A STUDY ON UTILITY & COST COMPARISON INVOLVED DURING WET PROCESSING OF REGENERATED CELLULOSIC FABRIC

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Abstract
The wet processing of regenerated cellulosic fabrics involves a complex interplay of chemical treatments, process control parameters, utility consumption, and associated costs. This review provides a comparative study of different regenerated cellulosic fabrics - such as viscose, lyocell, modal and Bamboo by evaluating the chemical recipes used, process control parameters employed, utility consumption patterns, and the cost per kg of fabric during the wet processing phase. The review aims to offer insights into the optimization of wet processing operations, contributing to reduced resource consumption, cost efficiency, and sustainability in the textile industry.

Keywords
wet processing, regenerated cellulosic fabric, chemical recipes

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1.0 Introduction:

Regenerated cellulosic fibresderived from natural cellulose sources, are an important segment in the textile industry, offering diverse characteristics and applications. Wet processing of these fabrics includes various stages such as scouring, bleaching, dyeing, and finishing, which are necessary to enhance the fibre properties and prepare them for end-use. This study compares the wet processing parameters, chemical recipes, and utility consumption of different regenerated cellulosic fabrics (viscose, lyocell, and modal) to assess their environmental impact, energy requirements, and economic viability.

2. Manufacturing process of regenerated cellulose fibres

The manufacturing process of viscose, modal, lyocell and baboo fibres is as below,

Viscose Process

Wood Pulp → Alkali Treatment (NaOH) → Aging → Xanthation (CS_2) → Dissolution in NaOH (Viscose Dope) → Filtration & Degassing → Wet Spinning (Acid Bath) → Regeneration → Washing & Cutting → Finishing

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Modal Process

Beechwood Pulp → Alkali Treatment (NaOH) → Short Aging → Mild Xanthation → Dissolution (Modal Dope) → Filtration & Stretching → Wet Spinning (Acid Bath) → Regeneration → Washing & Cutting → Finishing

Lyocell Process

Wood Pulp (Eucalyptus, etc.) → Dissolution in NMMO Solvent → Filtration → Dry-Jet Wet Spinning → Water Coagulation Bath → Washing & Solvent Recovery → Drying → Cutting & Finishing

Bamboo Process

Bamboo Plant → Crushing & Cooking to Bamboo Pulp → Alkali Treatment (NaOH) → Aging → Xanthation (CS_2) → Dissolution (Viscose Dope) → Wet Spinning (Acid Bath) → Regeneration → Washing & Cutting → Finishing

3. Properties that specifically influence wet processing of fabric

TheProperties that specifically influence wet processing of viscose, modal, lyocell and baboo fabric is as below,

Properties	Viscose	Modal	*Lyocell (TENCEL™)*	*Bamboo*
Water Absorbency	Very high	Very high	High	Very high
Moisture Regain	~11–13%	~12–14%	~11–13%	~11–13%
Swelling in Water	Significant (high swelling)	Moderate	Controlled swelling (less fibrillation)	Significant
Wet Strength	Poor (strength drops 40–50%)	Better than viscose	Very good wet strength	Poor
Alkali Resistance	Poor (damaged by strong alkalis)	Slightly better	Good resistance	Poor
Colour Uptake / Dye Affinity	High	Very high	High (but requires fibrillation control)	High
Dye Penetration Uniformity	Excellent	Excellent	Needs care to avoid surface fibrils	Good
Bleaching Sensitivity	Sensitive to strong bleaching agents	Slightly better	Tolerates eco-friendly bleaching	Sensitive
Fibrillation Tendency	Low	Low	High (needs enzyme/desizing control)	Low
Shrinkage During Processing	High	Low to moderate	Very low	Moderate
Drying Behaviour	May shrink, needs controlled drying	Improved dimensional stability	Very stable, fast drying	May shrink, soft feel retained
Softness Retention After Wash	Decreases	Retains softness	Retains smooth hand feel	Retains softness
Pilling Tendency	Moderate	Lower than viscose	Can pill if fibrillation untreated	Moderate
Finish Compatibility	Accepts softeners and finishes well	Good response to softeners	Needs anti-fibrillation/enzymes	Good
Fabric Handle Post Processing	Soft, but weaker	Softer and stronger	Smooth, stable, premium	Soft, plush

4. Overview of Wet Processing Stages

Wet processing refers to a series of treatments that fabric undergoes to achieve the desired appearance and functionality. These treatments typically include:

- Desizing: Removal of size (Woven Only)
- Scouring: Removing natural impurities.
- Bleaching: Whitening or lightening the fabric.
- Dyeing: Imparting colour to the fabric.
- Soaping/ Washing:
- Finishing: Final treatments for fabric texture and performance (e.g., softening, water-repellent finishes).

