cottonworks™

Advancements in Cationic Cotton Technologies

cottonworks™

With hundreds of easily searchable resources, we're your go-to textile tool for discovering what's possible with cotton.

cottonworks.com

@cotton_works

Webinar Support

Type your questions in the Q&A window at any time during the webinar.

Find the presentation slides and other resources at **cottonworks.com** at the conclusion of the webinar.

Please turn off your pop-up blocker to participate in this webinar.

Meet the Presenters

Matt Farrell
Textile Chemistry Research Manager
Cotton Incorporated

Esma Talu
Marketing Manager & Sustainability Manager
Dow

cottonworks™

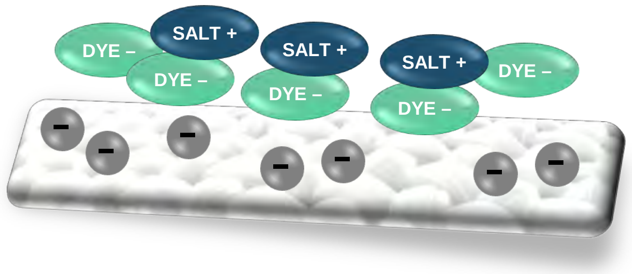
Advancements in Cationic Cotton Technologies

Basics of Cationic Cotton

- Previous Cationic Cotton Webinar: *Subtle to Striped: Sustainable Fashion With Cationic Cotton*, June 26, 2016.
- Cationic cotton refers to cotton that has been chemically modified to possess a permanent cationic (positive) charge
- Concept has been researched for ~50 years
- Ionic attraction of negatively charged dye to cationically charged cotton
- Negates the use of salt, reduces dyestuff, reduces process consumables, and can lead to overall lower costs

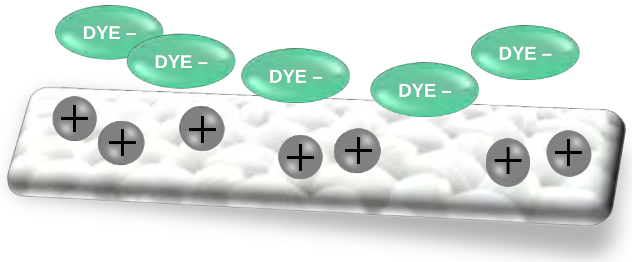
Conventional cotton

Natural negative charge repels dye and requires salt



Cationic cotton

Permanent positive charge attracts dye



Value to the Industry

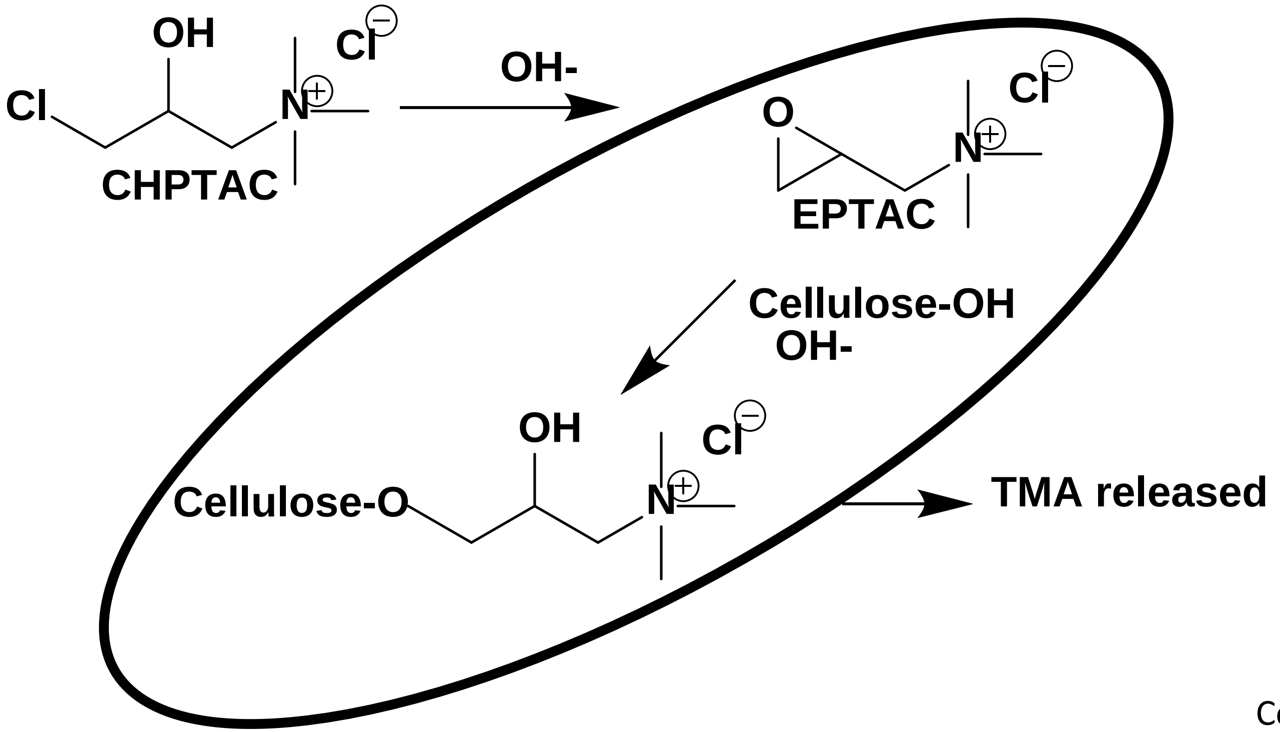
*If consumption trends continue, we'll need **3x as many natural resources** to produce clothing in 2050 compared to 2000.*

