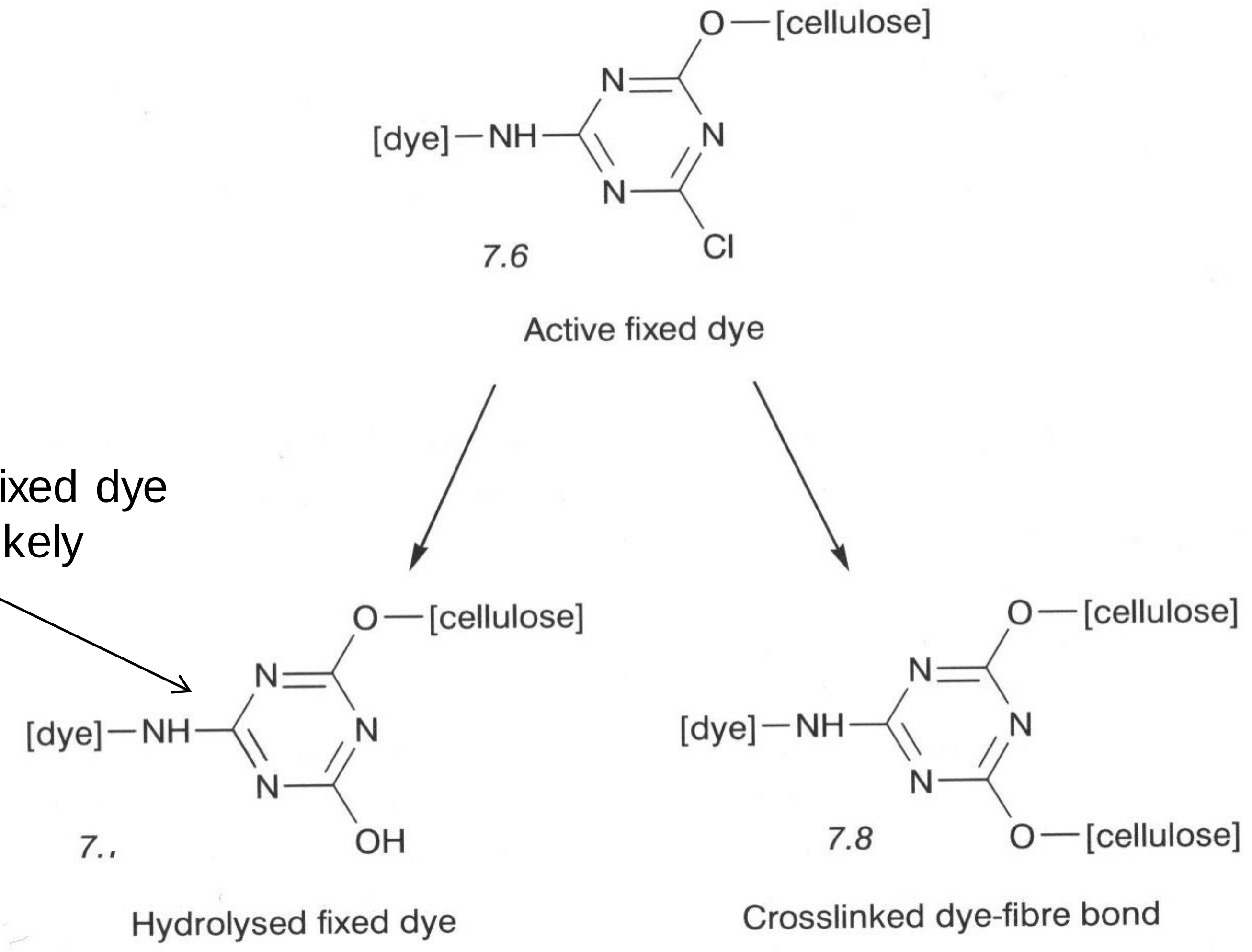
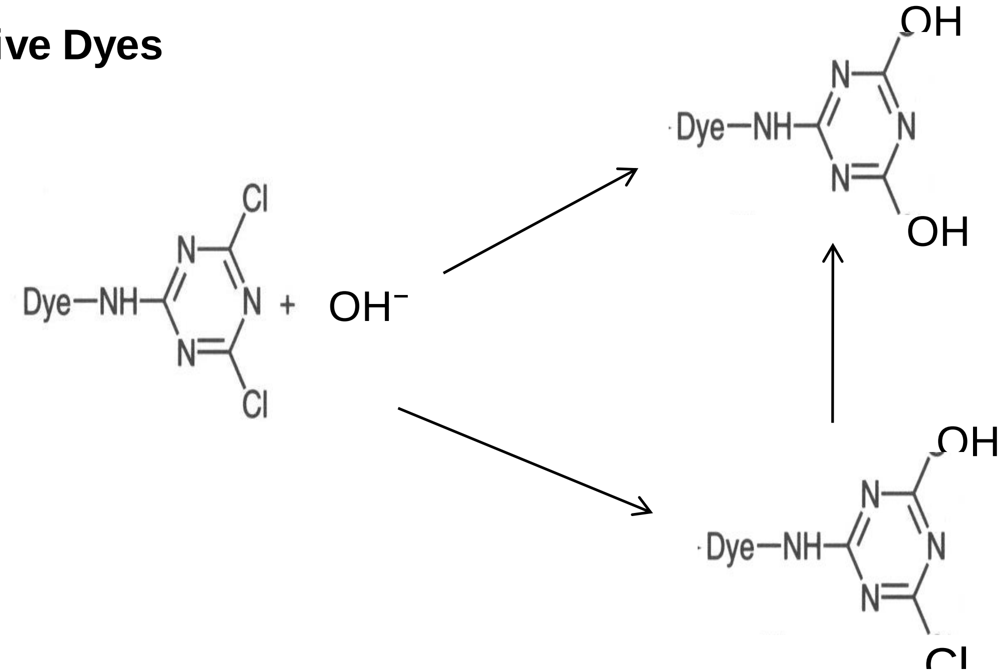
Fixation Reaction with Cotton

