Sustainable Solutions for Denim Processing
With hundreds of easily searchable resources, we’re your go-to textile tool for discovering what’s possible with cotton.

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Sustainable Solutions for Denim Processing
Sustainable Options for Dyeing with Indigo
Denim and the Environment

- Denim was introduced in America in the late 18th century
- Worn by miners during the California Gold Rush
- A utilitarian fabric that was prized for its durability
Denim and the Environment

• Denim has historically been dyed with indigo
  • Originally natural indigo was used
  • Replaced in early 1900’s by synthetic indigo which is Vat Dye 1

• A recent study finds:
  • Harvest about 84 lbs of pigment per acre
  • Replacing synthetic indigo would require 2.1 million acres
  • Natural indigo would be 80 times more expensive than synthetic

LEVI’S® 501® JEAN LIFECYCLE IMPACT

The entire lifecycle of one pair of Levi’s® 501® jeans equates to:

Climate Change:
33.4 kg CO₂-e...
- 69 miles driven by the average US car
- 246 hours of TV on a plasma big-screen

Water Consumed:
3,781 liters...
- 3 days worth of one US household’s total water needs

Eutrophication:
48.9 g PO₄-e...
- The total amount of phosphorous found in 1,700 tomatoes

Land Occupation:
12 m²/year...
- Seven people standing with arms outstretched, fingertips touching, would form one side of a square this size
Sustainable Options

• New advances in indigo
• Indigo alternatives
• Innovative dyeing methods
• Environmental impact measurement
New Advances in Indigo: Denisol

- Archroma’s Denisol® Indigo 30
  - Aniline-free* liquid indigo
  - Same indigo look and performance
  - Less indigo required to achieve same color depth
  - Manufacturing the pre-reduced indigo solution at a “zero liquid discharge” plant in Pakistan
  - Introduced at Planet Textile Vancouver 2018

New Advances in Indigo: Cadira

• Cadira Denim from DyStar
  • Combines DyStar Indigo Vat 40% Solution with the ecological advanced reducing agent Sera® C-RDA.
  • This combination allows a salt free dyeing with a strong effluent load reduction.
  • Sulfates can be reduced up to 95% compared to dyeing with Indigo powder in combination with the conventional reducing agent Sodium dithionite (Hydrosulfite).

https://www.dystar.com/dystar-launching-cadira-denim/
New Advances in Indigo: Cadira

• Cadira Denim from DyStar
  • COD will decrease up to 80% compared to dyeing with Indigo powder and Hydrosulfite
  • Total solids can be reduced up to 90% compared with Indigo powder and Hydrosulfite.
  • Cadira Denim additionally reduces substantial waste quantities from the ETP’s (effluent treatment plants) because no additional salt is created.

https://www.dyestar.com/dystar-launching-cadira-denim/

Photo courtesy of DyStar
Indigo Alternatives: Archroma

- Based on the Denim-Ox and Pad/Sizing-Ox dyeing processes, Archroma’s multi-awarded ADVANCED DENIM, dyeing technology allows savings of up to 92% in water, 87% in cotton waste and 30% in energy, compared to a conventional denim dyeing process.

Indigo Alternatives: Archroma

- **Optisul® C**, "soft colors" made easy
- Produce soft denim colors in continuous dyeing processes or with coating and printing.
- Optisul® C sulfide-free dyes can be combined together to create garments suitable for wash-down effects in a wide array of easily achievable and reproducible soft colors.
- They are suitable for GOTS and bluesign® approval.

Indigo Alternatives: Archroma

- **Diresul® RDT Ocean Blues, ocean-themed bright sulfur blue dyes**
  - A collection of ocean-themed bright sulfur blue dyes.
    - Bottoming
    - Topping
    - Fresh blue hues

Photo courtesy of Archroma
Indigo Alternatives: Archroma

• **Diresul® blacks & greys, a cosmos of greys and deep black and navies**

Archroma’s dye portfolio of conventional and black Diresul® specialties allow to create a universe of greys and deep black and navies. From superficial to solid blacks for both extreme wash-down and stay black effects.

Indigo Alternatives: Archroma
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
Innovative Dyeing Methods: Spray

• DyStar and RotaSpray together have developed a method to spray apply indigo onto yarn
  • Combines DyStar Indigo Vat 40% Solution & Sera® Con C-RDA reducing agent.
  • With the EPO patented RotoDyer® and the RotoCoater® spraying technology.

Innovative Dyeing Methods: Foam

- Foam dyeing has been available for a while
  - Beginning with pigments
  - Expanding to reactive dyes

- Foam uses air as a medium to carry color to the fabric

- Technical issues to consider
  - Uniform tension
  - Uniform coverage of the color on the substrate
    - Avoid tailing
  - Penetration of the dye into the substrate (or not)
Innovative Dyeing Methods: Foam

• The foam-dyeing process for indigo: IndigoZERO
  • Foam dyeing, a new technology for dyeing cotton yarn that is being applied to denim production for the first time
  • Eliminates the use of several chemicals
  • Can reduce water use by up to 90% compared to traditional dyeing.
  • Smaller footprint to traditional indigo ranges
  • Dye remains on the surface of the yarn
    • Able to achieve desired washes


Photo courtesy of IndigoZERO
Innovative Dyeing Methods: Foam

• Developed at the Fiber and Biopolymer Research Institute at Texas Tech University (Lubbock; www.texastech.edu)

• IndigoZero is powered by a special applicator developed by machinery company Gaston Systems Inc. and Tejidos Royo, along with a foam dye developed by Gaston and Indigo Mill Designs (IMD).

