



Sustainable Solutions for Denim Processing



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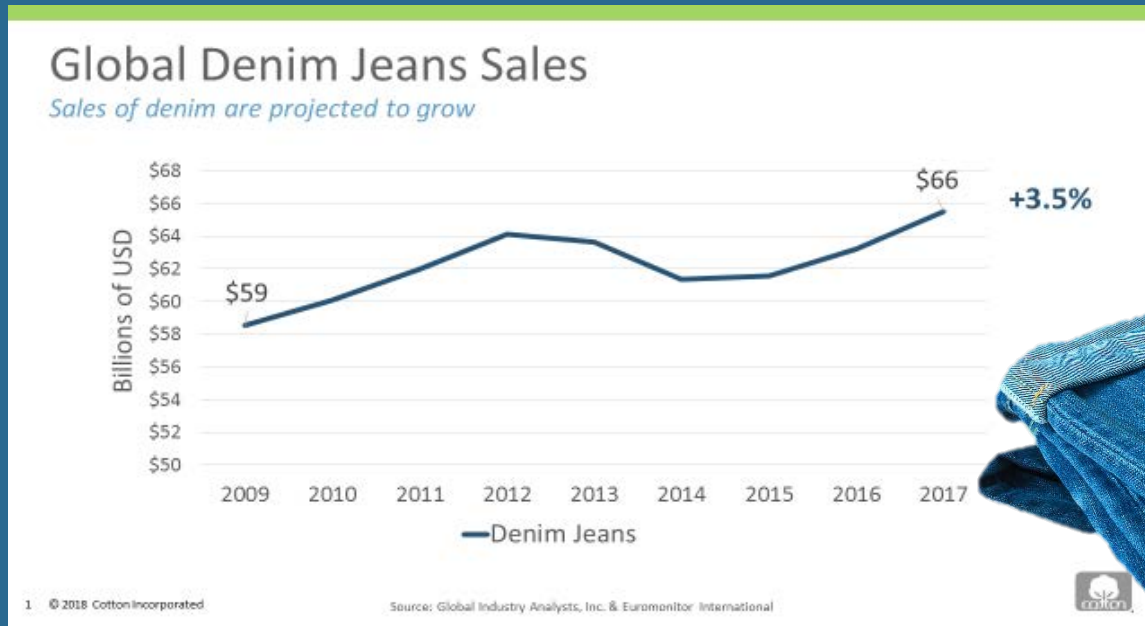
Sustainable Solutions for Denim Processing



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...

Water Consumed:

3,781 liters...

Eutrophication:

48.9 g PO₄-e...

Land Occupation:

12 m²/year...



- 69 miles driven by the average US car
- 246 hours of TV on a plasma big-screen

3 days worth of one US household's total water needs

The total amount of phosphorous found in 1,700 tomatoes

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



Photo courtesy of Archroma

New Advances in Indigo: Cadira

- Cadira Denim from DyStar
 - Combines DyStar Indigo Vat 40% Solution with the ecological advanced reducing agent Sera[®] Con 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).