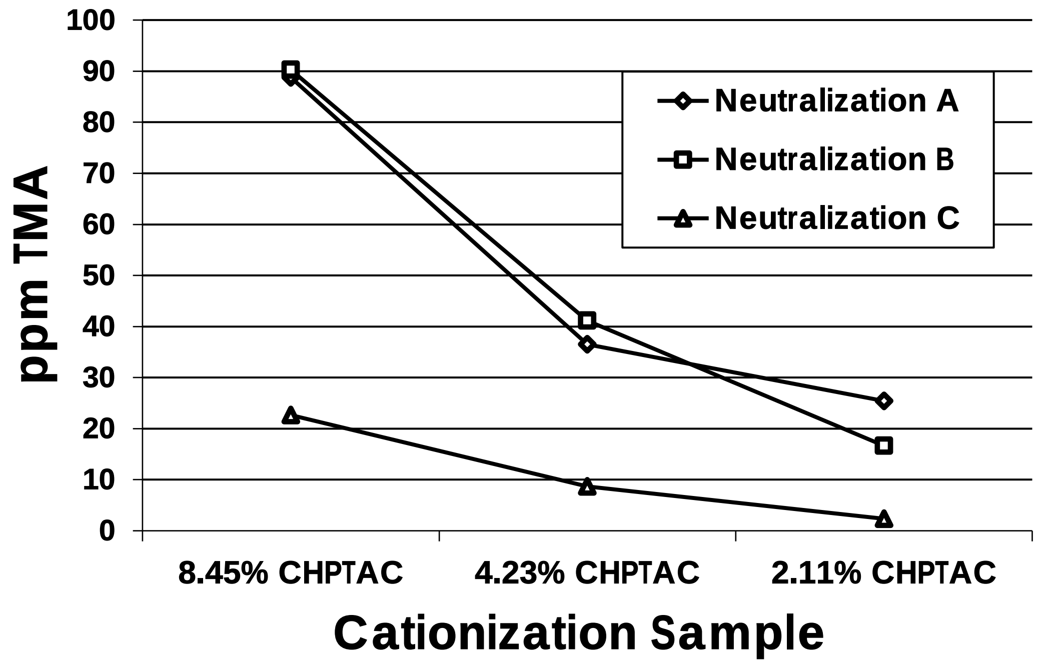
Cationic cotton can play a key role in more sustainable textile production.

Chemistry of Cationic Cotton

Typical cationization reagent, 3-chloro-2-hydroxypropyltrimethylammonium chloride (CHPTAC)

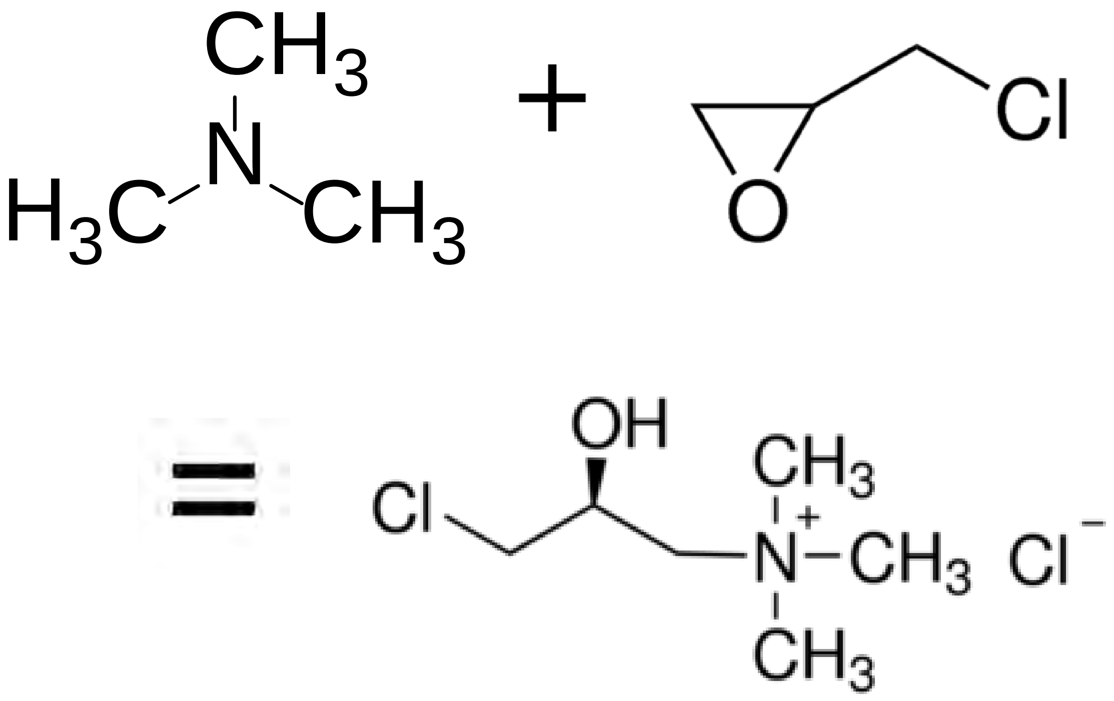
“Quat 188”





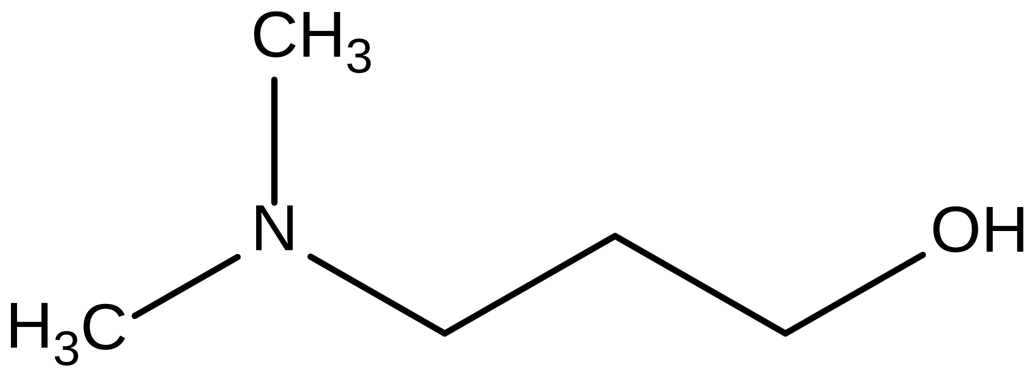
Cellulose (2015) 22:3435-3439
DOI 10.1007/s10570-015-0692-1 (2015) 22:3435–3439

