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Bio finishes on protein fiber

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ABSTRACT

The requirement of finish for any textile fiber / yarn / fabric is dependent on its final usage and its requirement to fulfill the end purpose. The finishes related to end purpose are categorized as aesthetic and functional finishes, the former is responsible for improving the hand and look of the textile material while the latter works on achieving a specific performance required as per the end use of the material.The paper focusses on the data collected from various secondary resources about the finishes applied on wool to achieve the better required properties. The data has been compiled as a review paper which maps the application of finishes with their effects from chemical to bio finishes which includes enzymatic finishes on wool.

Key Words : Finishes, Wool, Textile softeners, Enzyme finish, Bio – finish

INTRODUCTION

Finishing of wool :

Wool fabrics reportedly have been finished with Durable Press finish, Shrink control and machine washable, wrinkle recovery, antimicrobial/ antifungal, moth proof, rot and mildew, soil release, flame retardant, photostabilization, softening, anti-pilling, antistatic, hydrophilizing, phase-change (microencapsulation), abrasion resistance, back coating and multi-purpose finishes. These finishes have been applied as per the requirement and end purpose of the fabrics (Table 1).

Softening agents :

Softeners are applied on fabrics to provide good handle, softness and make the successive procedure application friendly (Table 2). Overall it improves the aesthetic properties of textiles (Nostadt and Zyschka, 1997).

Enzyme treatment on woolen products :

Along with softeners, enzyme treatment on woolen products has been practiced as

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Table 1 : Properties achieved on wool after finishes applied

Finishes	Properties
Durable Press finish	It resists wrinkling and improves the performance of washable fabrics. The finishing agents are formaldehyde, Urea/formaldehyde, melamine/ formaldehyde and carbamates resins and Non – formaldehyde DP finishes like Butanetetracarboxylic Acid and Glyoxal.
Shrink control and machine washable	To prevent felting shrinkage in wool after washing Hercosett-57, BAsolan MW and Synthappret-BAP are used.
Wrinkle recovery finish	As wrinkle recovery reduces under high humidity, this finish helps in recovering the property through large organic compounds such as ninhydrin, benzoquinone, phenyl isocynate and polymers like ailicones or polyurethanes.
Antimicrobial/ antifungal finish	It protects fabric from fungal and microbial attack through application of compounds like N- (2, 2'-dichlorovinyl) salicyl armide, benzalkonium chloride, salicylanilide, dedecyltrimethyl ammonium chloride, dichlophen and pentachlorophenol.
Moth proof finish	To protect wool from the attack of moths, inorganic compounds like chromium fluoride, sodium silico fluoride, antimony fluoride and salts of phosphotungstic acid, antimony tungstic acid, molybdic acid are used. Some organic compounds like Pentacholorophenol, DDT, Dieldrin and dinitro naphthol based acid dye (Mitin FF, Eulan CN) are also used.
Rot and mildew finish	To prevent wool from rotting and breakdown of fibers, compounds like Organo- copper, Organo-tin and chlorinated phenols are used to resist the attack of mildew. Copper napthenate and copper-8-hydroxyquinolinate are biocides used for resisting the attack of fungi, bacteria and algae.
Soil release finish	For good laundering purpose chemicals based on poly acrylic like Polymethacrylic Acid and Methacrylic Acid – ethyl Acrylate Co-Polymers are used.
Flame retardant finish	There are four categories for flame retardant finish: 1. Phosphorous containing flame retardants as THPC, THPS, THPOH-NH_3, vinyl phosphonate. 2. Halogenated products based on chlorine and bromine. 3. Zirconium, titanium and other metal complex eg. K2TiF6, K2ZrF6. 4. Sulfated wool containing sulphur as main component.
Photostabilization finish	To safeguard wool from getting yellow on exposure to sunlight, derivatives of 2-hydroxybenzophenone (I), phenyl esters and salicylates (III and IV), derivatives of 2 – (2' – hydroxyphenyl)-benzotriazole (II), substituted cinnamic acid derivatives (V), P-aminobenzoates, Polymeric and polymerisable absorbers, Stabilizers like Ni-chelates (VII), complexes and other salts are used.
Softening finish	For better handle of the fabric softening finish is applied using softeners which also function as surfactants or water repellents.
Antipilling finish	Formation of small ball of fibers called as pills due to rubbing is called as pilling. This can be avoided by chlorination of woolen fabrics.
Antistatic finish	Wool has a tendency of building up static charge due to lack of moisture regain and conductivity, hence to resist this, antistatic finishes are applied. These are either durable like polyamines, polyethoxylated amine, ammonium salts and carboxylic salts or non-durable like quaternary ammonium salts, phosphate esters and ethoxylated fatty acids.