New Advances in Indigo: Cadira

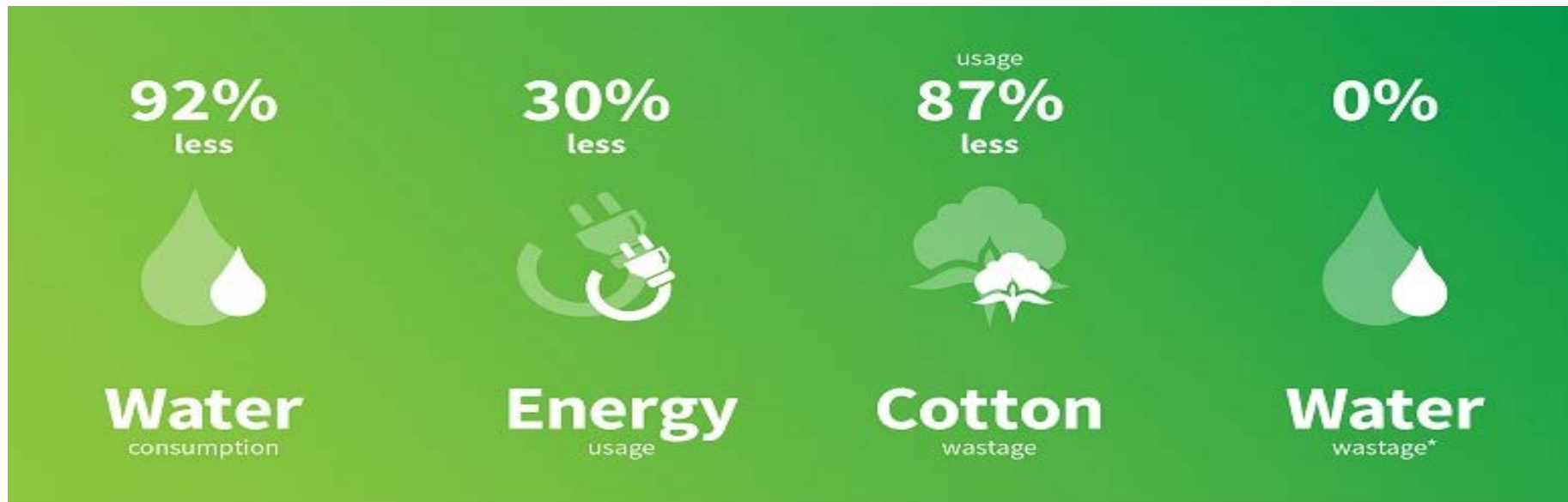
- Cadira Denim from DyStar
 - COD will decrease up to 80% compared to dyeing with Indigo powder and Hydrosulfite
 - Total solids can be reduced up to 90% compared with Indigo powder and Hydrosulfite.
 - Cadira Denim additionally reduces substantial waste quantities from the ETP's (effluent treatment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



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.
 - Can be combined with [Denisol® Indigo 30 liq](#)
 - Bottoming
 - Topping
 - Fresh blue hues