Synthesis of CHPTAC



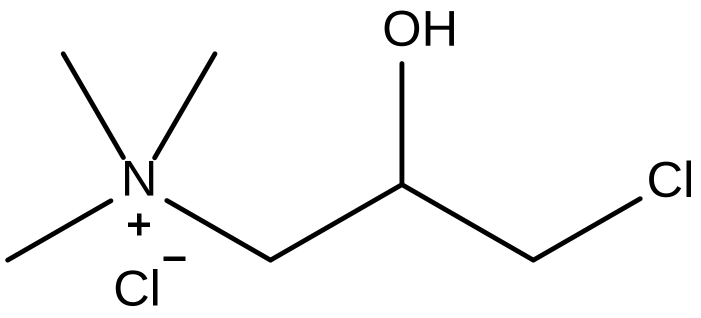
Alternative non-volatile amines

- Low steric hindrance
- Minimal side reactions with EPI
- Economical

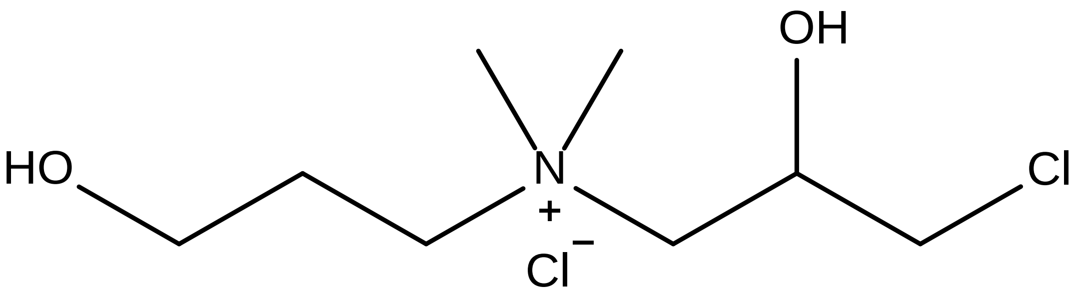


Reducing Cotton's Dependence on Water for Coloration, AATCC 2018 ICE

Molecule Comparison



CHPTAC
Quat 188

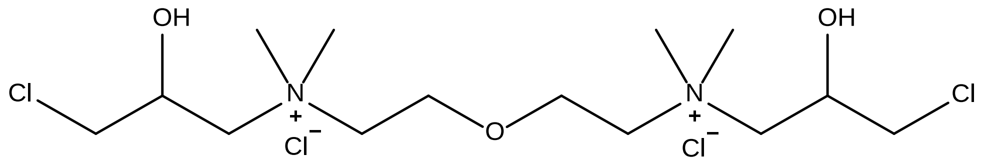


CHPDMAP

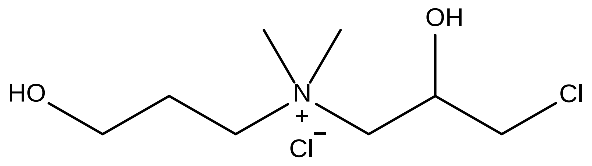
ECOFAST™ Pure Textile Treatment

- Dow was approached for interest in producing the new molecule
- Dow shared their newly patented cationization molecule, BEDQ, tradename ECOFAST™ Pure
- Also made from a non-volatile amine, bifunctional in reactivity and cationic sites
- **No odor**

BEDQ
ECOFAST™ Pure



CHPDMAP



Testing Cationic Cotton Treatments

cottonworks

Dyeing Comparison

- Initial applications to confirm product efficacy and no odor
- Presented at 2018 AATCC ICE, ECOFAST™ Pure officially launched

		Reactive Dyes	o.w.g.	Sodium Sulfate	Sodium Carobonate	Sodium Hydroxide
Conventional Dyeing	**Black Shade**	Black	3.79%	90 g/L	3.0 g/L	3.5 g/L
		Orange	0.74%			
		Red	0.11%			
Cationic Dyeing	**Black Shade**	**Reactive Dyes**	**o.w.g.**	**Sodium Sulfate**	**Sodium Carobonate**	**Sodium Hydroxide**
		Black	2.46%	N/A	1.5 g/L	1.75 g/L
		Orange	0.48%			
		Red	0.07%			

- 33% Less Dye
- No Salt
- 50% Less Alkali
- 20% Time Savings
- 2 less rinses*

Dyebath Comparison

- Improved dye use efficiency and less water use in rinses

Conventional

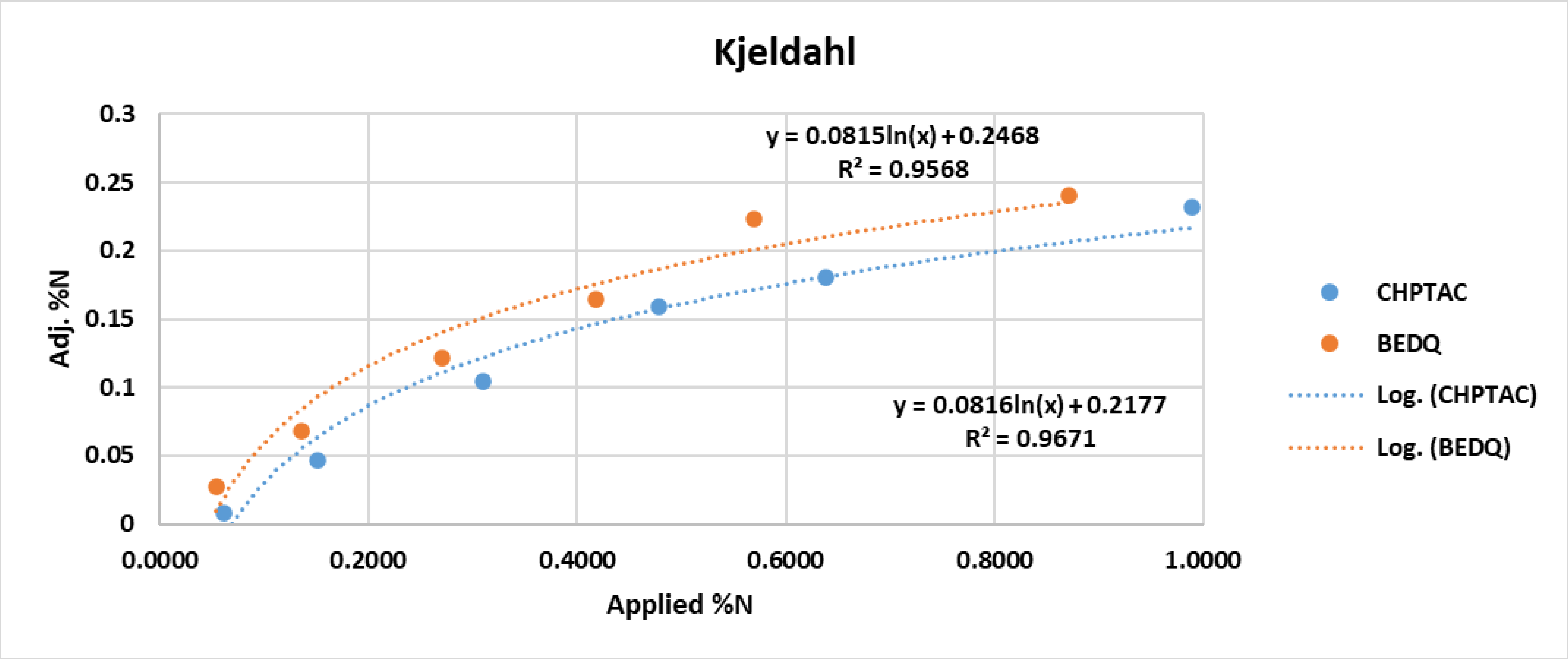
CHPTAC

BEDQ
ECOFAST™ Pure

Increased Collaboration for Impact

- Cotton Incorporated and Dow have collaborated to explore and validate ECOFAST™ Pure, including comparison to Quat-188
- Analytically evaluated ECOFAST Pure vs Quat 188 in cold pad batch, pad steam, exhaust, and pad dry cure processes
  - ECOFAST Pure outperforms and improves cationization efficiency in all processes
- Evaluated nitrogen both by Kjehldahl and combustion techniques
- Evaluated effect of wet pick up on cationization efficiency
- Collaborated to build Dow’s kinetic calculator