Table 1 contd…

Contd… Table 1

Hydrophilizing finish	It is to improve the moisture holding power of the fabric. Many anionic, non-ionic surfactants, antistats, flame retardants and softeners provide hydrophilicity to the wool fibers.
Phase-change finish (microencapsulation)	Microcapsules which are like tiny containers of solids or liquids release their core contents under controlled conditions for specific purpose.
Abrasion resistance finish	Many softeners application improves the abrasion resistant property of wool fabric.
Back coating	Back coating is done in carpets for dimensional stability.
Multi-purpose finishes	Fluorocarbon combinations are used in multipurpose finishes.

Table 2 : Categorization of textile softeners with their functioning procedure

Classification and properties of textile softeners		
Ionic activity	Electric charge	Properties
Nonionic	No charge	They are applied through forced application and are perfect for finishing optically brightened white articles (fatty acids, fatty esters and fatty amides) (Le Marechal, A.M. et.al)
Slightly Cationic	At acid pH's slightly positive	They are responsible for best soft handle and are applied through exhaust method (quartenary ammonium compounds, amino amines, imidazolines)
Cationic	At acid pH's very positive	
Quaternary	Positive no matter of pH	
Amphoteric	Dependent on pH slightly negative to slightly positive	These give an average handle to fabrics and are compatible with white fabrics. They also provide good hydrophilicity and anti-static properties.
Anionic	Negative	They don't improve handle finish.
Special Softener		
Psuedo cationic softeners	They lie between non-ionic and cationic softeners and are good for white and colored fabrics for soft handle.	
Silicone micro emulsions	These are Amino functional silicones and are best in surface smoothening and softening of fabrics. The silicone micro emulsions are small in size and therefore can penetrate inside the fiber core and provide the fabric more smoothness without greasiness. Properties like abrasion resistance, creasing angle, elasticity and sewability improves on their action.	
Multi-functional softeners	These softeners provide multiple functioning properties like hydrophilicity, sewability, anti-static, surface smoothening, shearing stability etc. Few examples of multi-functional finish are Jet softeners, Hydrophilic softners, sewability softeners	

value addition in many researches. Enzyme finishes on cellulosic fabrics have been tried and successful in many ways; however on wool it is still being tested. Enzymes are best to use as they are organic and biodegradable and they accomplish their task without any residual pollutant.

Enzymes are natural proteinaceous bio catalysts present in all plants and animals with 200-250 amino acids in their specialized protein complexes and their molecular weight is in the order of 104 - 105 (Zubay *et al.*, 1995). Hydrolysis, oxidation, reduction, coagulation and decomposition are few of the most common reactions achieved by enzymes (Ammayappan, 2013).

Mode of enzyme action :

Enzyme + Substrate ? Enzyme-Substrate Complex ? Enzyme + Product of Enzyme action

Factors affecting the rate of enzyme reaction :

1. Concentration of substrate: Higher the concentration of the substrate higher the rate of enzyme reaction.
2. Concentration of enzyme: The rate of enzymatic reaction is directly proportional to the concentration of enzymes.
3. pH and Temperature: All enzymes work at optimum temperature and pH , any change in the temperature or pH can hamper the rate of enzymatic reaction.
4. Concentration of reaction products: Higher concentration of reaction products can lower the rate of enzymatic reaction.
5. Time: Under optimum conditions enzymes work in the shortest time.
6. Activators: They stabilize enzyme-substrate complex, which make them more susceptible to the attack of enzymes like some specific bivalent metal cation.
7. Additives: In order to improve the reactivity of the enzymes some inorganic salts such as magnesium ion or complex organic molecule act as co-enzymes.
8. Inhibitors: Copper, mercury, lead, iron etc are lethal for the action of the enzymes.

Protease enzymes:

Protease is a class of enzyme that is active only on protein macromolecules and their activity begins with hydrolysis of the covalent peptide bonds that link successive amino acid residues in a polypeptide chain and this process is termed as proteolysis. These enzymes are classified in four categories based on their chemical reaction *i.e.* serine protease, cysteine protease, aspartic protease and metallo-protease (Shukla, 2001).

Enzyme Assisted Finishing :

Anti felting and shrink proof :

Though Chlorination is one of the methods commonly used to modify the scales of the wool fibers in increasing their felt shrinkage resistance, El Sayed et al. (2002) developed an enzyme based anti-felting process using lipase enzyme in pre-treatment step, then glutathione reductase in reduction step and papain enzyme in the after treatment step. Enzymes are also used in increasing the shrink proof resistance of the fabric.