Photo courtesy of Archroma

Indigo Alternatives: Archroma

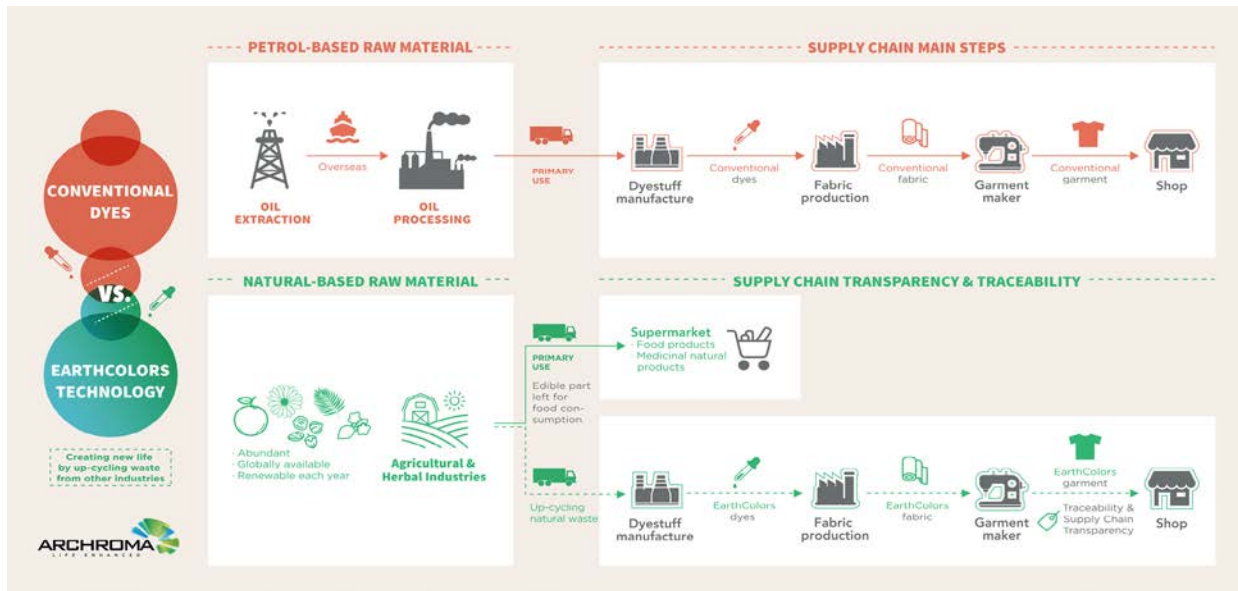


- **Diresul® blacks & greys, a cosmos of greys and deep black and navies**
Archroma's dye portfolio of conventional and black Diresul® specialties allow to create a universe of greys and deep black and navies. From superficial to solid blacks for both extreme wash-down and stay black effects.

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](http://www.indigomilldesigns.com) (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)

eliot™
(DyStar)



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



CHEMICALS



WATER

Potassium Permanganate Alternatives



- Acticell BD
- Acticell RT



- organIQ



- Avol oxy white



- Nearbleach Sky White



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

EARTHCOLORS®



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.