• Being commercialized by Indigo Mill Designs LLC (IMD; Greensboro, N.C.; www.indigomilldesigns.com).

Environmental Impact Measurement Tools for Measuring Sustainable Dye Methods

Photos courtesy of Archroma

ONE WAY Systematic Approach to Actionable Sustainability (Archroma)

Photos courtesy of DyStar
Environmental Impact Measurement
By Jeanologia

- An environmental impact software tool to measure water, chemical and energy consumption as well as worker health in the production process and how they affect the ecological footprint.
- Aimed at laundries and garment finishers

Sustainable Options for Denim Finishing
Sustainable Options

• Enzyme washing
• Potassium permanganate alternatives
• Ozone bleaching
• Alternative abrasion methods
• Laser etching
Enzyme Washing: Biopolishing

- Neutral cellulase enzymes remove the surface of the fiber
- Low temperature wash process
- Can be used independently or to enhance abrasion processes
- Improves softness and hand
- May weaken the fabric, enzymes must be deactivated

Desized  Desized and Biopolished

TIME  ENERGY
Enzyme Washing: Fading

**Laccase**
- Targets only indigo dye molecules
- Rapid fading
- Low temperature and neutral pH

**Esterase**
- Targets sulfur dyes and other colorants
- Requires addition of hydrogen peroxide
- Moderate temperature and neutral pH
**Potassium Permanganate Alternatives**

**Potassium Permanganate**
- Widely used
- Bleaches at ambient temperatures
- Produces harmful decomposition products
- Requires large volumes of water for washing and neutralization
- Can cause yellowing if not well neutralized

**Alternative Products**
- New to the market
- May require heating to bleach
- Multi-component mixes
- Break down quickly, some are biodegradable.
- Require less water for after-washing
Potassium Permanganate Alternatives

<table>
<thead>
<tr>
<th>Company</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACTICELL</td>
<td>Acticell BD, Acticell RT</td>
</tr>
<tr>
<td>CHT</td>
<td>organIQ</td>
</tr>
<tr>
<td>Garmon</td>
<td>Avol oxy white</td>
</tr>
<tr>
<td>Nearchimica</td>
<td>Nearbleach Sky White</td>
</tr>
</tbody>
</table>
Ozone Bleaching

- Ozone is a powerful bleaching agent that is generated from oxygen.
- O₃ is not persistent in the environment and is converted back into oxygen and water.
- Rapid process.
- Fewer rinses compared to sodium hypochlorite or potassium permanganate bleaching.

**CHEMICALS**  **TIME**  **WATER**

Desized only displayed with desized and ozone bleached.
Ozone Bleaching

• Ozone bleaching may be conducted as a wet or dry process, depending on manufacturer recommendations.

• Oxygen can be supplied via industrial grade compressed gas cylinders or an oil-free air compressor depending on the type of ozone generator.
Alternative Abrasion Methods

**Stonewashing**
- High environmental impact from mining operations
- Energy and labor intensive process for stone removal
- Pumice stones deteriorate quickly, generating dust and sludge

**Tonello NoStone®**
- Reusable plates available in various textures
- Removable to allow garment washing machines to be used for other purposes
- Developed in collaboration with Levi Strauss & Co.
Alternative Abrasion Methods

Desized

Desized and NoStone®
Laser Etching

- Digital design files allow rapid prototyping and adjustment
- Highly reproducible
- Can provide an alternative to many traditional denim finishing techniques
  - Potassium permanganate spraying
  - Sandblasting
  - Hand-sanding
Laser Etching
Modes of operation

**Bitmap**
- Short pulses
- Photorealistic images
- Use for potassium permanganate or sandblasted effects
- Control through Pixel Time (µs) and Grey Scale

**Vector**
- Continuous lines
- Line art/Hatching
- Use for hand-sanded effects or cutting
- Control through Speed (m/s)
Laser Etching
Potassium Permanganate Alternative

- Rapid, superficial etching of fabric surface
- Indigo is easily discharged
- Suitable for lightweight fabrics
- Design files from Jeanologia™ are purple to reflect the color of potassium permanganate
Laser Etching
Sandblasting Alternative

- Multilayer bitmap design files produce realistic effects
- Moderate etching of fabric surface
- Surface fiber is removed to reveal the white core of the warp yarns
- Suitable for mid-weight wovens and heavier
Laser Etching
Hand-sanding alternative

- Rapid slicing of yarns using vector design files
- Slower process when using bitmap design files
- Reduced tear strength

Photos courtesy of Jeanologia™
Laser Etching
Hand-sanding alternative

- Vector design file
- Different effects from etching technical face vs. technical back of twill fabrics

100% Cotton Broken Twill
Lasered Face

100% Cotton Broken Twill
Lasered Back
Laser Etching
Hand-sanding alternative

- Vector design file
- Different effects depending on file marking speed

100% Cotton Twill
Sulfur Grey
EARTHCOLORS®
by Archroma

7072-1C

7073-4A, 7073-4B
Tonello Kit
Batik™ and
permanganate alternative
Tonello
No Stone ®
Tonello
NoStone®
Sustainable Solutions for Denim Processing
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