Handle modification :

As per Levene *et al.* (1995) most of the enzymes provide reduction in scaling and improvement in handle or softness of the wool. Sawada *et al.* (2001), reported that protease enzymes improve anti felting property and tensile strength of woolen fabrics.

Kondo et.al in 2001 showed that proteolytic enzymes along with potassium permagnate, ammonium sulphate, acetic acid and sodium bisulphate when treated on wool fibers, they provide better softness. According to Moses and Ammayappan (2008), successive treatment of wool and cotton blended fabric with cellulose and protease enzymes provides better handle due to improvement in moisture regain, drapeability, crease recovery angle, however it reduces the tearing strength of the fabric.

Cardamone *et al.* (2004) researched that pretreatment of woven and knitted fabric with peroxy carboximide and proteolytic enzymes gives biopolishing to the wool and controls shrinkage with out loss in strength and elasticity. The same facts were supported by the study of Shridhar *et al.* (1995) and Ammayappan (2008).

Further, research studies by Ammayappan and Moses (2010b) and Ammayappan (2008) revealed that the successive treatment of wool blended fabrics with cellulose and protease enzymes followed finishing by cationic softeners or silicone softeners improves handle and physical properties like wrinkle recovery, antimicrobial, softening and shrink resistant of the fabric. Ammayappan (2011) researched that protease treatment using Savinase 16.0L Ex followed by combination of polyurethane based softener and micro polysiloxane emulsion finishing imparted shrink resist and softening finish while cellulose enzyme treatment followed by β- Cyclodextrin + Finish –VLF + Sanitized -9919 combination of finish provides antimicrobial and shrink resistant finishes on wool and cotton blend fabrics.

A study on reducing the woolen yarn itching property just close to the skin researched by the Wool Research Association, Thane in 2010, the sample with DBD plasma with 1%, 2%, 3%, 4%, 5% (owf) with sebalkaline protease enzyme. OFDA-100. On doing SEM and tensile testing thereafter the reduction in diameter of wool reduced, the scales were damaged and the mechanical properties were reduced. It was also found that 4% and 5% enzyme treated and 3%, 4% and 5% plasma and enzyme treated became completely itchfree.

As per Wool Research Association Thane (2013) Chitosan (modified nontoxic biopolymer obtained by deacetylation of chitin) is used for shrink resistant and antimicrobial finish.

Wool Research Association Thane (2012) researched that lavender, citronella and eucalyptus oils are used in providing moth proof resistant. In 2012, they explained that plasma treatment along with enzyme treatment results in increase in hand value and if a softener is added then the hand value increases 2 times more.

Research findings of the association on coarse Indian wool softening using di-electric barrier discharge plasma treatment using enzymes, polymer grafting and softener treatment showed better SEM results in terms of soft handle and lustre.

Few other researches conducted by Wool Association Research, Thane:

1. Proteolytic enzymes with transglutaminase provide improvement in shrink resistance, softness, strength, handle, appearance, wettability, whiteness and reduction of felting tendency and pilling. However these treatments lead to weight loss and fiber damage.

2. Wool fabrics on treatment with air plasma in a DBD reactor showed significant reduction in felting shrinkage, increase in thermal insulation value and hydrophilicity. The

inorganic nano particle improves the surface topography of the wool fibers with the help of ultrasonic energy and plasma technology. Wool treated with inorganic materials and ultrasonic energy showed better dimensional stability, resistance to bacteria, fungi and resistance to generation of static energy.

3. Wool when treated with DBD Plasma along with chemical treatment (Organo-Phosphorous FR chemical) using Pad-Dry-Cure method achieved flame retardancy and soil repellency. This also provides hand washable property to the wool fabrics.

4. Wool carpets pretreated with enzymes followed by mild acid / alkali treatment provides it good luster and softness.

5. Angora rabbit wool products got smoothened and soft handle on treatment with enzymes.

6. Extracts from Belladona, Neem and Custard Apple were applied on woolen fabrics in various proportions and was evaluated against moth attack. The impregnation was temporary and effectiveness was poor.

Finishes using Bio enzymes and softeners on wool and cotton union fabric :

In a Doctoral research study titled 'Study on improvement in aesthetic properties of woolen products by different chemical finishes' done by Ammayappan, L. under the guidance of Jeyakodimoses (2015) following results were noted on testing of union fabric (cotton and wool) with enzymes and finishes in the sequences mentioned below. The complete research was divided in 5 sections.