Jeanologia
The Science of Finishing

BLASTEX



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

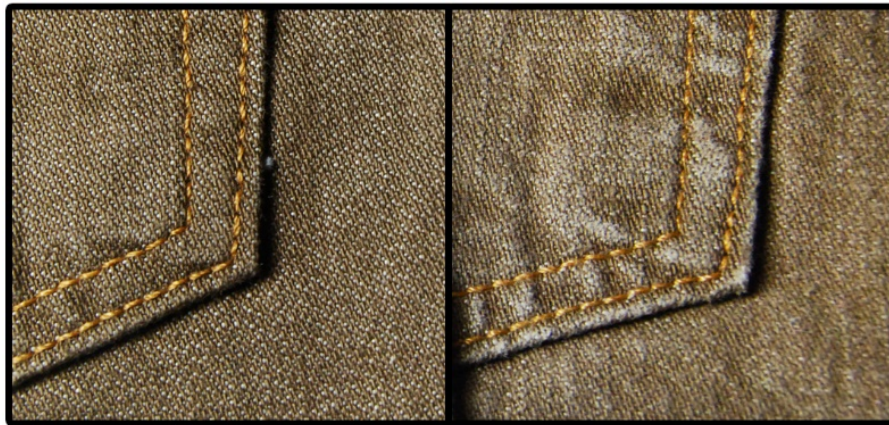


Tonello NoStone®

- 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®

Tonello



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



WATER



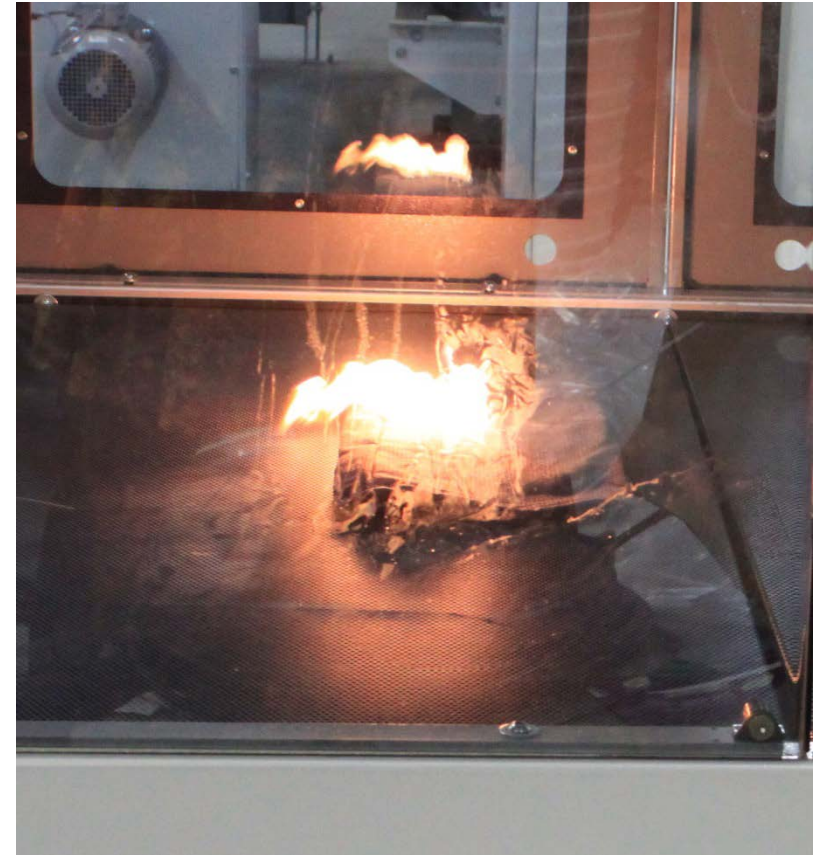
ENERGY



TIME



CHEMICALS



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

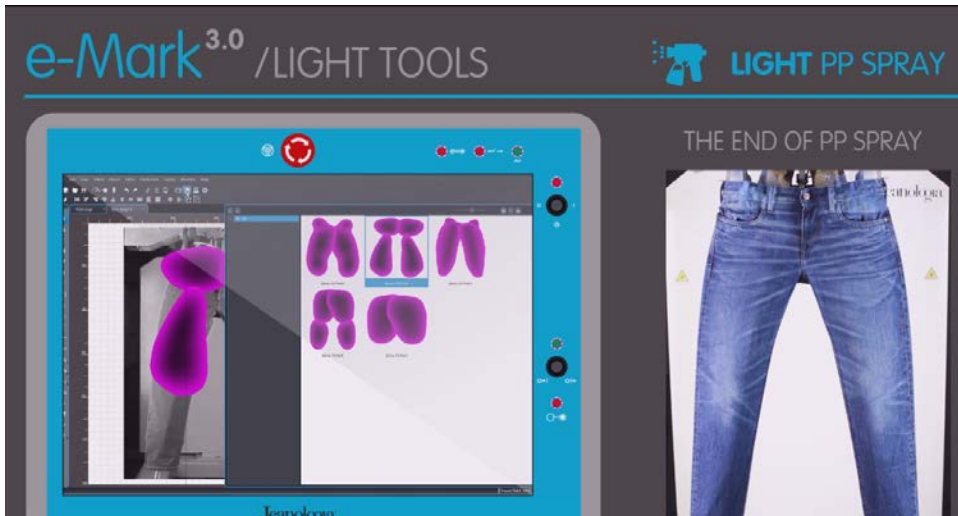


Photo courtesy of Jeanologia™



SK-2060-2A
100% Cotton Jersey

Laser Etching

Sandblasting Alternative

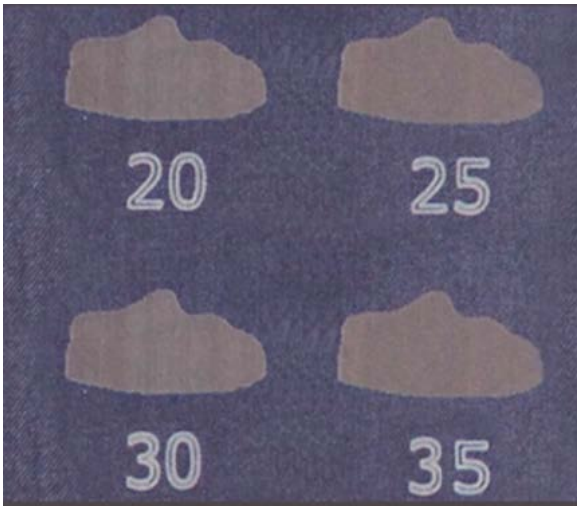
- Multilayer bitmap design files produce realistic effects
- Moderate etching of fabric surface
- Surface fiber is removed to reveal the white core of the warp yarns
- Suitable for mid-weight wovens and heavier