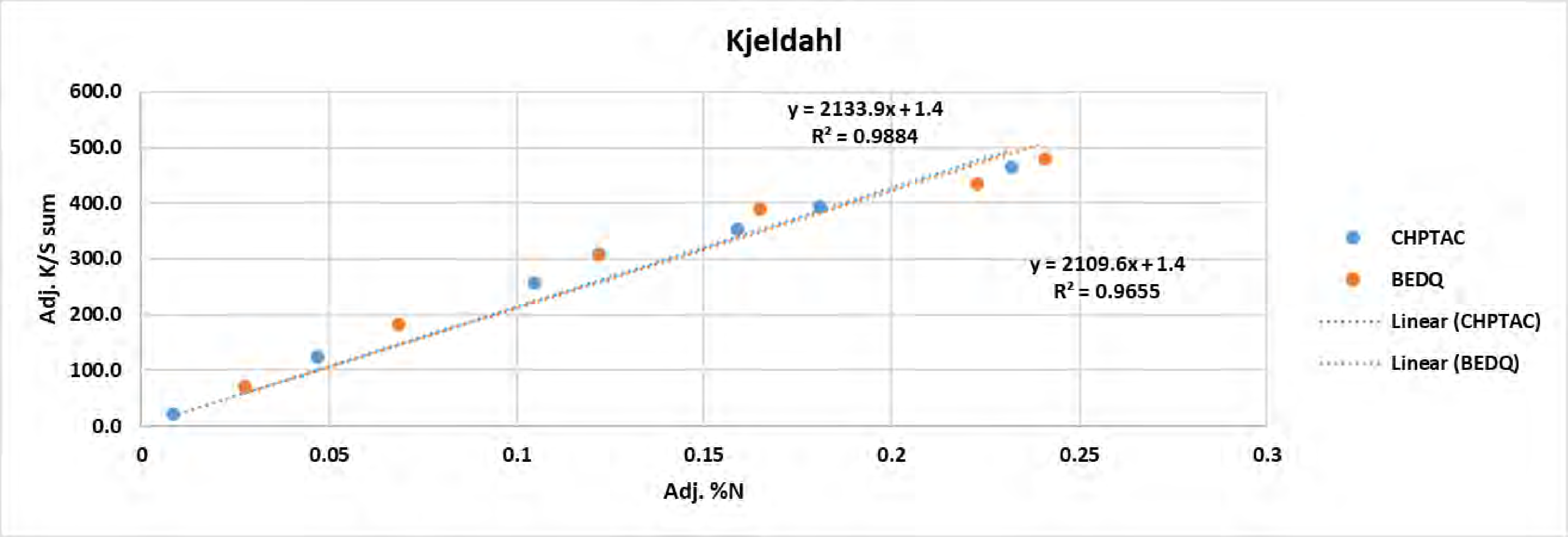
Cold Pad Batch Comparison



Cold Pad Batch Dyeability

Is there a difference in dyeability?

With limited dyes evaluated, have not observed appreciable blocking effects



Validating the Benefits

ECOFAST™ Pure enables...

↓ **90%** process chemicals

↓ **50%** dye

↓ **50%** water

↓ **40%** energy

Key Life Cycle Assessment Insight

↓ **63%** GHG emissions when using ECOFAST™ Pure

Other considerations

- Optimized with pad application
- Registered at **ZDHC** Gateway
- Meets **MRSL** standards

Addressing Common Concerns with Cationic Cotton

cottonworks

Challenges Utilizing Pre-Cationized Cotton

- Purchasing pre-cationized fiber can be an attractive alternative to fabric treatment
- Dark shades such as black or navy may only require a simple scour for, bright shades and/or performance requirements may dictate a bleach preparation
  - Typical bleach formulas and process over-activate hydrogen peroxide species causing extensive fiber damage, loss of dyeability, and low whiteness index
- Without the ability to control the treatment levels, and in general, the cationization may work “too well” in attracting dyestuffs
  - Quick strike of dyes onto cationic cotton can cause unlevel dyeings, splotchy appearances, and may impact fastness properties

Investigating the Bleaching of Pre-Cationized Cotton

Table I.
Effect of Bleaching Temperature on Cationized Cotton Fabric

Cotton Fabric	Bleaching Temperature	Bath after Bleaching		Final Fabric Properties		
		% NaOH Consumption	% H_2O_2 Consumption	WI-CIE	Burst (PSI)	% Strength Loss
Uncationized	Greige	—	—	9.5	81.3	—
	100 °C	32	51	82.0	90.0	–10.7
Cationized	Greige	—	—	20.3	63.2	—
	100 °C	82	94	50.5	30.1	52.4
	90 °C	72	90	52.0	30.2	52.2
	80 °C	54	67	53.2	38.4	39.2
	70 °C	42	44	49.2	41.9	33.7
	60 °C	37	31	43.8	50.3	20.4

- Statistical analysis of design of experiments with factors including bleach temperature, time, concentration of caustic and hydrogen peroxide and magnesium sulfate
- Responses included whiteness index, burst strength, and dyeability