Study 1: The union fabric of wool and cotton was treated with Cellulase Enzyme (CE) Bactosol – CA, Protease enzyme (PE) Bactosol –WO individually and successively. After enzyme treatment 7 finishes were applied namely, Nuva-HPU, Finish –VLF, Ceraperm – MW (C-MW), Sandosoft-SPG (S-SPG), Ceraperm –MW + Sandosoft-SPG (S-SPG), Ceraperm – Aqua and Chitosan.

The above treatments resulted in following findings: Least weight loss in fabric after treatment with CE, in comparison to PE; however maximum weight loss was after the successive treatment with CE and PE.Better shrink resistance was observed in PE treated fabric than only CE treated fabric. More shrink resistance was observed in fabrics treated with enzyme and finishes successively. Among which N-HPU finish on CE, PE and CE+PE showed best shrink resistance than others. Sandosoft-SPG showed minimum shrink resistance.Enzyme treated (CE+PE) and combined S-SPG and C-MW finished fabrics showed better smoothness and softness. Hydrophilic siloxanes increased the wearing comfort of the fabric while cationic softener acted as lubricator and reduced friction. Hence enzyme treated fabric with S-SPG and C-MW finishes showed better results than others.

Study 2: The union fabric of wool and cotton was treated with Cellulase Enzyme (CE) Bactosol – CA, Protease enzyme (PE) Savinase 16.0L Ex (SAV) individually and successively. After enzyme treatment polysiloxane emulsion and polyurethane based finishes were applied namely Ceraperm –TOWI (C-TOWI), Ceraperm –MW (C-MW), Ceraperm –Aqua (C-Aqua) and S-RPU.

The above treatments resulted in following findings: The results obtained from these applications were finish add on, which was more in CE and PE successive treated fabric with finishes applied on to them as compared to the only CE and PE treated fabric. Better shrink resistance was observed in PE treated fabric than only CE treated fabric. Best shrink resistance was observed in fabrics treated with enzyme CE + PE and finishes successively in comparison to only CE or PE treated fabrics. In all Polyurethane based finishes showed best result in shrink resistance on CE+PE treated fabric and in silicone emulsion it was recorded that as the size of the silicone emulsion increased, the shrink resistance also increased.The enzyme treatment improved finish add-on, moisture regain, wickability, drapeability, dry crease recovery angle, shrink resistance and softness however tearing strength and bending modulus of yarn decreased.

Study 3: The union fabric of wool and cotton was treated with Protease enzyme (PE) Savinase 16.0L Ex (SAV) and Protease enzyme 2 (PE 2) Papain URPP individually and finishes like Sandosoft-SPG (S-SPG), Sandosperm-SE1, Ceraperm –TOWI (C-TOWI), Ceraperm –MW (C-MW), Ceraperm –UP, Sandosperm RPU, Ceraperm-Aqua, Sandosperm RPU+ Ceraperm-Aqua and Sandosoft-SPG (S-SPG)+ Ceraperm –MW (C-MW)+ Ceraperm –UP were applied after the enzyme treatments on the fabric swatches.

The above treatments resulted in following findings: The result obtained from Savinase treated fabrics showed less weight loss in comparison to Papain.Enzyme (Savinase /papin) treatment with finishes increased the finish add-on, wickability, wettability and moisture regain property of the fabrics.Tearing strength of the fabric reduces higher in weft direction than warp on treatment only with Savinase or Papain enzymes, though after the Papain + finish treatment, the fabrics showed better improvement in tearing strength in warp and weft direction than Savinase + finish treated fabrics.Savinase + S-SPG+ C-MW+ C-UP treated fabric showed better softness and handle property. Savinase enzyme treatment followed by cationic softener, micro and macro polysiloxane (S-SPG+C-MW+C-UP) resulted in better aesthetic property in terms of smoothness and total hand value in comparison to Papain treated fabrics. SEM study showed improvement in handle of wool on treatment with enzyme and S-SPG+C-MW+S-SE1+C-UP finished fabrics.Bending length, flexural rigidity and Bending modulus reduces after treatment with enzyme and decreases further after the application of finishes except in S-RPU finishing in the first two cases.Dry crease recovery angle also improved in warp direction with Savinase + finish and in weft direction with Papain + finishes.

