Advances in Sustainable Dyeing Methods, Machinery, and Processes
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Advances in Sustainable Dyeing Methods, Machinery, and Processes
Need for Sustainable Dyeing Methods

**EPA Definition**
Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

Photo courtesy of Seametrics.com
Life Cycle Assessment Overview

INPUT
- Water
- Energy
- Chemicals

OUTPUT
- Raw Material
- Manufacturing
- Consumer Use
- Disposal

- Emissions
- Wastes
- Co-products
Sustainable Dyeing Processes
Many of the technologies needed to significantly reduce the environmental footprint in textile manufacturing already exist.
Environmetally Friendlier Preparation for Dyeing

Enzyme Applications

- Specialized proteins found in all living organisms and serve as natural catalysts for biochemical reactions.
- Safe and easy to use.
- **Attack** and degrade specific substrates under mild conditions.
- Can replace harsh solvents and other organic compounds.
- Amylase, Cellulase, Pectinase, Laccase, Catalayse
Environmentally Friendlier Preparation for Dyeing Cationic Cotton
Environmentally Friendlier Dyes
High Fixation – Low Impact Reactive Dyes

• Higher Fixation Rates (as high as 90% or greater)
• Multiple anchor groups (reactive groups) within molecule
• Greater efficiency – more depth with less dye and less salt
• Lower dye temperatures (as low as 40°C)
• Lower Liquor Ratios (less than 6:1 L/R)
• Lower rinse and soap-off temperatures
• Fewer Rinses (reduced water consumption)
• Compared to conventional reactive dyes, use less water, energy, and time.
Environmentally Friendlier Dyes
High Fixation – Low Impact Reactive Dyes

- **Avitera® SE** (Huntsman)
  - Poly-reactive dyes
  - 93% fixation, leaving only 7% unfixed dye to remove
  - Lower washing off temperatures
  - Compared to conventional reactive dyes, use less water, energy, and time.

Photos courtesy of Huntsman
Environmetal ly Friendlier Dyes

High Fixation – Low Impact Reactive Dyes

• **Bezaktiv GO** (CHT/Bezema)
  - Third part of the 4 Success process
  - Fixation rate as high as 90%
  - Lower Dyeing Temperature
    - 40°C
  - Lower Rinse Temperatures
    - Cotoblanc SEL (40°C)
  - Lower Liquor Ratios
  - Minimum consumption of water, energy, and salt
  - Short process times in exhaust and CPB processes

Photos courtesy of CHT/Bezema
Environmentally Friendlier Dyes
High Fixation – Low Impact Reactive Dyes

- **Cadira® Reactive** (DyStar)
  - Uses select Levafix® and Remazol® reactive dyes
  - Higher fixation yield
  - Good wash off properties
  - Optimized dye process
    - Lower Dyeing Temp. (50°C)
    - Lower Liquor Ratio (5:1)
  - Special Wash off Process
    - Sera® Fast C-RD
    - Soap-off Rinse at 60°C
  - Shorter process times

Photos courtesy of DyStar
Environmentally Friendlier Dyes
Sustainably Produced Dyes

- **EARTHCOLORS®** (Archroma)
  - Fully traceable biosynthetic dyes derived from natural waste products of the agricultural and herbal industries
  - Transformed natural waste-based colorants synthesized using up to 100% of raw materials from natural waste such as non-edible shells of nuts, leaves, and cotton gin waste.
  - Traceable with NFC technology.

Photos courtesy of Archroma
Environmentally Friendlier Dyes
Sustainably Produced Dyes

- **Levafix® ECO (DyStar)**
  - A new range of reactive dyes based on chemistry which is free of p-CA and other regulatory controlled amines.
  - Enhanced fastness properties leading to improved sustainability.
  - The shade range can be extended by the use of additional existing p-CA-free Levafix® and Remazol® dyes.
Environmental Impact Measurement
Tools for Measuring Sustainable Dye Methods

ONE WAY
Systematic Approach to Actionable Sustainability (Archroma)

(Photos courtesy of Archroma)

eliot™
(DyStar)

(Photos courtesy of DyStar)
Sustainable Dyeing Equipment
Dyeing: The Road to Sustainability

- Fabric sits in water
- 20:1 or higher liquor ratios
- High energy use
- High steam use
- Inefficient
- Gentle to fabric
- Floats in bath
- Paddle dyeing still in use

Image courtesy of TextileApex.blogspot.com

Images courtesy of Azmir Latif, MSc. Engr. (Textile)
Efficient Package Dyeing for Yarn

- Lower liquor ratios for cotton
  - 1:3 or 1:4
- More efficient circulation pumps draw significantly less energy
- Only require enough bath to run the pump
- Less water means less salt and auxiliaries (up to 30% reduction)
- Intelligent rinsing reduced water
- Innovative water extraction means less time and energy to dry
Low Liquor Ratio Jet Dyeing

- Soft flow for gentle fabric action
- Use air rather than water to move the fabric
- Reductions in water, salt, auxiliary chemicals and time
  - 3:1 LR for cotton
  - Faster drop/fills
- Dyeing takes place in the venturi, not in the bath

Photo courtesy of Fong’s Europe GmbH - THEN
Low Liquor Beam Preparation and Dyeing

- Low liquor beam dyeing means bleaching and dyeing using less than 20 L/Kg of fabric!
  - 30-50% reduction in water use vs. typical beam dye machines
- Low steam use
- Low energy use related to pump efficiency
- Less water means less salt and alkali required for dyeing
- Preservation of surface appearance
- Virtually no stretch applied to fabric

Photo courtesy of Lab-Pro

Photo courtesy of Alliance Machines
Cold Pad Batch Dyeing

- Low water requirements
- No salt needed
- Dyeing at room temperature
- Applicable to knits and wovens
- Preserves surface appearance

Photo courtesy of Erbatech, GmbH

Photo courtesy of Benninger
Monforts E-Control

- Continuous dyeing of knit fabrics
- More efficient when compared to exhaust applications
- Reduction in water usage
- Alternative for cold pad/batch
- Reduction or elimination of salt
- Reduced effluent loading
- Aesthetically better fabric surface appearance

Schematic courtesy of Monforts
Foam Dyeing and Finishing

• Reduce water consumption up to 80%
• Reduce energy usage
  • Increase range speed
• Reduce chemical costs
  • Single sided application
• Increase versatility
  • Dyeing or finishing

Photos courtesy of Gaston Systems
Garment Dyeing: Tonello Core

• Versatile garment dye unit
• Completely programmable
• Able to process cotton at ultra-low liquor ratios at 1:1
• Create uniform dyeing
• Create novel effects
• Can apply both dyes and finishes
• Core unit can attach to any Tonello garment machine

Photo courtesy of Tonello Srl
Jeanologia e-Flow

- Nanobubble carriers for chemistry
- Significant savings in water, energy, and chemistry are reported
- Considerable reduction in effluent
- Can be connected to any garment washing machine
- Applicable to many fabric types including denim

“Water is over, air is the future”
Sustainable Drying Technology

- Ultra-efficient dryers
- Heat exchangers
  - Remove moisture from air
- Recirculate dry air into dryer
- Lower energy use
- Automatic cleaning
- Computer integrated airflow control

Photos courtesy of Monforts
Control & Measurement Systems

- Improvements can only be made once conditions are benchmarked
  - Water meters on dye machines
  - Installation of a control system to monitor water, energy and steam use
  - Scheduling controls for machine use to minimize cleaning
  - Controls for weighing, mixing and delivery of dye and alkali to machine

Photo courtesy of Adaptive Control Inc.
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