5. Details of process route for viscose, modal, lyocell and bamboo:

Viscose (100%)	Modal (100%)	Lyocell (100%)	Bamboo (100%)
Desizing (woven only) ↓ Scouring (5-6 gpl Soda ash, wetting agent) ↓ Peroxide Bleaching (1.5–2% H_2O_2, stabilizer) ↓ Neutralization (Acetic acid) ↓ Reactive Dyeing (Salt 40–60 gpl, Soda 15–20 gpl, 60–80°C) ↓ Soaping (Non-ionic detergent, 70–80°C) ↓ Acid Rinse (pH 5–6) ↓ Softening (Cationic or Silicone)	(Desizing if needed – Enzymatic) ↓ Mild Scouring (4-5 gpl Soda ash or Enzymatic) ↓ Mild Bleaching (1–1.5% H_2O_2) ↓ Neutralization (Acid rinse) ↓ Reactive Dyeing (Salt 30–50 gpl, Soda 10–15 gpl, 60–80°C) ↓ Soaping (High-temp, non-ionic) ↓ Acid Rinse (pH 5–6) ↓ Softening (Silicone preferred)	Bio-Scouring (Enzymatic – pectinase, 55°C) ↓ Optional Mild Bleaching (0.5–1% H_2O_2, stabilizer) ↓ Neutralization (Acid rinse) ↓ Reactive Dyeing (Cold brand dyes, Salt 20–30 gpl, Soda 10 gpl, Max 60°C) ↓ Anti-Fibrillation Enzyme Treatment (Cellulase, 50–55°C) ↓ Soaping (50–60°C) ↓ Acid Rinse (pH 5) ↓ Softening (Low-cure, fibrillation control)	Mild Scouring (4-5 gpl soda ash, wetting agent) ↓ Bleaching (1–1.5% H_2O_2, stabilizer) ↓ Neutralization (Acetic acid rinse) ↓ Reactive Dyeing (Salt 40–50 gpl, Soda 15–20 gpl, 60–70°C) ↓ Soaping (Non-ionic detergent, 70–75°C) ↓ Acid Rinse (pH 5–6) ↓ Softening (Cationic softener)

6. Details of chemicals used and process control parameters maintained:
**** All doses are in g/L, and M: L = 1:10 (standard for winch, soft flow)**

Process	Fabric Type	Chemicals	Dosage	Purpose / Notes	Temp / Time
Desizing	Viscose (Woven)	α-amylase enzyme	1.5–2.0	For starch removal	60–70°C / 20–30 min
		Wetting agent	0.5–1.0	Helps enzyme penetration	
		Soda ash (Na_2CO_3)	0.5	Mild pH (~7–8) support	
	Modal(Knits or Woven)			Desizing if needed – Enzymatic	
	Lyocell / Bamboo (Knits or Woven)	—	—	Usually not required (not sized)	—
Scouring	Viscose (Woven)	Soda ash	5–6	Removes oils, waxes	90°C / 30–40 min
		Wetting agent	0.5–1.0	Surface tension reduction	
		Sequestering agent (EDTA)	1.0	Controls hardness	
	Modal (Woven)	Soda ash	4–5	Softer alkali to retain strength	85°C / 30 min
		Anti-creasing agent (if rope form)	1.0	Prevents creases	
	Lyocell (Knit)	Bio-Scouring (Enzymatic – pectinase, 55°C)	2-3	Lower alkali to prevent fibrillation	80°C / 25–30 min
		Anti-creasing + Wetting agent	1.0 + 0.5	Essential for loop/rope process	
	Bamboo (Knit)	Soda ash	4–5	Similar to viscose	85°C / 30 min
		Wetting agent	0.5–1.0	Surface tension reduction	

Table continue...