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



Cotton Incorporated's
FABRICAST™ Collection



7072-1C



7073-4A, 7073-4B

EARTHCOLORS®
by Archroma



7098-2



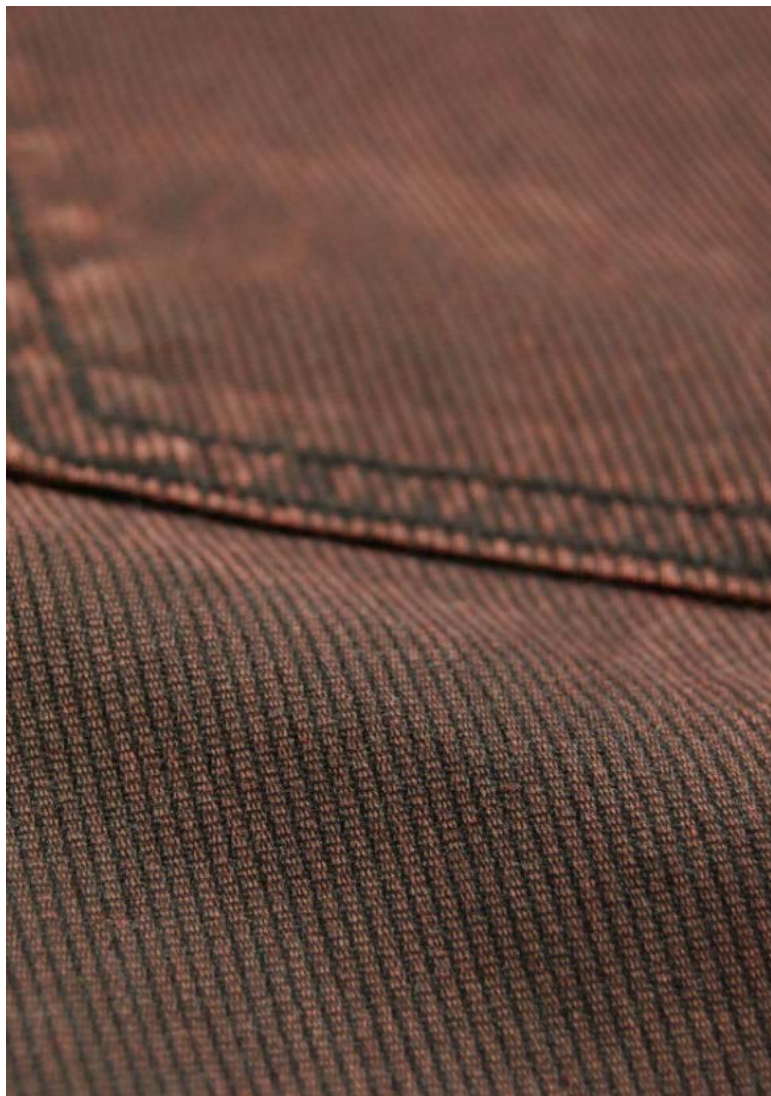
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Tonello Kit
Batik™ and
permanganate
alternative