Hydrolysed fixed dye
is most likely



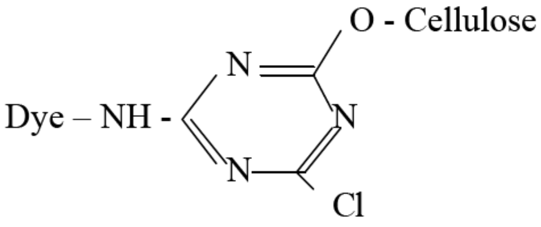
Reactive Dye

Hydrolysis of Reactive Dyes

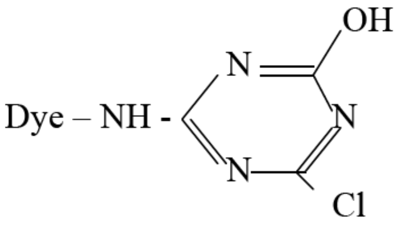


Hydrolysed dye is unreactive

Partially hydrolysed dye is still reactive



Dichloro-s-triazinyl dye reacted with cellulose



Dichloro-s-triazinyl dye hydrolysed – reacted with water

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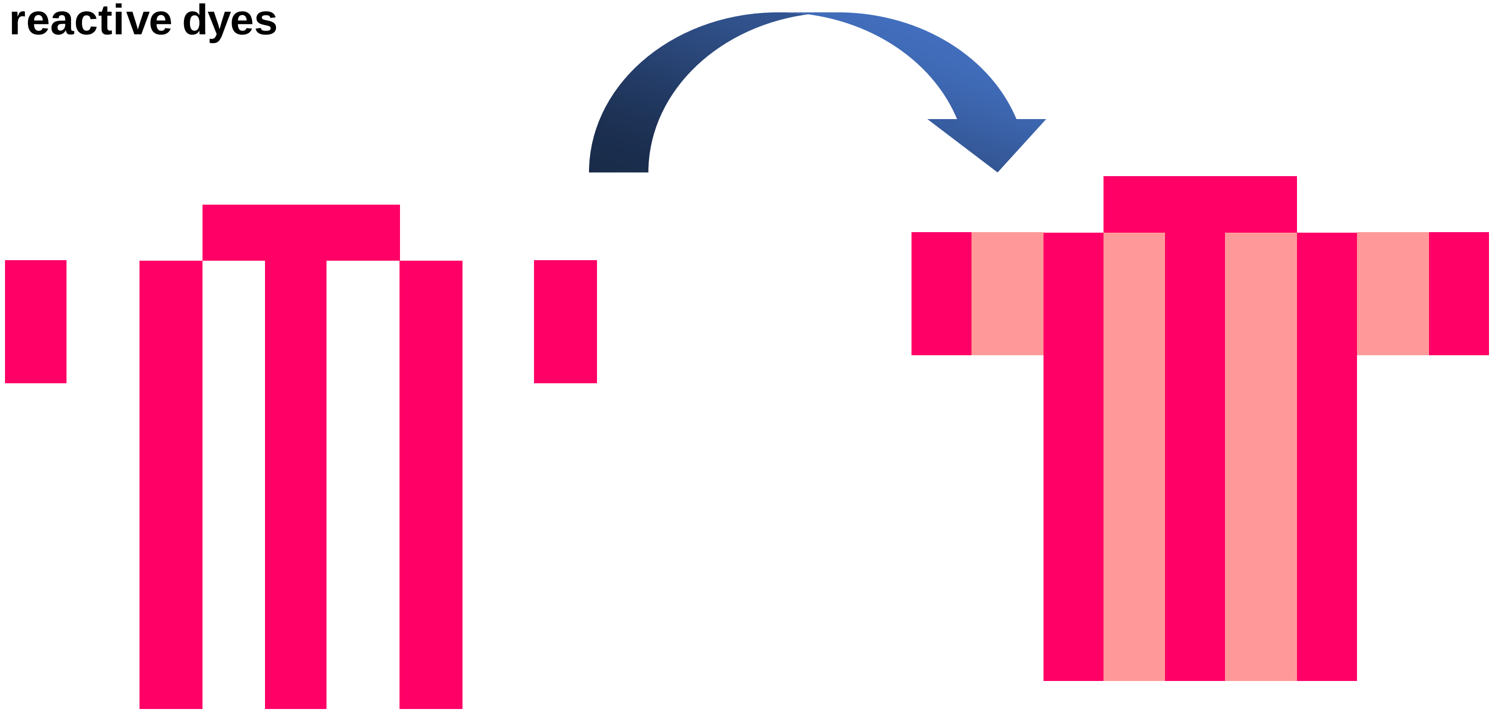
Reactive Dye

Washing-off reactive dyes

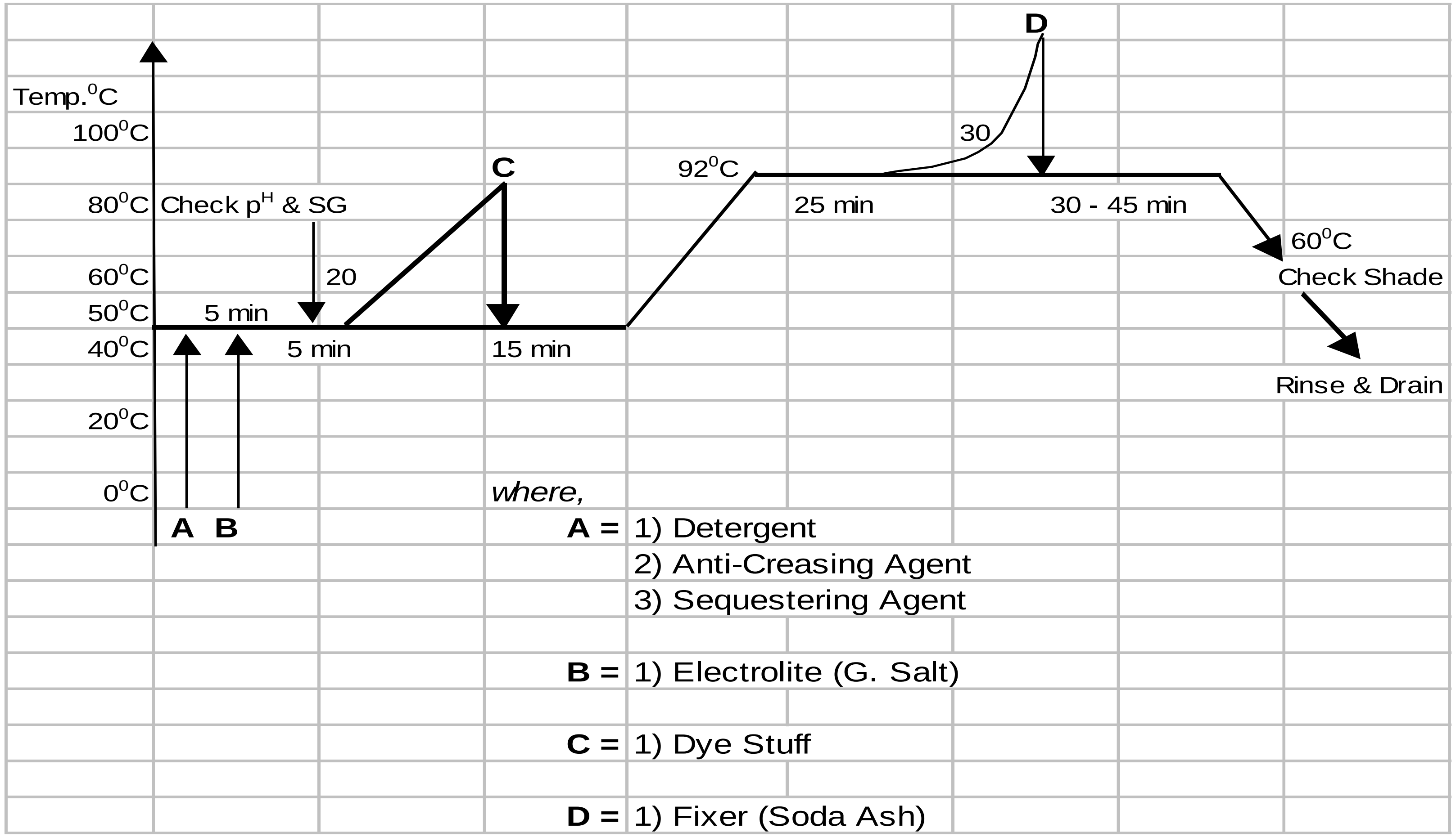


Poor wash fastness

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.