Process	Fabric Type	Chemicals	Dosage	Purpose / Notes	Temp / Time
Bleaching	Viscose/Modal/ Bamboo	Hydrogen peroxide (35%)	1.5-2%		
	Lyocell	Hydrogen peroxide (35%)	0.5-1%	Decolorization	85–90°C / 30–45 min
		Soda ash	3–5	pH 10.5–11.0 for safe activation	
		Peroxide stabilizer	0.5–1.0	Prevents catalytic breakdown	
		Sequestering agent	0.5–1.0	Controls metals (Fe, Cu)	
Neutralization	All	Acetic acid	0.5–1.0	Final pH ~6.5–7.0	40–50°C / 10 min
Dyeing	Viscose	Reactive dye (HE or ME brand)	X% owf	Based on shade depth	60°C -80 °C / 45–60 min
		Common salt / Glauber's salt	40- 60	Salt addition in 2 steps	
		Soda ash	15–20	pH 10–11 for fixation (2-step addition)	
	Modal	Reactive dye (hot brand)	X% owf	Stronger fiber, tolerates standard recipe	60°C -80 °C / 45 min
		Common salt / Glauber's salt	30-50	Salt addition in 2 steps	
		Soda ash	15–20	pH 10–11 for fixation (2-step addition)	
	Lyocell	Reactive dye (cold or medium temp)	X% owf	Use soft liquor flow, low agitation	40–50°C / 45 min
		Common salt / Glauber's salt	20-30	Salt addition in 2 steps	
		Soda ash	10–15	Avoid high pH to limit fibrillation	
	Bamboo (Knit)	Reactive dye (cold/hot brand)	X% owf	Similar to viscose	60°C-70°C / 45 min
		Common salt / Glauber's salt	40-50	Salt addition in 2 steps	
		Soda ash	15-20	Avoid high pH to limit fibrillation	
Soaping	All	Soaping agent	1–2	Removes unfixed dye	75–80°C / 15 min

Notes:

- Lyocell requires the gentlest treatment due to fibrillation risk — always use low pH, low agitation, and anti-creasing agents.
- Modal behaves similar to cotton but needs moderate alkali strength.
- Bamboo performs like standard viscose.
- Always use soda ash instead of caustic soda to protect cellulosic fibre integrity in these regenerated fibres.

7. Comparison of utility consumption:

	Viscose		Modal		Lyocell		Bamboo	
	(Batch)	(Continuous)	(Batch)	(Continuous)	(Batch)	(Continuous)	(Batch)	(Continuous)
Water (L/kg)	60	40	55	38	50	30	70	45
Steam(kg/kg)	1-1.5 kg/kg		0.8-1.2 kg/kg		0.5-1 kg/kg		1-1.5 kg/kg	
Electricity (kWh/kg)	0.5-1 kWh/kg		0.6-1 kWh/kg		0.4-0.8 kWh/kg		0.5-1 kWh/kg	
Wastewater (L/kg)	50	30	45	28	35	20	55	35

8. Comparison of wet processing cost (Rs. /kg)

	Viscose		Modal		Lyocell		Bamboo	
	Batch Processing (Rs/kg)	Continuous Processing (Rs/kg)	Batch Processing (Rs/kg)	Continuous Processing (Rs/kg)	Batch Processing (Rs/kg)	Continuous Processing (Rs/kg)	Batch Processing (Rs/kg)	Continuous Processing (Rs/kg)
Chemical Costs	45-50	35-45	50-60	40-50	60-75	50-65	55-70	45-60
Water Consumption	20-30	15-20	20-30	15-20	25-35	20-30	20-30	15-20
Energy Consumption	15-25	10-15	15-20	10-15	20-30	15-20	15-25	10-15
Labour and Maintenance	10-15	5-10	10-15	5-10	15-20	10-15	10-15	5-10
Total Cost	**90-125**	**65-90**	**95-130**	**70-95**	**120-160**	**95-130**	**100-140**	**75-105**

* Note: Above tables are meant to serve as a general guideline and may vary depending on the specific setup of a textile processing plant.

9. Benefits to the textile industry:

Stakeholder	Key Benefits
Production/Processing	- Helps select optimal process parameters for different fibres- Reduces processing errors and rework- Informs choice of auxiliaries and chemicals
Cost Management	- Enables better budgeting by comparing chemical, water, and energy consumption - Supports decision-making on most economical fibre choice
Quality Assurance	- Improves consistency and dyeing quality- Helps troubleshoot defects like fibrillation, shade variation, etc.
Technical Teams (R&D)	- Identifygaps and process improvement opportunities- Aids in developing new recipes or machinery settings
Sustainability / EHS	- Allows comparison of environmental impact (e.g., water, alkali, temp) - Supports implementation of cleaner and safer processes

10. Conclusion

The comparative study of cost, utility requirements, and process parameters across different regenerated fibres viz., viscose, modal, lyocell, and Bamboo providescritical operational and strategic insights to the textile industry and its associated stakeholders. Overall, it helps in knowledge-based decision making, risk mitigation, better resource utilization, higher customer satisfaction, greater innovation and compliance

In conclusion, manufacturers seeking to optimize their wet processing operations should consider the trade-offs between chemical usage, water and energy consumption, and overall cost. Further innovations in chemical recipes and process control technologies may further enhance the environmental and economic viability of regenerated cellulosic fabrics.

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