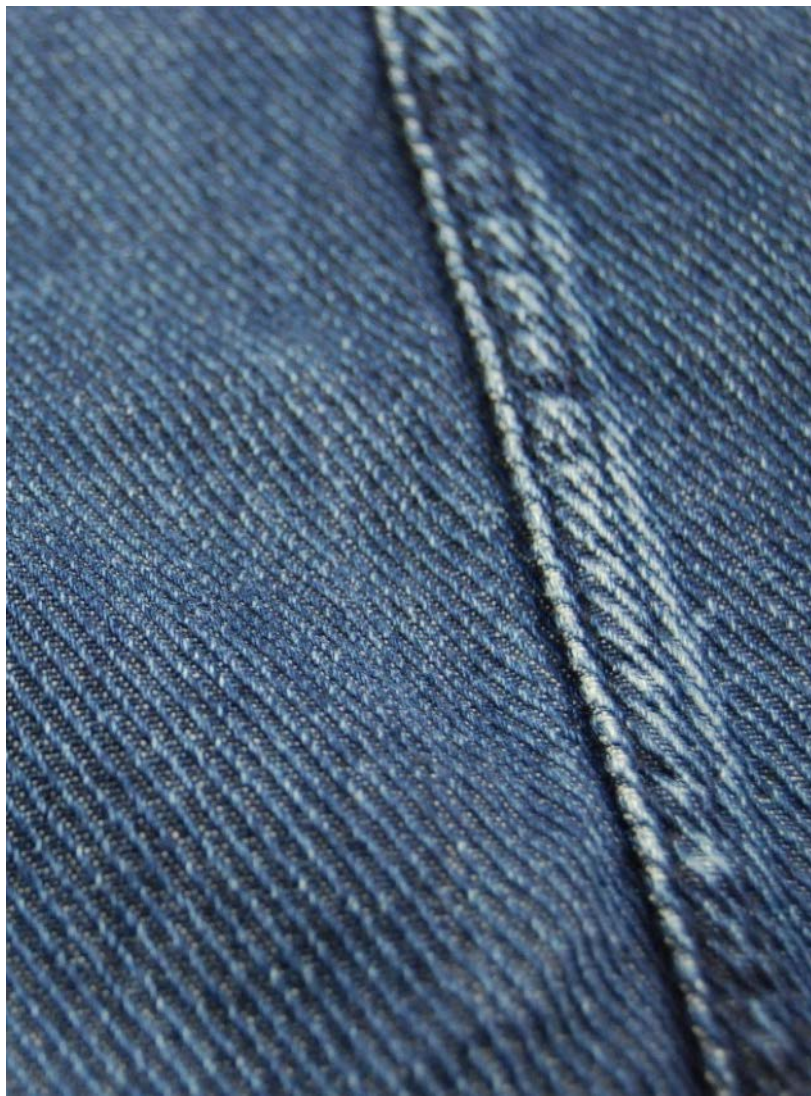


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Laser Etching



7064



7066

Tonello
NoStone®

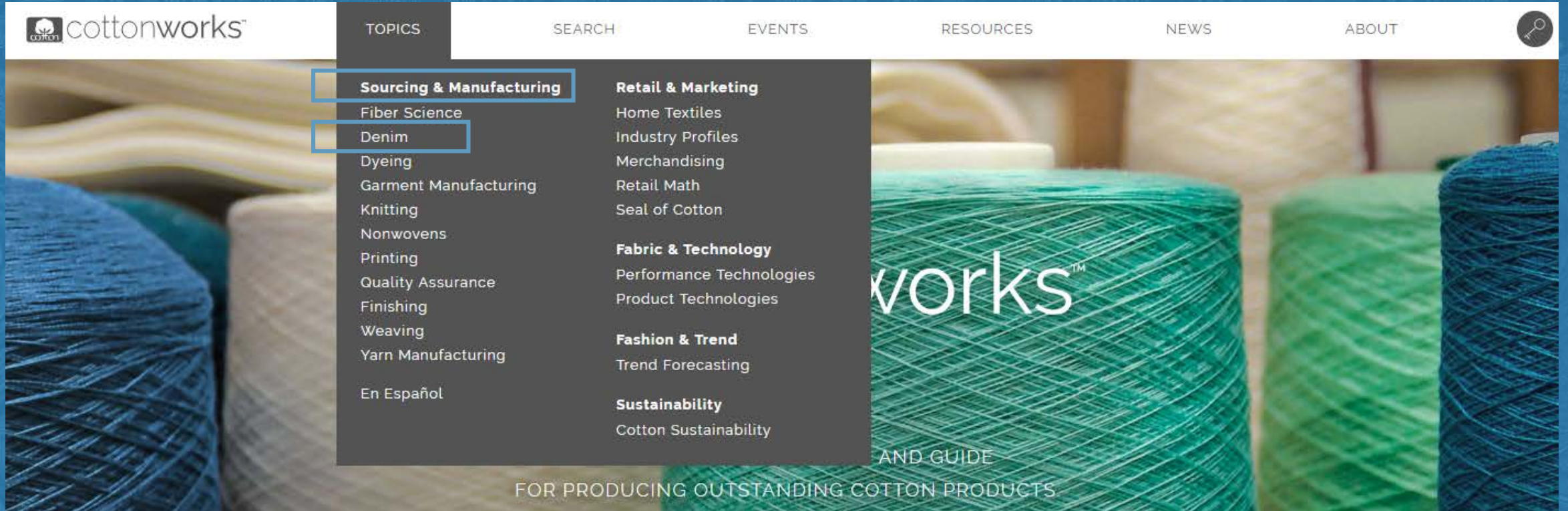


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