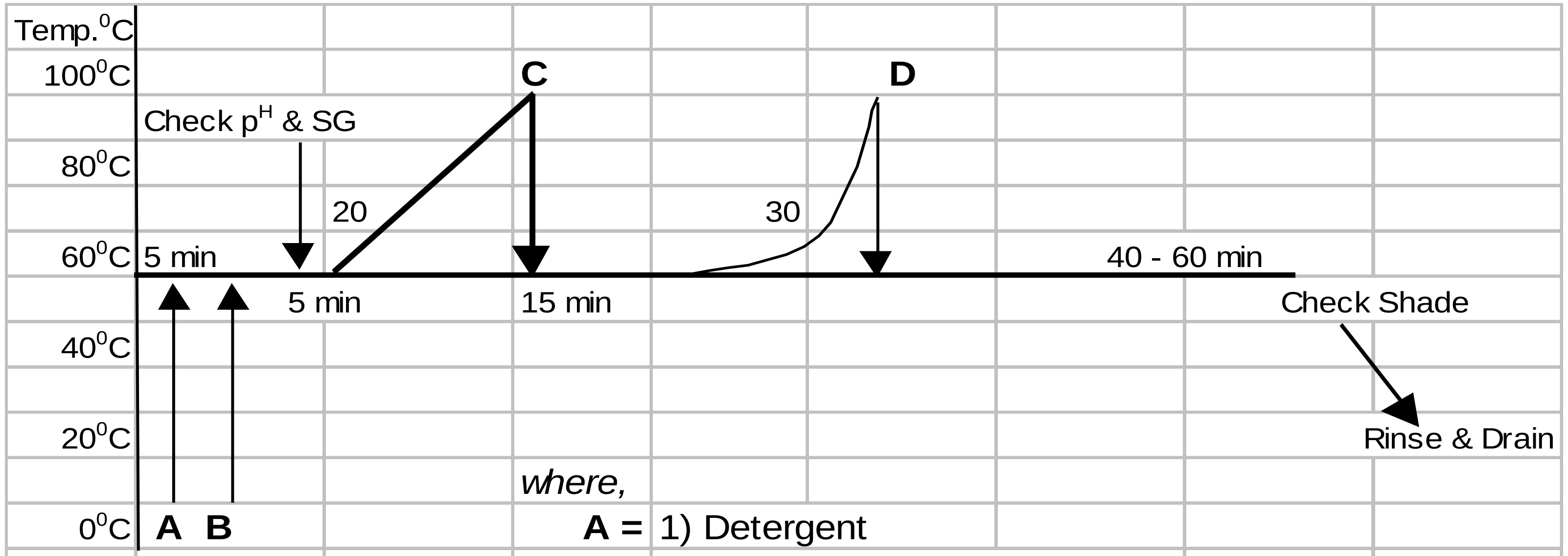
Reactive Dyeing

Dyeing Procedure: An Example



Reactive Dyeing

Dyeing Procedure: An Example



where,

A = 1) Detergent
2) Anti-Creasing Agent
3) Sequestering Agent

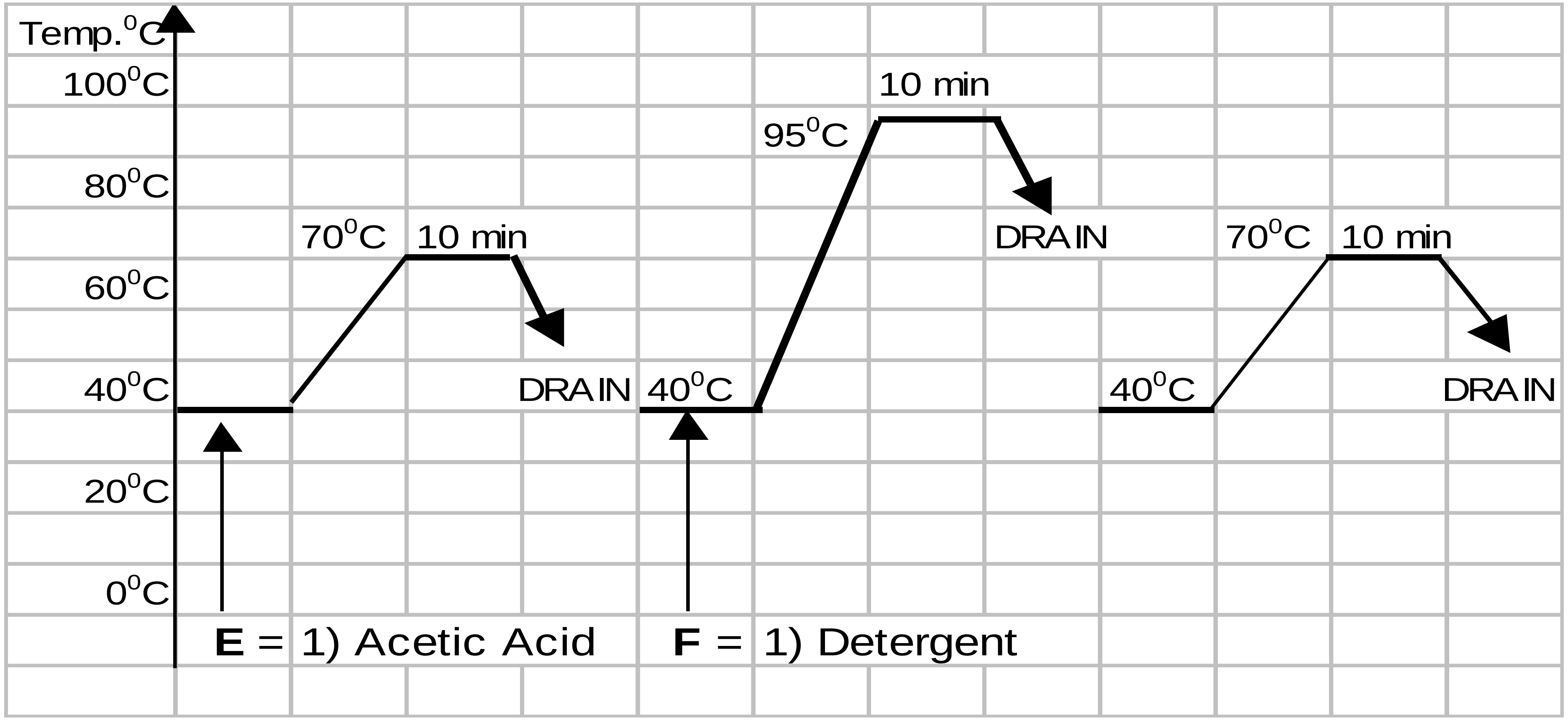
B = 1) Electrolite (G. Salt)

C = 1) Dye Stuff

D = 1) Fixer (Soda Ash)

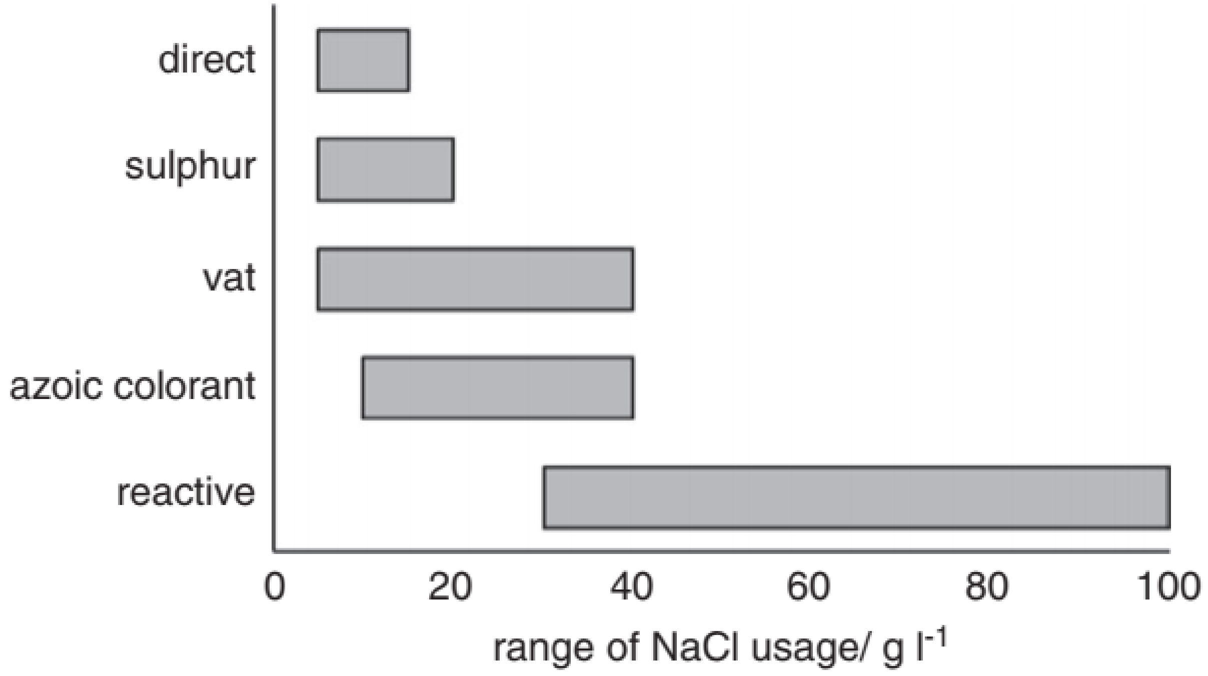
Reactive Dyeing

After treatment



Reactive Dyeing

Salt requirements



Typical amounts of NaCl required for dyeing of cotton according to dye class. Source: Burkinshaw 2021