AATCC Journal of Research DOI: 10.14504/ajr.6.5.4

Key Considerations for Bleaching Pre-Cationized Cotton

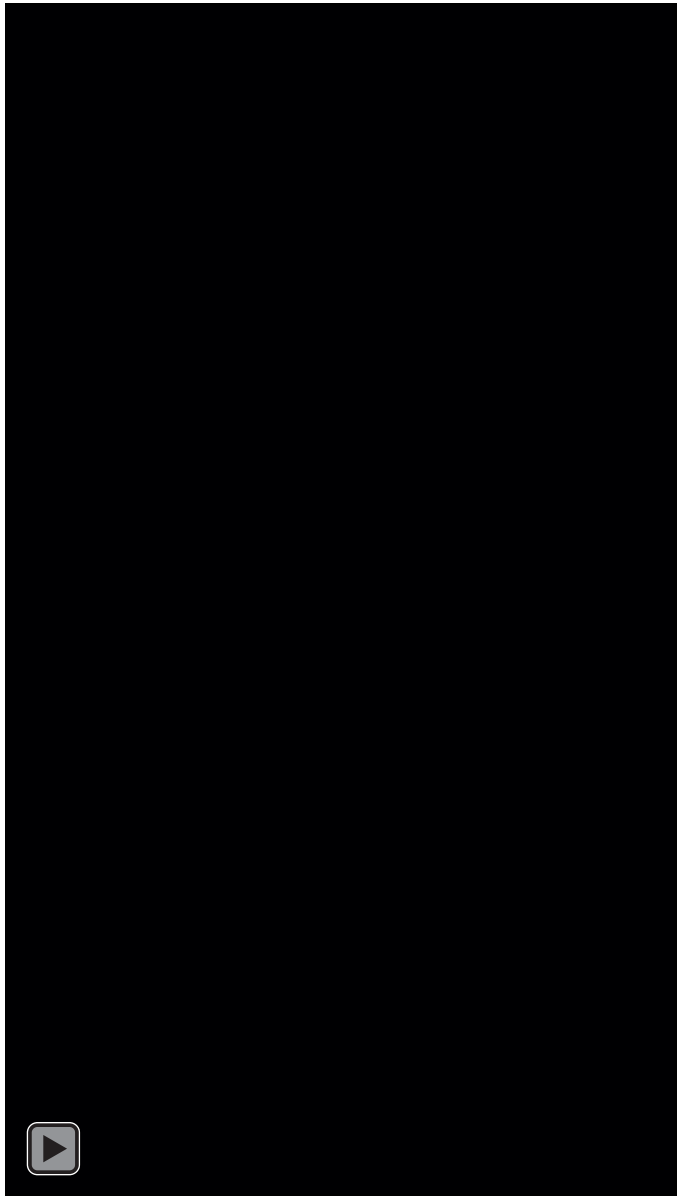
- Direct input of magnesium sulfate (Epsom salt) key in quenching over activation of peroxide system
- Difficult to increase whiteness, burst strength, and dyeability responses at once
- 3-7 g/L of H_2O_2 and 0.5-1 g/L of $MgSO_4$ are suggested in consideration of all responses
- Other factors including time, temperature, and caustic determined by fabric requirements

AATCC Journal of Research DOI:
10.14504/ajr.6.5.4

Bleaching Visualization

Table III.
Effect of $MgSO_4$ on Bleaching Cationized Cotton Fabric

Bleaching Temperature	$MgSO_4$ Conc. (g/L)	Bath after Bleaching		Bleached Fabric Properties		
		% NaOH Consumption	% H_2O_2 Consumption	WI-CIE	Burst (PSI)	% K/S_{dyeing}
100 °C	0	82	94	50.5	30.1	81.5
	0.5	46	27	64.4	58.0	90.9
90 °C	0	72	90	52.0	30.2	82.5
	0.5	41	18	59.6	61.8	95.8



AATCC Journal of Research DOI:
10.14504/ajr.6.5.4

Controlling Strike Rate by Process Changes

- The influence of temperature, dye structure, and addition of soda ash on dyeing kinetics and levelness of cationized cotton were evaluated utilizing real-time dyebath monitoring
- For most of the dyes, significantly better dyeing levelness was obtained by lowering the dyeing temperature although the strike rate was minimally slowed
- Addition of soda ash has different effects on dyeing kinetics and levelness for different dyes
  - For VS-MCT dyes, the addition of soda ash has a relatively small influence on the dyeing performance.
  - For MCT-MCT dyes, eliminating soda ash from the initial dyebath significantly reduced the dye strike rate and improved dyeing levelness.

Cellulose
DOI 10.1007/s10570-016-1008-9

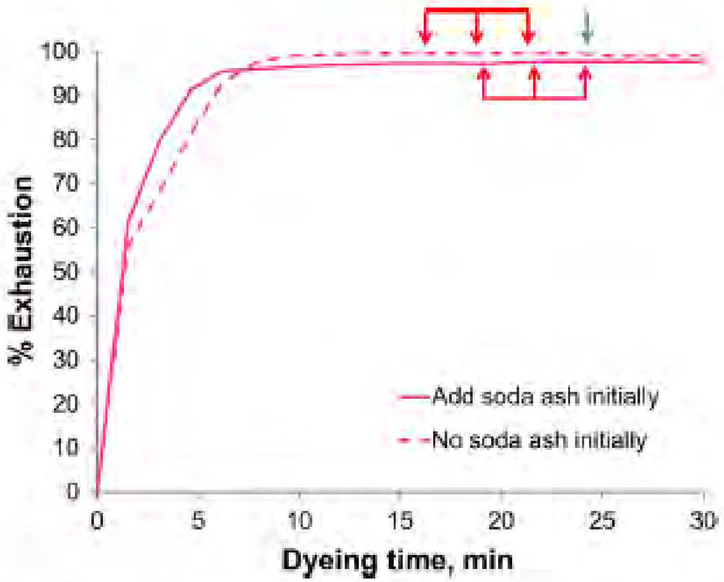
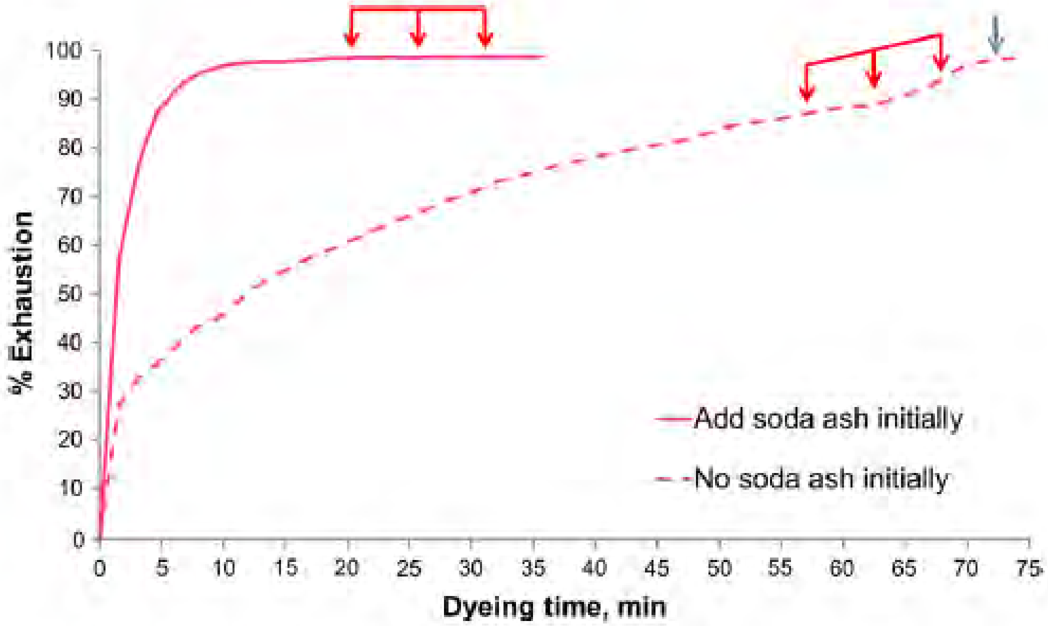
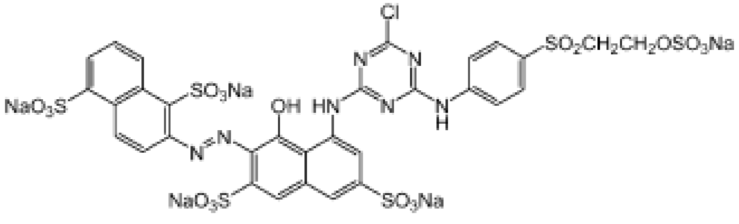
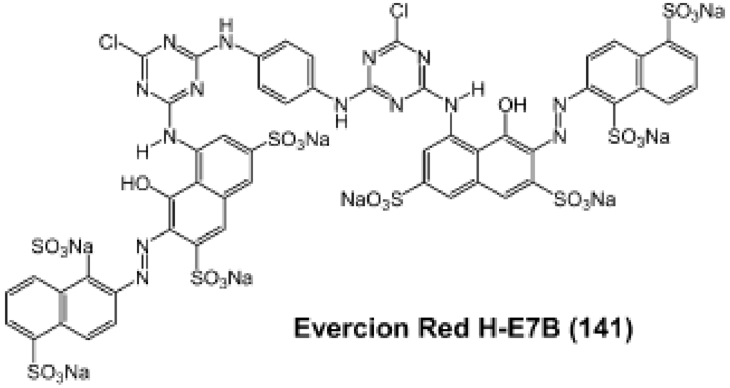


