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Review Article

A Review: To Improve Aesthetic Properties of Cotton Khadi Fabric by Enzyme Treatment & Nano Silicon Finish

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Abstract

Khadi is a traditional hand-spun and hand-woven cotton fabric, but it's rough handle, subdued lustre, and lack of functional finishing limit acceptance among younger consumers. Conventional pre-treatments for khadi rely on strong alkalis and oxidizing agents, which are difficult to control in small-scale hand-processing and impose high water, energy, and chemical loads. This work evaluates an eco-friendlier enzymatic pre-treatment and finishing route to improve the aesthetic properties of cotton khadi suiting and shirting fabrics.

Grey khadi fabrics were desizing with α amylase, bio scoured with pectinase, bio polished with acid cellulase, and finished with a nano silicone softener. For comparison, parallel samples underwent conventional processing: desizing with hydrochloric acid, scouring with sodium hydroxide, bleaching with bleaching powder, and softening with a conventional silicone or nano silicone finish. All samples were evaluated for mass per unit area, thickness, bending length, flexural rigidity, crease recovery angle, ends and picks per inch, shrinkage, vertical wicking, yarn friction, reflectance, and whiteness index using standard textile testing procedures.

Introduction

Khadi is defined as any cloth produced from cotton, wool, silk, or their blends that is both hand-spun and hand-woven, and cotton khadi is specifically made from hand-spun cotton yarn woven on handlooms. Historically closely associated with the Indian freedom movement, khadi is valued for its durable, long-lasting character and its comfort in both summer and winter climates. Despite these advantages and extensive governmental efforts to promote it, khadi still faces low acceptance among younger consumers due to its relatively rough handle, subdued appearance, poor crease recovery, and lack of modern functional finishes.

Conventional wet processing of cotton and khadi typically involves desizing, scouring, bleaching, and softening with strong mineral acids, concentrated sodium hydroxide, and oxidative bleaching agents. These treatments are often carried out in small, decentralized units with limited process control, leading to variable quality, harsh handle, and potential fibre damage. In addition, conventional processes are water- and energy intensive and generate effluents with high chemical loads, which is increasingly problematic as environmental regulations tighten and resource costs rise.

Enzyme technology offers an attractive alternative for cellulosic textiles by enabling desizing, scouring, bleaching assistance, and bio polishing under milder conditions. α Amylase enzymes can selectively hydrolyse starch-based sizes without damaging the cellulose substrate, while pectinase breaks down pectic substances

and associated waxes in the cuticle, improving wettability with minimal strength loss. Acid cellulase enzymes used for bio polishing can remove protruding surface fibres, thereby improving smoothness, lustre, and pilling resistance of cotton fabrics. Enzymatic processes generally operate at lower temperatures and near neutral pH, reducing water, energy, and alkali consumption as well as effluent load.

In parallel, silicone softeners are widely used to enhance softness, flexibility, and sew ability of cotton fabrics, and nano emulsion silicone finishes have emerged to improve penetration, durability, and handle at lower add on levels. Nano silicone particles can form more uniform films on cellulosic fibres, achieving a smoother surface and superior softness compared with conventional macro emulsion silicones. However, limited attention has been given to integrating fully enzymatic pre-treatment with nano silicone finishing specifically for hand woven cotton khadi fabrics, which are not usually processed on modern continuous machinery and often lack specialty finishing chemicals.

The present work addresses this gap by developing and comparing an enzymatic processing route versus a conventional chemical route for cotton khadi suiting and shirting fabrics. In the enzymatic route, khadi fabrics are desized with α amylase, bio scoured with pectinase, bio polished with acid cellulase, and finished with a nano silicone softener. In the chemical route, fabrics undergo desizing with hydrochloric acid, scouring with sodium hydroxide, bleaching with bleaching powder, and softening with a conventional silicone or nano silicone softener under typical conditions.

Materials and Methods

Materials

Grey cotton khadi suiting and shirting fabrics were sourced from a khadi production unit and used as the base material. Fabric specifications, including ends and picks per inch, mass per unit area, and yarn counts in warp and weft, were recorded prior to processing. Commercial aqueous preparations of α-amylase, pectinase, and acid cellulase suitable for textile applications were used as enzymatic agents, along with a nano-silicone softener and a conventional silicone softener. For the chemical route, hydrochloric acid, sodium hydroxide, sodium carbonate, calcium hypochlorite (bleaching powder), sodium hypochlorite, wetting agents, and auxiliary chemicals were employed according to typical khadi processing practice.

Processing routes

Two parallel processing sequences were applied to both khadi suiting and shirting fabrics.

Enzymatic Desizing: Fabrics were padded with an α-amylase desizing bath and held under controlled temperature and pH conditions, then thoroughly washed.

Bio scouring: Desized fabrics were treated with pectinase in the presence of suitable wetting agents and, where appropriate, chelating agents, at 40–70 °C and near-neutral pH to remove non-cellulosic impurities.

Bleaching: Brief description, e.g., peroxide-based or mild oxidative conditions, if included in the original work.

Bio-polishing: Pre-treated fabrics were treated with acid cellulase to remove surface fibrils and improve fabric smoothness and lustre.

Nano-silicone finishing: finally, fabrics were padded in a nano-silicone softener bath, dried, and cured under standard conditions to impart durable softness.

Conventional chemical route

Desizing: hydrochloric acid desizing was performed by padding the grey fabrics in dilute acid solution, batching at room temperature, and washing thoroughly to remove degraded size and mineral salts.

Scouring: fabrics were scoured in a hot sodium hydroxide bath, containing sodium carbonate and surfactants, at elevated temperature to saponify oils and waxes, hydrolyse proteins, and remove pectic substances.

Bleaching: calcium hypochlorite or sodium hypochlorite bleaching was applied to remove natural colouring matter and increase fabric whiteness, followed by thorough washing and neutralization.

Softener finishing: conventionally processed fabrics were finished using either a standard silicone softener or a nano-silicone softener, applied by padding followed by drying and curing.

Testing methods

All processed and control fabrics will be conditioned under standard atmospheric conditions before testing. Bending length will be determined using the cantilever method, and flexural rigidity will be calculated from bending length and fabric mass per unit area to assess fabric stiffness. Crease recovery angle will be measured in warp and weft directions using a standard crease recovery tester to evaluate wrinkle resistance. Mass per unit area (GSM) will be determined from cut samples using an electronic balance, and fabric thickness was measured with a thickness gauge.

Ends and picks per inch will be counted using a pick glass at multiple random locations to quantify fabric density. Cloth dimensional stability (shrinkage) will be measured according to ASTM D6207 by marking known distances, laundering under controlled conditions, and calculating percentage change in length. Vertical wicking and total water absorbency tests will be used to assess liquid transport and wetting behaviour. Yarn friction and other handle-related parameters will be evaluated using the instruments specified in the project, and reflectance and whiteness index will be measured to quantify optical appearance. Statistical significance of differences between enzymatic and chemically processed fabrics will be analysed using t-tests for key properties in both warp and weft directions.

Conclusion

Enzymatic pre-treatments combined with nano-silicone finishing not only enhance the aesthetic and handle properties of cotton khadi but also offer potential reductions in chemical, water, and energy usage compared with traditional processes.