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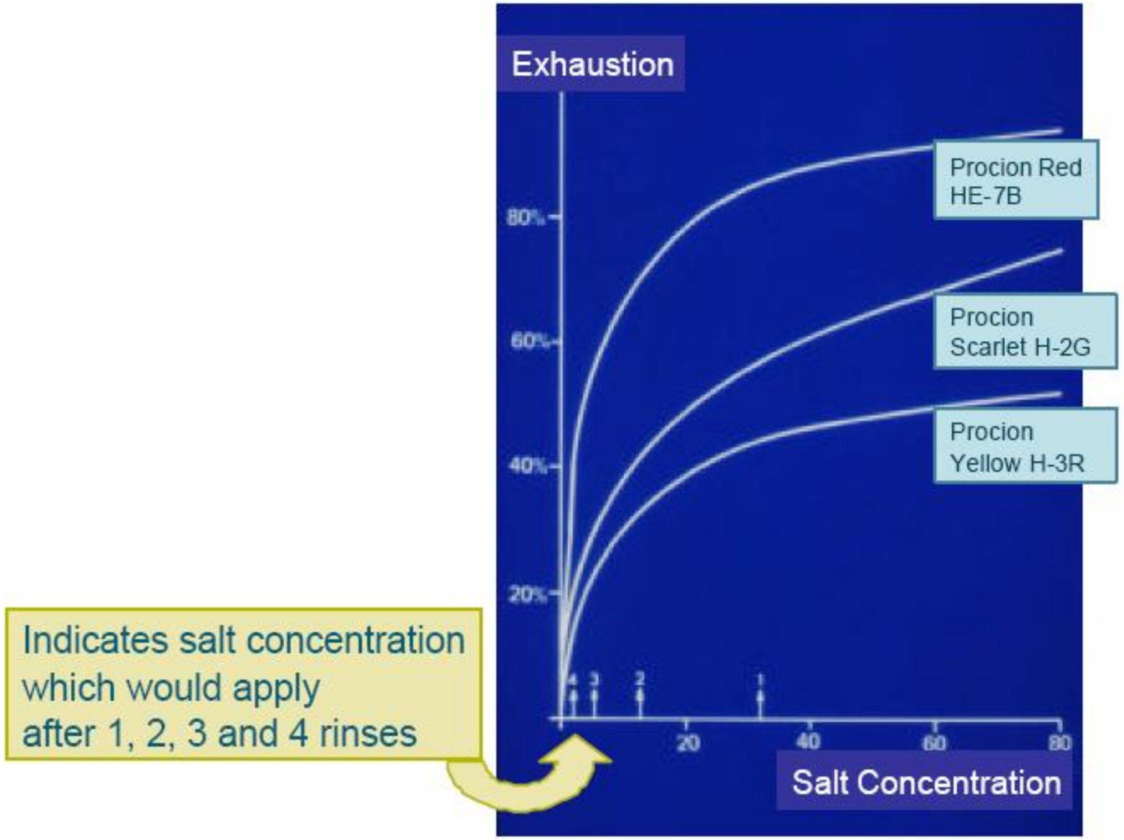
Reactive Dyeing

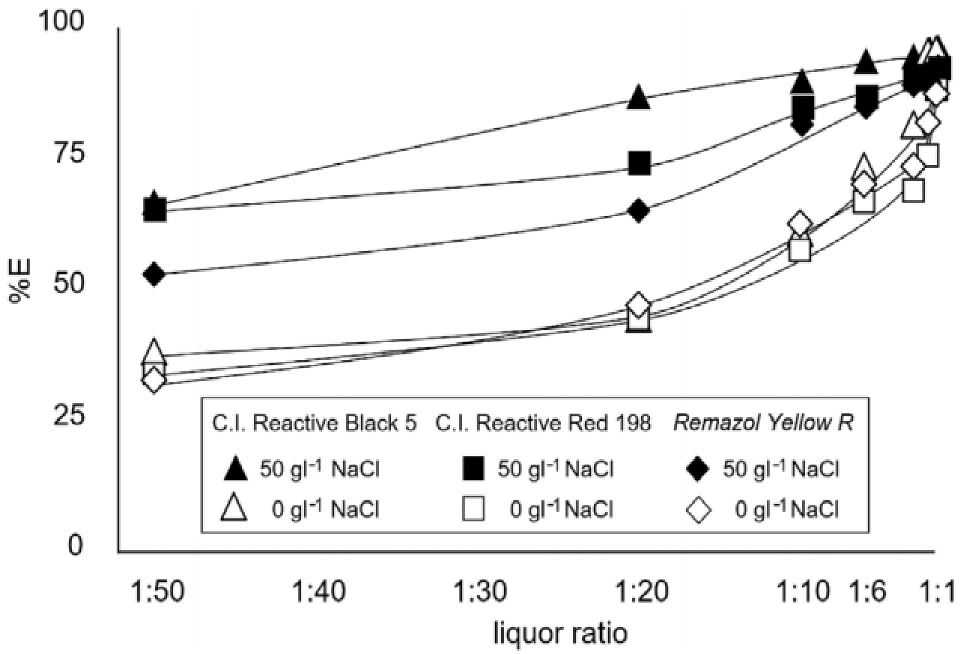
Effect of Salt in Reactive dyes - Exhaustion of 5% shade at 5:1 liquor ratio as affected by salt



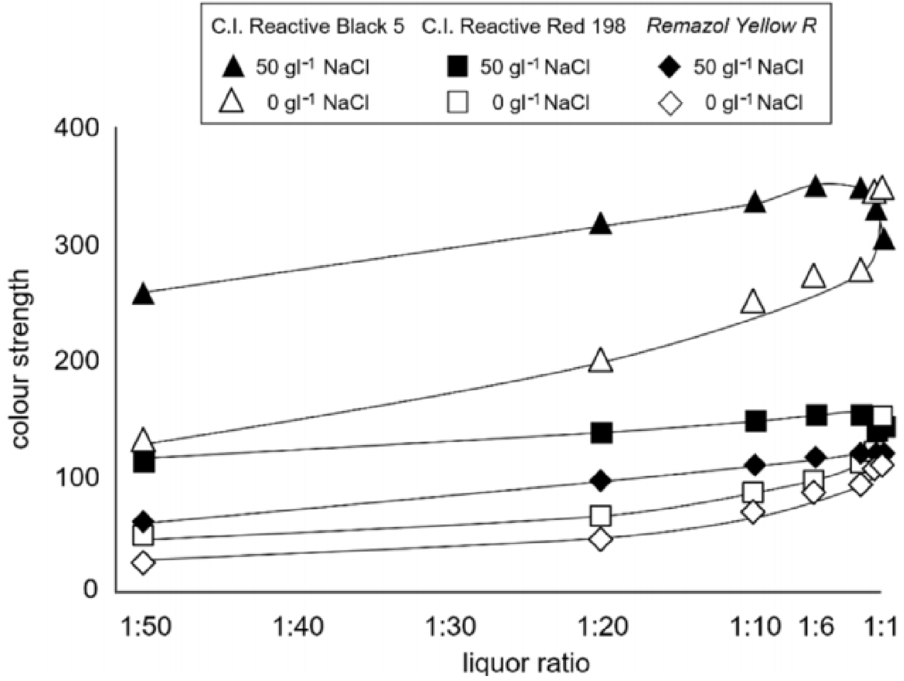
The graph shows requirement of salt necessary to exhaust a reactive dye. In the same way salt concentration must be reduced to 1g/l for efficient wash off

Reactive Dyeing

Effect of liquor ratio and salt consumption
Source: Burkinshaw2017



Effect of liquor ratio on dye exhaustion; absence and presence of 50 g/L NaCl.



Effect of liquor ratio on colour strength; absence and presence of 50 g/L NaCl

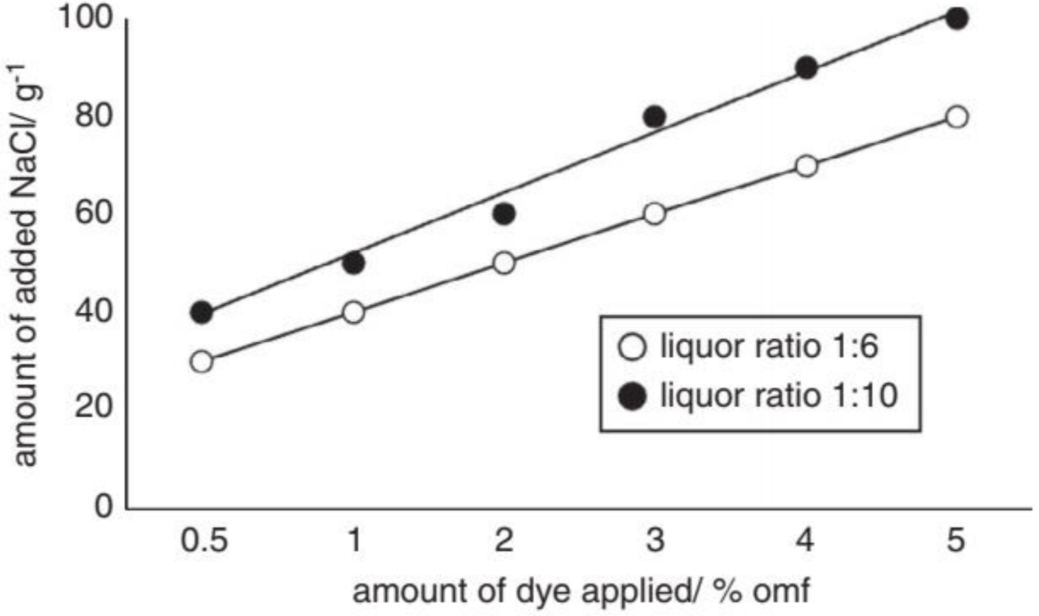
Reactive Dyeing

Effect of liquor ratio and salt consumption

Liquor ratio	Dye applied/% omf						
	<0.5	0.5	1	2	3	4	≥5
≤1:6	10	20	30	40	50	60	70
1:6 < LR ≤1:8	20	30	40	50	60	70	80
>1:8	30	40	50	60	80	90	100

variation of the amount of added NaCl/g l−1 required for the exhaust application of Novacron FN (Huntsman) dyes to cellulosic fibres in the presence of Na_2CO_3, as a function of liquor ratio and amount of dye applied