Fig. 9 The influence of soda ash on the exhaustion kinetics of Everzol Red 3BS





Everzol Red 3BS (239)



Evercion Red H-E7B (141)

Cellulose
DOI 10.1007/s10570-016-1008-9

Controlling Strike Rate by Chemical Means

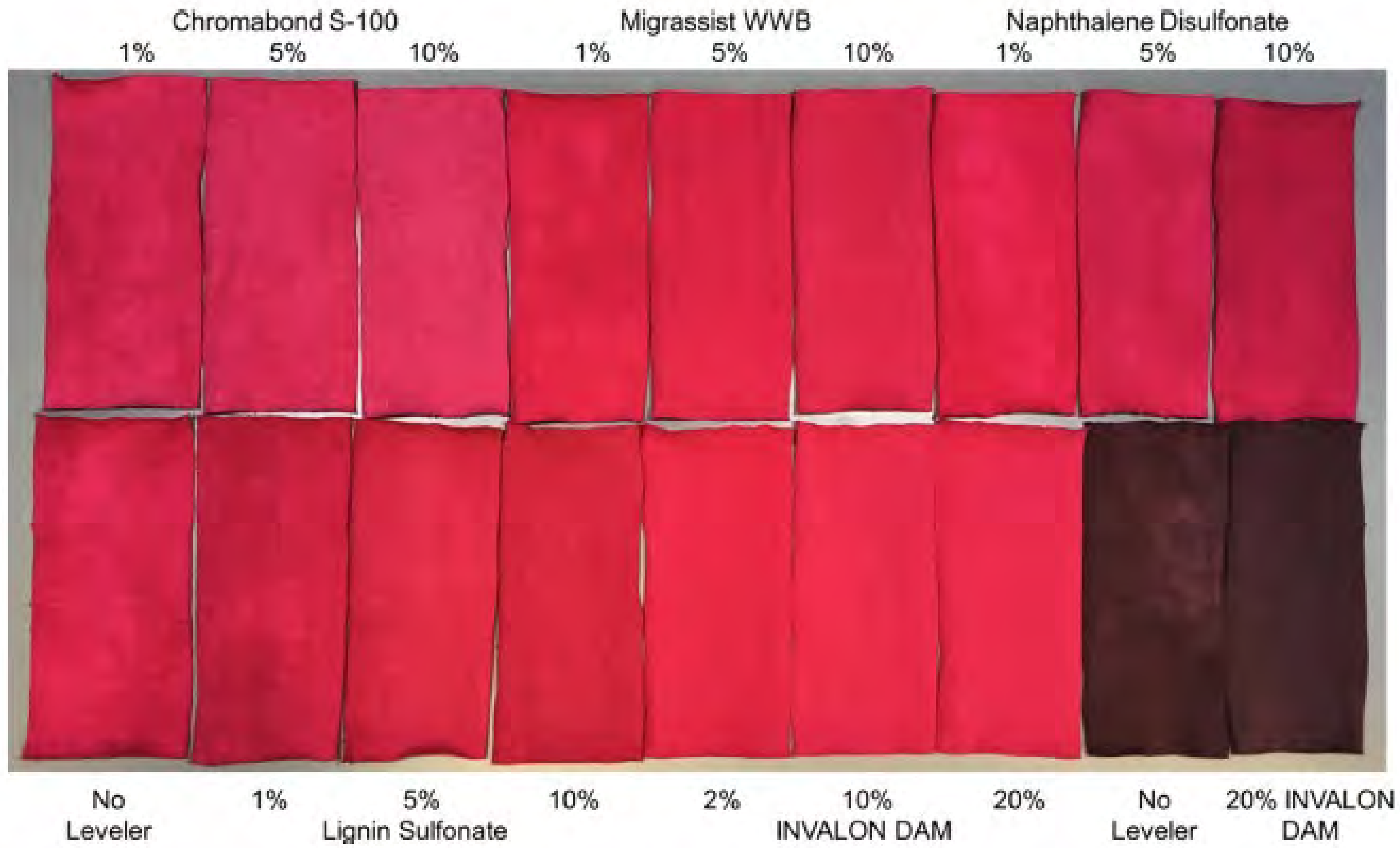
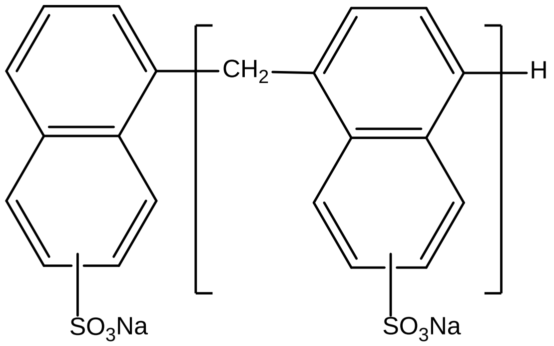