Source: Burkinshaw 2021



Relationship between the amount of added NaCl required for dyeing 1 kg of cellulosic fibre and the amount of *Novacron FN* (Huntsman) dye applied for liquor ratios of 1:6 and 1:10;

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Reactive Dyeing

Group task - Salt Consumption

Can you calculate how much salt will be consumed for a factory

Factory production 20 tons/day

Liquor ratio= 1:6

Salt use say 40 g/L

Find out the water consumption in a day and in a year

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Reactive Dyeing

Salt Consumption

- Out of 400 + Washing, Dyeing, Finishing, 200 uses salt
- Dyeing capacity, say 20 tons/day = 20,000 kg/day
- Conservatively, say uses 100 L/kg but only dyeing steps consumes salt, say 6 L/kg
- Salt use say 40 g/L, which means 40 g/L x 6 L/kg ~ 0.24 kg salt/kg of fabric

So total salt consumption in a day could be in
200 x 20,000 Kg x 0.24 kg/Kg ~ 960,000 kg
= **960 tons of salt/day**

Reactive Dyeing

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

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

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

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Reactive Dyeing

Common salt dilution at L.R. 8:1

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.

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

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

Residual salt concentration g/l

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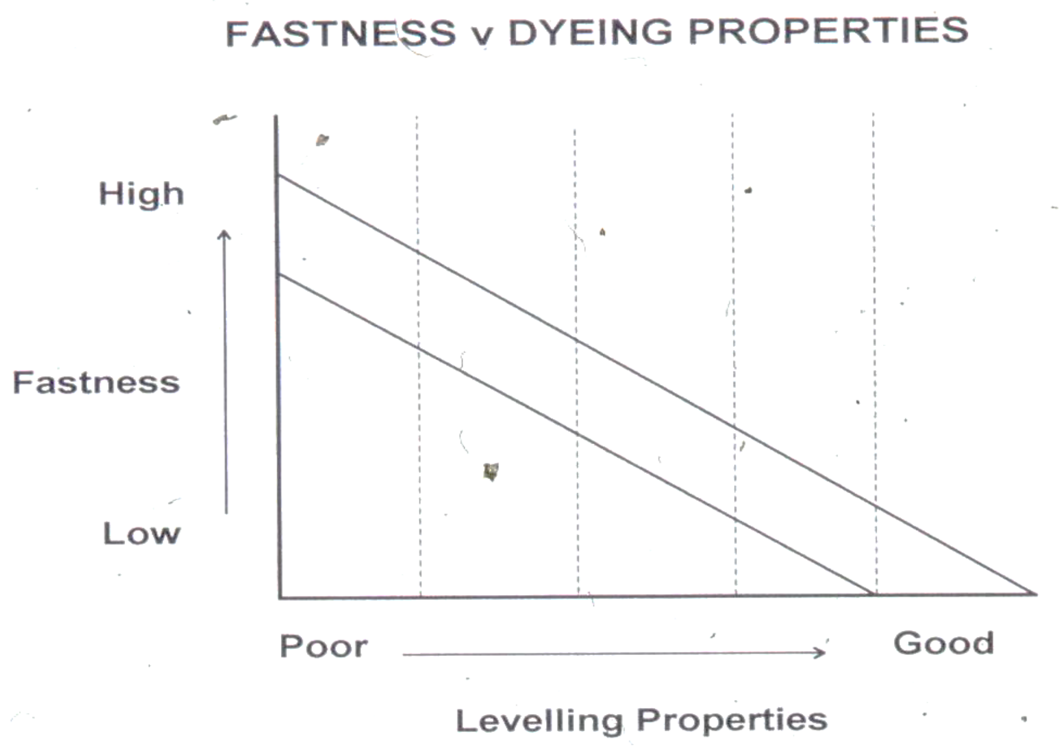
Reactive Dyeing

Typical Fastness v Dyeing properties



Group Exercise

A. A batch of 1200 kg 100% cotton knit fabric (S/J) has to dye with a recipe as follows:
Auxiliaries 18g/L
Dyestuffs 2.3% shade with 75% dye pick-up and Liquor ratio 1:6 and 10 bathes programme.

Calculate the following:

1. Total water consumption in m3
2. Total required dyes and chemicals in kg and
3. Total ETP load in volume of wastewater m3 and chemicals with dyes kg

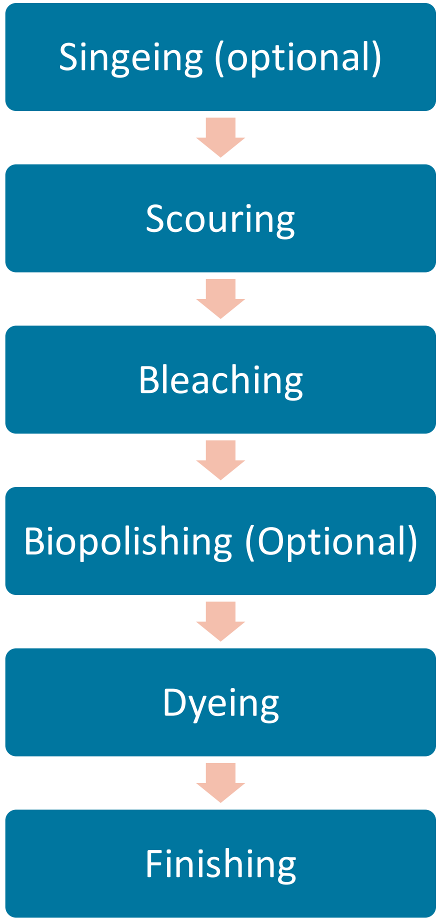
Shortening of Process sequence

Reactive Dyeing

Shortening of process sequences

- For woven and knit fabric processing some common and additional steps used; each of these process steps usually followed by intermediate washing steps
- Scope for shortening processes (for example)
  - Combining scouring and bleaching
  - Reducing biopolishing
  - Semi-scouring and semi-bleach
  - Enzymatic processing at dyebath pH
  - Removing bleaching for dark shade

Knit fabric processing sequence



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Reactive Dyeing - **Shortening of process sequences**

Process specific water conservation
Conventional Cotton knit fabric dyeing – medium to dark shades

Total Water Consumption = 128 L/kg

Pretreatment

- Fill (1:8) and load
- Bleach @ 98°C, Drain
- 5’ CCR/Overflow Rinse (5*1.24 L/kg/min = 6.2 L/kg), drain
- Fill (1:6), Hot wash @ 90°C
- 10’ CCR/Overflow Rinse (10*1.24 L/kg/min = 12.4 lit/kg), drain
- Fill (1:6), Acid, Peroxide killer, Enzyme, drain
- 10’ CCR Rinse (10*1.24 L/kg/min = 12.4 L/kg), drain

Dyeing

- Fill (1:6), Dye at 60°C + drain

Aftertreatment

- 20’CCR Rinse (20*1.25 L/kg/min = 25 L/kg), drain
- Fill (1:6), neutralise
- 10’ CCR/Overflow Rinse (10*1.25 L/kg/min = 12.5 L/kg), drain
- Fill (1:6) – soaping at 95°C
- 15’ CCR/Overflow Rinse (15*1.25 L/kg/min = 19 L/kg), drain
- Fill (1:6), softener
- Unload

Pre-treatment water consumption = **51 L/kg**

After-treatment water consumption = **71 L/kg**

Dyeing water consumption = **6 L/kg**

Reference: Mohammad Abbas Uddin 2017

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Reactive Dyeing - **Shortening of process sequences**

Process modified cotton knit fabric dyeing – medium to dark shades

Total Water Consumption = 64 L/kg

Pretreatment

- Fill (1:8) and load
- Scoured and Bleach @ 98°C, Drain
- Fill (1:6) Normal hot (70°C) , drain
- Fill (1:4), Run wash, drain
- Fill (1:4), Acid, Peroxide killer, Enzyme, drain
- Fill (1:6), Rinse, Drain

Dyeing

- **Fill (1:6), Dye at 60°C + drain**

Aftertreatment

- Fill (1:6), 10' wash at 50°C, Drain
- Fill (1:6), 10' 70°C, neutralise, Drain
- Fill (1:6), 15' at 95°C, soaping, Drain
- Fill (1:4) – 10' wash at 70°C, drain
- Fill (1:4) 10' wash at 50°C, drain
- Fill (1:4) 20' at 40°C, softener, drain
- Unload

Pre-treatment water consumption = **28 L/kg**

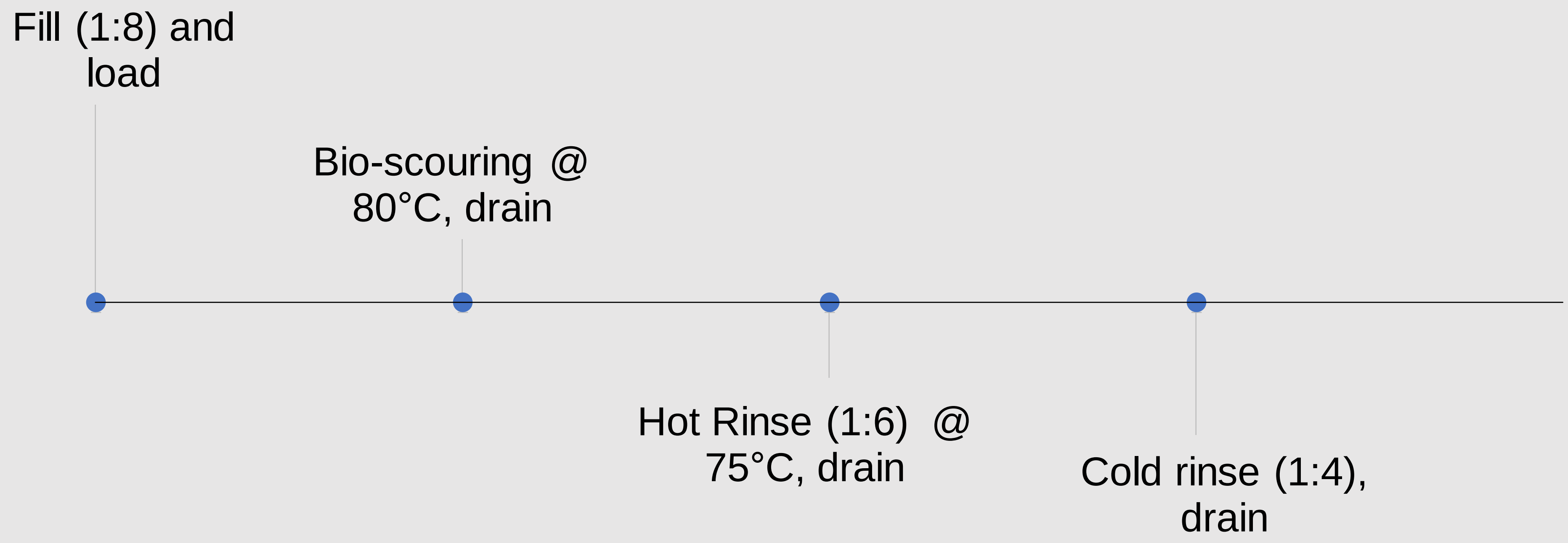
After-treatment water consumption = **30 L/kg**

Dyeing water consumption = **6 L/kg**

Reference: Mohammad Abbas Uddin 2017

Reactive Dyeing - **Shortening of process sequences**

Option 1: Pretreatment with bio-scouring (No bleaching)



Pre-treatment water consumption = 8+6+4 = **18 L/kg**

Source: Mohammad Abbas Uddin 2017

Reactive Dyeing - **Shortening of process sequences**

Option 2: Bioscouring + Biopolishing (No bleaching)

Fill (1:8) and load

Bio-polishing and Bio-scouring @ 80°C, drain

Hot Rinse (1:6) @ 75°C, drain

Continue Dyeing

Pre-treatment water consumption = 8+6 = **14 L/kg**

Source: Mohammad Abbas Uddin 2017

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Reuse of water from washing and other processes

Reactive Dyeing – **Washing and reuse of water**

Optimisation in washing and rinsing

- In both batch and continuous processing, water consumption for washing is significantly higher than for the dyeing itself.
- In batch dyeing, depending on the machine type, in washing and/or rinsing step, water requires in a ratio of 1:8 to 1:20, for per kg of substrate.
- ‘Drain and fill’ and ‘smart rinsing’ are both developed to reduce water consumption more than conventional overflow rinsing.

Reactive Dyeing – **Washing and reuse of water**

Optimisation in washing and rinsing

Advantage

- Replacing each overflow rinse by two to four ‘drain and fill’ cycles can achieve a water consumption reduction of 50-75%.
- Smart rinsing system also allows combined cooling and heating, thus saves huge amount of steam and water

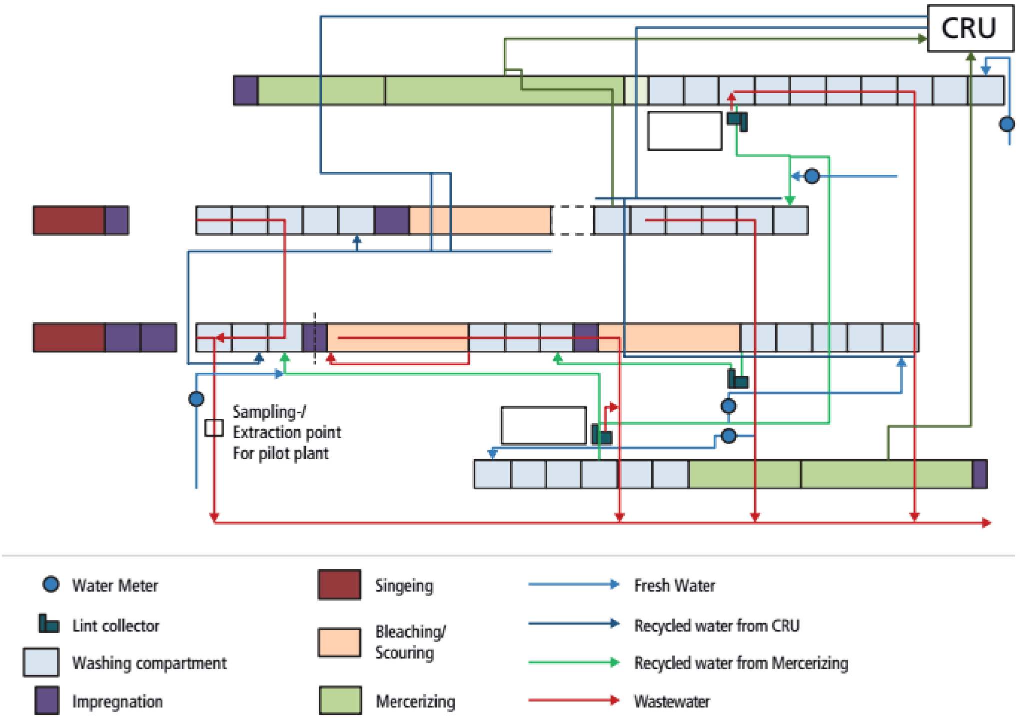
Reactive Dyeing – **Washing and reuse of water**

Reuse of water from intermediate washing steps

- Water coming from different processes can be reused in another washing or rinsing operation which accepts low grade water, or it can be reused as process water in wet processing operations with or without the addition of chemicals.
- Water savings of up to 2 to 4% during pretreatment of cotton woven fabric by reusing water from desizing, scouring, bleaching and mercerisation

Proposed approach

- Reuse washing water from bleaching for scouring
- Reuse washing water from scouring for desizing,
- Reuse washing water from mercerisation for desizing, scouring or bleaching



Source: Water as a Global Resource (GRoW) 2021

Use of Green chemicals and Advanced Chemistry requiring less water

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Reactive Dyeing – **Green and Advanced chemistry**

Enzymatic treatment

- Use of enzymes in chemical processing of fibres and textiles rapidly gaining wider recognition
  - ✓ at present about 75 enzymes already commonly used in textile industry processes, principal enzymes applied: hydrolases (amylases, cellulases, proteases, pectinases, and lipases/esterases) and oxidoreductases (catalases).
  - ✓ bio-scouring process built on protease, pectinase and lipase enzymes acting on proteins, pectins and natural waxes to affect cotton scouring