Fig. 12 Cationic cotton fabrics dyed with different leveling agents

Cellulose (2017) 24:3061-3071
DOI 10.1007/s10570-017-1291-0

Key Recommendations for Strike Rate



- Naphthalene sulfonate formaldehyde condensate is key component to allow dye retardation, obtain levelness, but still obtain near complete exhaustion

Cellulose (2017) 24:3061-3071
DOI 10.1007/s10570-017-1291-0

- Dye exhaustion temperature as low as possible
- Add soda ash late in process
- Utilize condensate levelling agent
- Add dye in parts or progressively

Fig. 13 The effect of adding dyes in portions on the exhaustion of Reactive Red 239

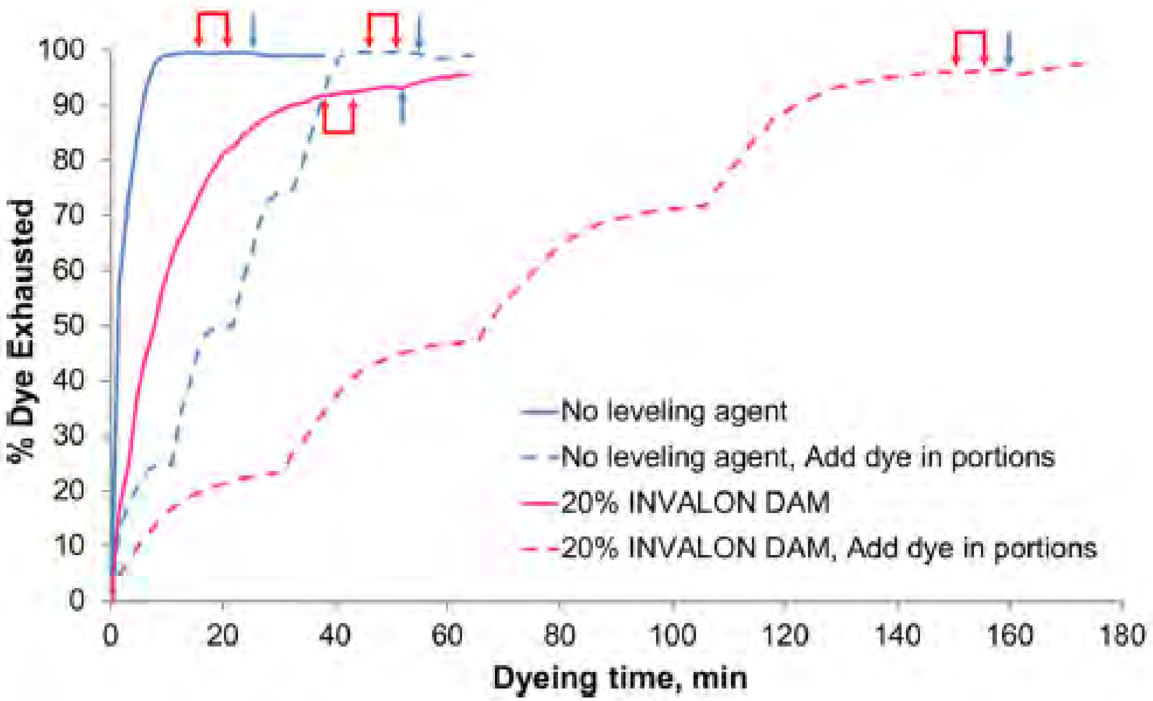


Table 7 The effect of adding dyes in portions on dyeing cationized cotton with Reactive Red 239

Addition of dye	Conc. of INVALON DAM	Dye exhaustion monitoring			Dyed cationized cotton		
		Initial rate (%/min)	Max. rate (%/min)	Final exhaustion (%)	L*	K/S	Levelness (σ)
All in	No leveling agent	36.8	11.1	99.0	40.71	13.95	0.678
	20%	15.3	5.8	95.5	42.59	11.14	0.318
Add in 4 portions	No leveling agent	8.1	6.2	98.3	40.31	15.81	0.796
	20%	3.2	2.1	98.3	41.80	12.12	0.217

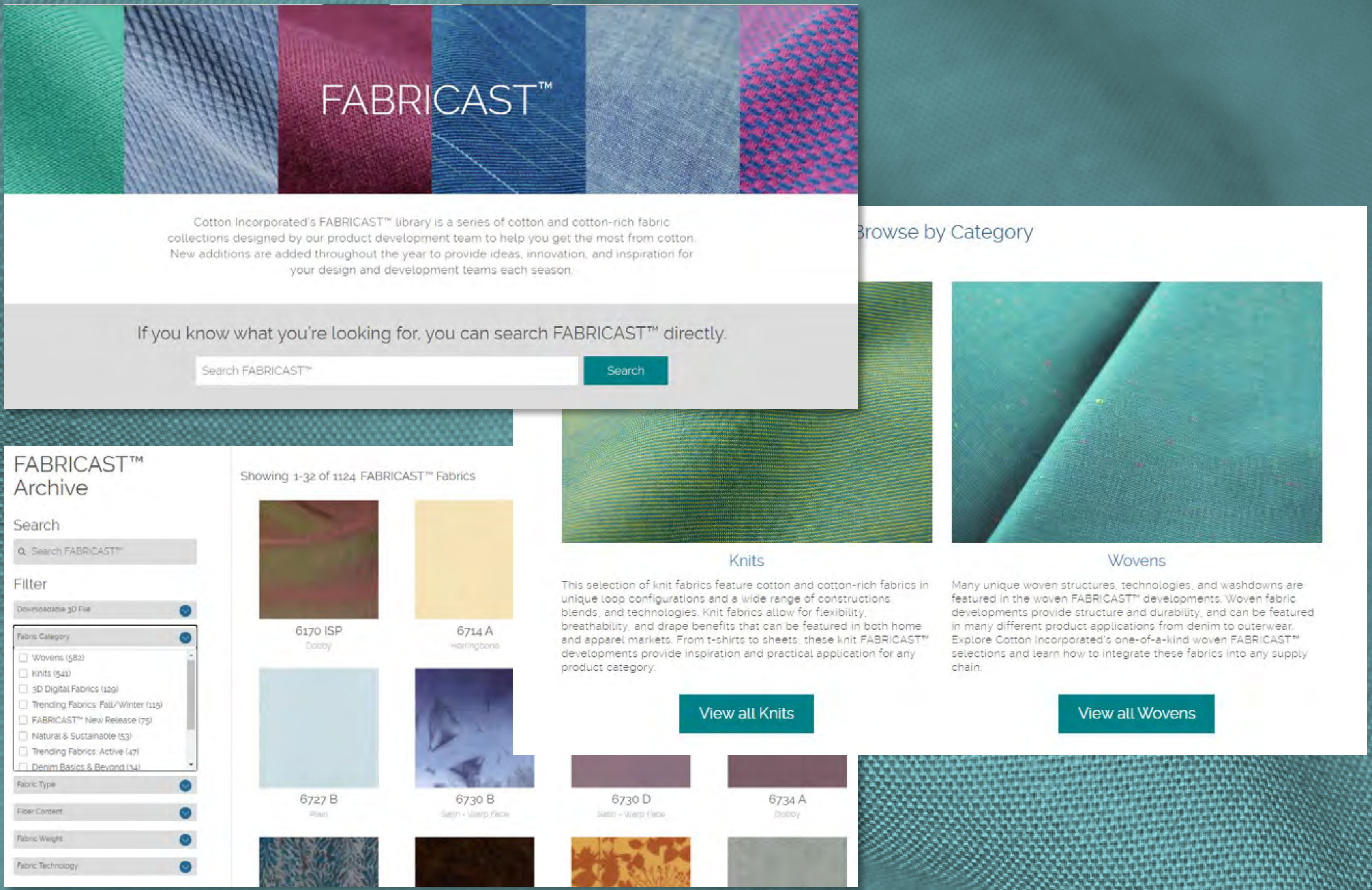
Advancements in Cationic Cotton Technologies