Advantages

- non-toxic and eco-friendly characteristics
- bio-scouring process resulting softer textiles
- Reduced water consumption between up to 20% due to reduced rinsing operation

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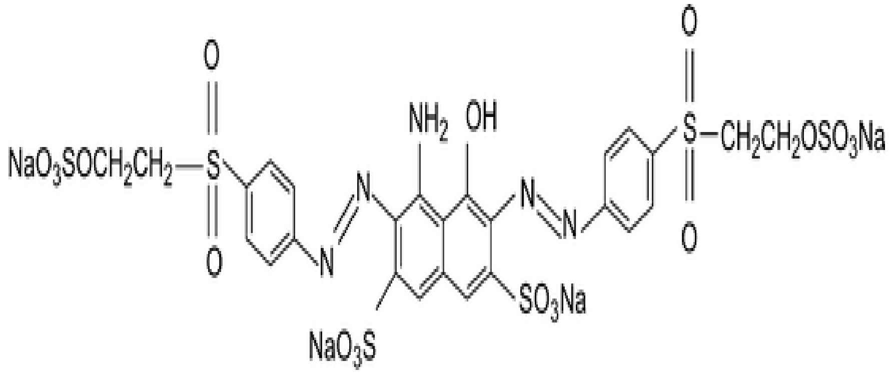
Reactive Dyeing – **Green and Advanced chemistry**

Use of high-fixation polyfunctional reactive dyes

- Reactive dyes used for mainly cellulosic fibre and wool fibres, which shows various issues such as poor dye fixation, high salt requirements and saline effluent.
- Depending on fixation type various types of reactive dyes are in use (e.g. Monofunctional, bifunctional, polyfunctional dyes.
  - monofunctional dyes, the fixation rate is approximately 60% (with an exhaustion rate of about 70%
  - bifunctional and polyfunctional reactive dyes, an 80% fixation rate and over 90% exhaustion rate are achieved
- High-fixation reactive dyes is particularly suitable for most modern low-liquor-ratio dyeing machines.

Advantages

- by combining the pretreatment and dyeing steps using polyfunctional dyes that fix at 90°C, savings of up to 40% in water and energy consumption and more than 30% of salt consumption are claimed



CI Reactive Black 5 – The most common reactive black dyes used in the world

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Reactive Dyeing – **Green and Advanced chemistry**

Example of reactive black Dyeing on cotton fabric

A comparative trial carried out in Pakistan dyehouse with help of German companies (i.e. textile machine manufacturer Thies and textile chemical supplier CHT)

- Same fabric has been used - 100% cotton single jersey
- Black colour with same depth
- Inhouse dyes vs CHT supplied high fixation reactive dyes

Five Samples were trialled with change in dyes and/or processes

- P0 is the local dyeing reference process (standard recipe) dyed onsite at a Pakistani dyehouse
- P1 is the imitated process P0 with the use of conventional dyes from CHT
- P2–P4 were dyed with the use of advanced dye systems with Bezaktiv GO dyes
- P4 shows a process without bleaching of the fabric

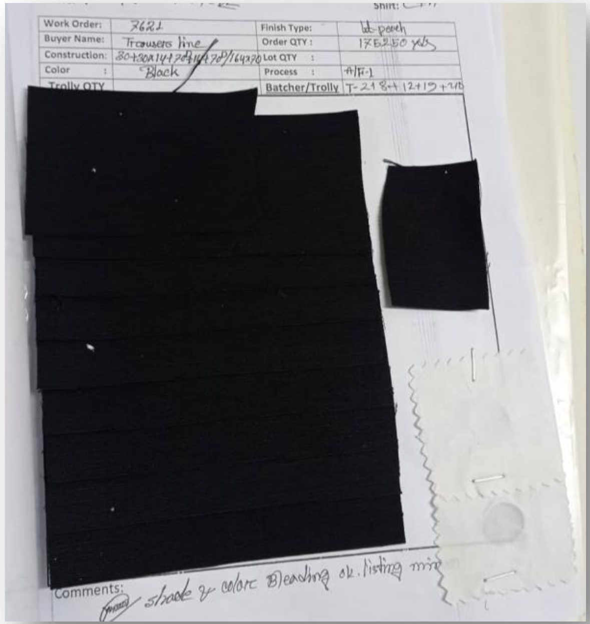

Photo: Kazi Farhan Hossain Purba

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Reactive Dyeing – **Green and Advanced chemistry**

Example of reactive black Dyeing on cotton fabric

REACTIVE DYEING PROCESS	P0	P1	P2	P3	P4
Recipe / Auxiliaries	STANDARD	STANDARD imitated	1st	2nd	3rd
			improvement	improvement	improvement
Liquor ratio	01:06	01:06	01:05	01:05	01:06
Water use [L] per kg textile	61	56	39	37	29
Water saving [L] per kg textile	-	5	22	24	32
Water saving [%]	-	8	36	40	53
Processtime calculated [h:min]	13	11:30	09:05	07:03	06:31
Used black dye [g] per kg textile	unavailable	38	52	50	50
Dye fixation rate black only [%]	unavailable	82 – 83	88-89	90	68 – 79
Unfixed black dye [g] in drain per kg textile	unavailable	6.8 – 6.5	6.2 – 4.6	5	16.0 – 10.5

Source: Water as a Global Resource (GRoW) 2021

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Process specific water conservation

Use of "green" and advanced chemistry

	Winch (L.R. 1:20)	Jet (L.R. 1:10)	Low L.R. Jet (L.R. 1:5)
Traditional dyes (salt 60 g/l)	1200 kg	600 kg	300 kg
Low salt dyes (salt 40 g/l)	800 kg	400 kg	200 kg

Advantages

- Reduction of washing/rinsing steps as reducing the salt from the fabric most challenging and requires increased number of washing/rinsing steps.
- Sometimes with these dyes, detergent is not required to wash off.
- Reduction of salt consumption and ionic load in wastewater

Dyeing machine and Automation

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Batch Dyeing machine

- Highest impact on water consumption in exhaust dyeing emanating from textile material to liquor ratio
- Common textile dyeing machines in use
  - ✓ Winch dyeing
  - ✓ Jet dyeing machines
  - ✓ Air jet dyeing machine

- The selection of the most adequate machine for the size of the lot to be processed, is fundamental to the resultant water efficiency of the process.

Winch dyeing machine

Jet dyeing machine

Photos: Kazi Farhan Hossain Purba

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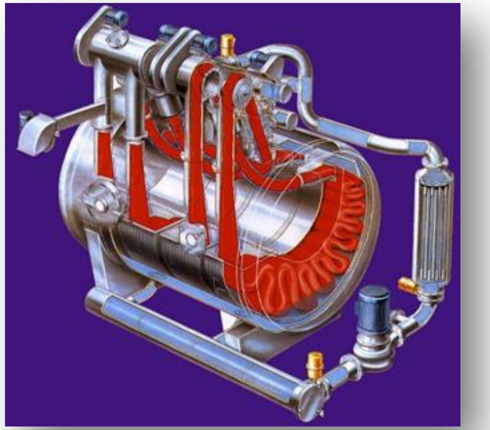
Batch Dyeing machine

Low liquor ratios

- In batch dyeing, the amount of water is the highest due to high liquor ratio. All major machine manufacturers now have units for dyeing at a low liquor ratio.
- Old technology - winch dyeing
- Jet dyeing machines
- Air jet dyeing machine
  - ✓ Lower liquor ratio – lower water consumption
  - ✓ Lower energy consumption
  - ✓ Lower chemical consumption
  - ✓ Lower effluent loading
  - ✓ Sophisticated controls – better right first time



Source: MCS air jet dyeing machine

The costs of this low liquor ratio machines range between approximately USD 200,000 to 500,000

Batch Dyeing machine

Sclavos: Athena 2/3/3A

http://www.sclavos.gr/index.php/machines/athena3a

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Batch Dyeing machine

Thies: iMaster H_2O

http://www.thiestextilmaschinen.com/249/Textile_Machines/Fabric_Dyeing/iMaster_H%3Csub%3E2%3C_sub%3EO.htm

Batch Dyeing machine

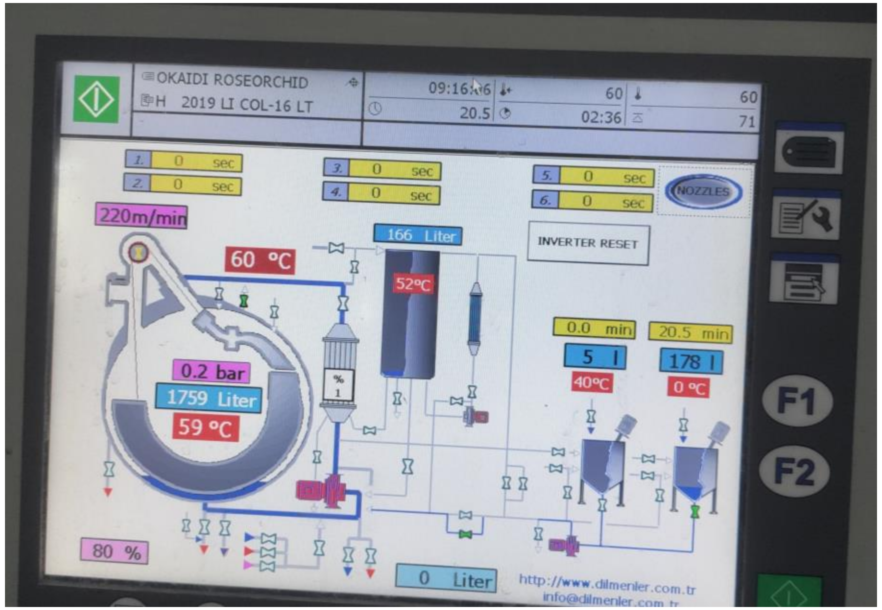
Jet Dyeing Fabric Dyeing for Synthetics

Batch Dyeing machine

Monitoring and control of operational parameters leading to Automation

Advanced automatic process controls and systems (e.g. for online monitoring) assists in monitoring key operational and process parameters such as

- ✓ volume, dosage, temperature, pH, concentration and liquor ratio and control of uptake of working liquors and treatment conditions in wet treatments;
- ✓ temperature, humidity and heat supply control in thermal treatments;
- ✓ machine rate control



Machine control system Mohammad Abbas Uddin 2022

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Batch Dyeing machine - Automation

Upgradation from basic control to sophisticated systems provide feedback on operational parameters and also to track water, energy and chemical consumption, to store procedures and recipes, to track changes. Most of these advanced control technologies are usually pre-installed in new equipment and machinery.

Example of installed features:

- Additional measurement system for
  - ✓ analysis and optimization of dyes
  - ✓ treatments for exhaust procedure
- Visual displays of treatment curves for easier analysis and adjustment.

Photo: Water as a Global Resource (GRoW) 2021

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Batch Dyeing machine - Automation

Use of water efficient textile machineries with built-in software controls

Example

Impact of software based optimization of water use at a textile finishing plant in Lahore.

- Trial T1 showing baseline for process without software optimization
- Trials 2 – 4 showing results after gradual optimization of processes and recipes

Trial	Liquor-Ratio (:1)	Water use (L/kg)	Water saving (%)
T1	6	69	Reference
T2	6	62	10.1
T3	5.5	62	10.5
T4	5.5	56	19.2

Courtesy: Thies DyeControl by Thies Textilmaschinen

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Batch Dyeing machine - Automation

Dye-house automation consisting of

- automatic dispensing system
  - ✓ dissolving/mixing system
  - ✓ transportation and distribution system for liquid, solid dyes and chemicals according to customer’s dyeing recipes and procedures

Advantages

- Accurate recipe prediction possible, helping achieving right first-time dyeing more than 95%
- Reduced water consumption due to less errors and approximations
  - ✓ Together with other measures water savings can be in the range of 10 to 15%.

Automatic dispensing machine, copyright: Mohammad Abbas Uddin 2022

Automatic distribution of dyes, copyright: Mohammad Abbas Uddin 2022

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Batch Dyeing machine - Automation

Automatic colour kitchen

- Switch to use of automatic colour kitchen in bulk production
- Advantages

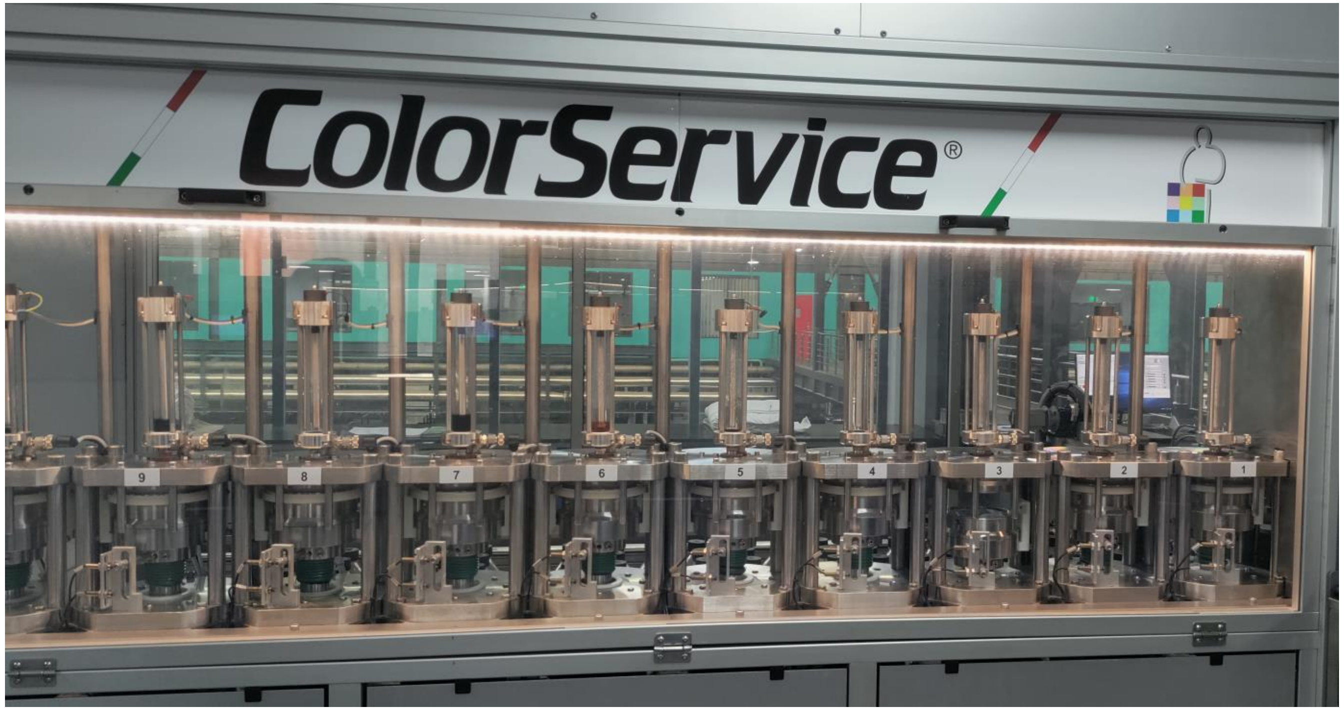
✓ ease of management,

✓ execution speed,

✓ accuracy, and

✓ repeatability of the recipes.

Automatic colour kitchen has the potential to increase the right first time over 90% and reduce the volume of effluents by up to 4.3%.



Automatic colour kitchen, copyright: Mohammad Abbas Uddin 2022

Conclusion

- Significant potential of water conservation through implementation of process-specific measures
- Key starting points to consider
  - ✓ Installation of water efficient textile machinery (e.g. low liquor ratio machines)
  - ✓ Switching to different process technologies (enzymatic processes)
  - ✓ Switching to advanced textile process chemicals (e.g. dyestuff) with special consideration green chemicals
  - ✓ Application of direct recycling of process water and recovery/reuse of process chemicals

Further Reading

- Reactive Dye Selection and Process Development for Exhaust Dyeing of Cellulose (1995) by Al. I. Bradbury, P. S. Collishaw and S. Moorhouse
- Water Efficiency in Textile Industry (WETI) in Pakistan
- Best Available Techniques (BAT) Reference Document for the Textiles Industry, European IPPC Bureau, https://eippcb.jrc.ec.europa.eu/sites/default/files/2020-01/TXT_bref_D1_1.pdf
- Clean By Design: https://www.nrdc.org/resources/green-textile-redux-clean-designs-10-best-practices-offer-even-greater-pollution-reduction
- Reducing the Water Footprint of the Global Cotton-Textile Industry towards the UN Sustainable Development Goals. Final Report of the Joint Research Project InoCottonGROW, BMBFGrant Number 02WGR1422A-M. FiW e.V., Aachen, Germany https://www.inocottongrow.net/

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