Cationic Cotton

Learn more about cationic cotton on CottonWorks™.

Go to **cottonworks.com/ cationic-cotton**.

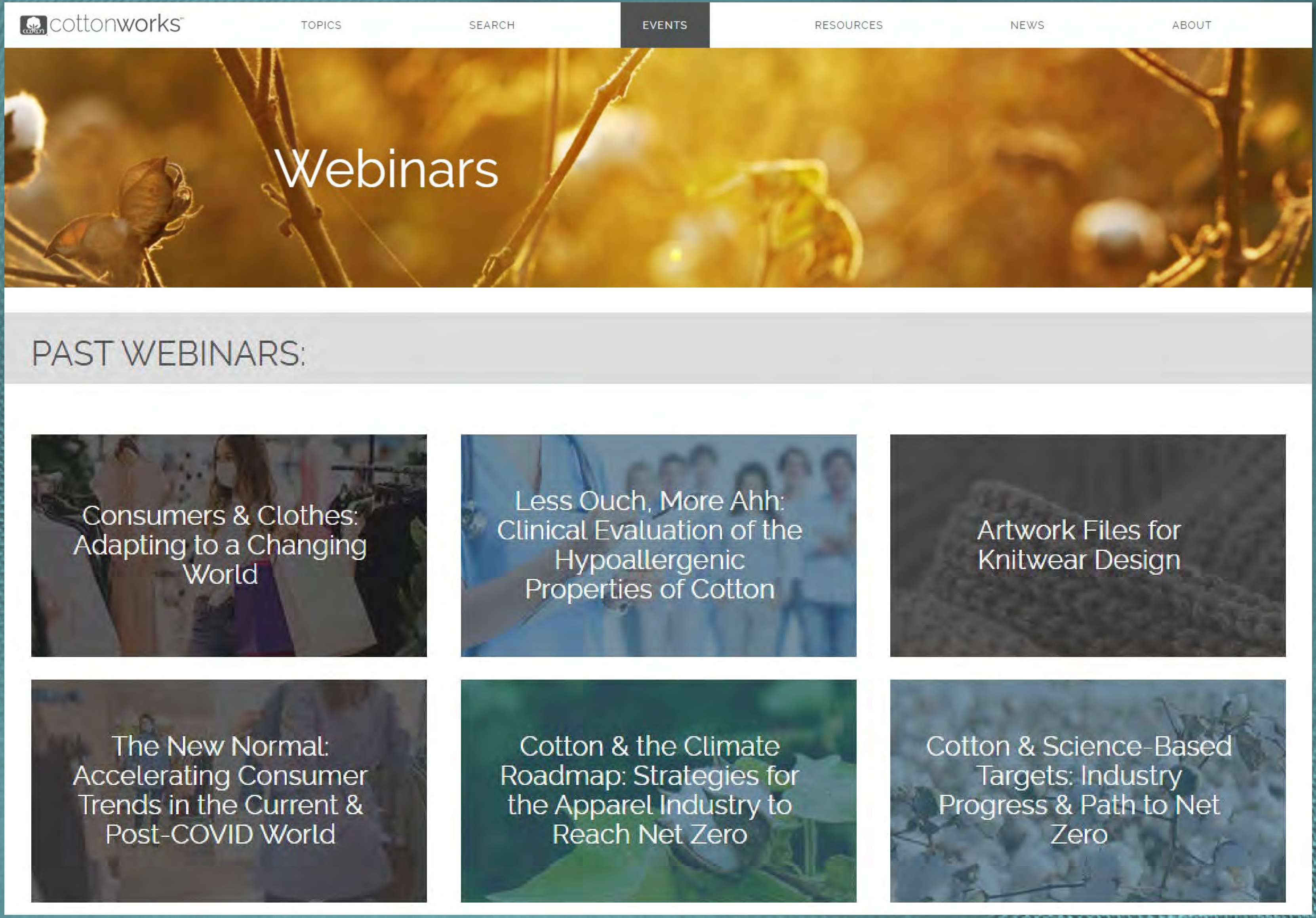
cottonworks



FABRICAST™

Our FABRICAST™ library is a series of cotton and cotton-rich fabric collections designed by our product development team to provide ideas, innovation, and inspiration.

Go to **cottonworks.com/ fabricast**.



Interested in sharing this content with a colleague?

Create a free CottonWorks™ account and find all past webinars at **cottonworks.com/ webinars**.

Please allow 24-48 hours for this webinar recording to be added.

cottonworks

cottonworks™

Advancements in Cationic Cotton Technologies

Submit all final questions now using the Q&A box on your screen.

Please take our brief survey on today's presentation prior to exiting the webinar.