Study 4: The union fabric of wool and cotton was treated with Protease enzyme (PE) Savinase 16.0L Ex (SAV) and Lipolytic enzyme 2 (LE) Lipolase 100T individually and applied finishes in combination of cationic softeners with polysiloxanes emulsion like Sandosoft-SPG (S-SPG) +. Ceraperm –MW (C-MW) + Sandosperm-SE1, Sandosoft-SPG (S-SPG) +. Ceraperm –MW (C-MW) + Ceraperm –TOWI (C-TOWI), Sandosoft-SPG (S-SPG) +. Ceraperm –MW (C-MW) + Sandosperm RPU, Sandosoft-SPG (S-SPG) +. Ceraperm –MW (C-MW) + Ceraperm –UP, Sandosoft-SPG (S-SPG) +. Sandosperm-SE1 + Ceraperm –UP, Sandosoft-SPG (S-SPG) +. Ceraperm –MW (C-MW) + Sandosperm-SE1+Ceraperm –UP

The above treatments resulted in following findings: The findings of the research showed that Savinase treated fabrics showed equal weight loss as lipase treated. However finish add-on is higher in Lipase treated fabric in comparison to Savinase treated.Moisture regain is high in Lipolase treated fabric than Savinase treated, however on the application of the finishes moisture regain reduces with higher rate in Savinase treated as compared to Lipolase treated fabric. Savinase treated fabrics loose tearing strength in weft direction than warp direction, while on further treatment with finishes the fabric retain tearing strength in weft direction.Sandosoft-SPG (S-SPG) +. Ceraperm –MW (C-MW) + Sandosperm RPU treated fabrics showed improvement in wettability and wickability on Lipolase pretreated fabrics. However S-SE1/ C-TOW1/ S-RPU treated fabrics with or without enzyme treatment shows better wickability.

With lipolase the results are just opposite in terms of warp and weft direction as in Savinase.Bending length, flexural rigidity and Bending modulus reduces after treatment with enzyme and decreases further after the application of finishes, especially with nano polysiloxane based finishes.Dry crease recovery angle improved after treatment with the enzymes.The combined application of polysiloxane emulsion with a cationic softener improves the handle of the fabric. Sandosoft-SPG (S-SPG) +. Ceraperm –MW + Ceraperm –UP+ Sandosperm – SE1 finish combination on Savinase treated fabric provided the best hand value.

Study 5: The union fabric of wool and cotton was treated with Cellulase Enzyme (CE) Bactosol –CA and Protease enzyme (PE) Savinase 16.0L Ex (SAV) individually and applied finishes in combination of cationic softeners with polysiloxanes emulsion like Synthappret –BAP, Synthappret -BAP +. Ceraperm –MW (C-MW), Synthappret -BAP + Sandosperm RPU, Finish VLF+ â-CD and Finish VLF+ â-CD+ Sanitized T-9919.

The result showed following findings:Finish add-on is higher in finish applied and Savinase treated fabric rather than Bactosol + finish applied fabrics.Savinase + finish treated fabric gained moisture regain and wickability. However Bactosol treated fabric with finishes showed more wettability.Tearing strength of the fabric reduces with the application of enzymes and finishes. Bactosol showed more reduction as compared to Savinase treated fabrics.Shrinkage reduces with the application of enzymes and the finishes.Bending length, flexural rigidity and Bending modulus reduces after treatment with enzyme and decreases further after the application of finishes.Dry crease recovery angle also improved in after treatment with enzyme and further increased after treatment with finishes.The Savinase treated fabrics showed better softness than Bactosol treated fabrics before and after finishing.

Conclusion :

There are many researches which have been done on the finishing of wool in national and international research projects and with the increase in demand of saving the mother earth, many new bio finishes are being sorted for. Hence to conclude the finishing of wool is a broad research area where many more experiments could be carried out at various stages, without harming the environment and get the best result required for the end product.

REFERENCES

Ammayappan, L. and Moses, J.J. (2010b). Study on physical and handle properties of wool/cotton union fabric treated with enzymes and different pre-polymer finishing chemicals. *Curr. Chemical Res.*, **1**(1):19-25.

Ammayappan, L. (2008). Study on improvement in aesthetic properties of woolen products by different chemical finishes. Ph.D. Thesis, Anna University, Chennai

Ammayappan, L. and N.P. Gupta. (2011). A study on the effect of enzymatic pretreatment on physio-chemical and mechanical properties of woolen yarn, manmade. *Textiles India*, **54**(7):244-248.

Ammayappan, L. (2013). Application of enzyme on woolen products for its value addition an overview, *J. Textile & Apparel, Technol. & Mgmt.*, **8** (3) : 1-12.

Cardamone, M. (2002). Proteolytic activity of Aspergillus flavus on wool, *AATCC Rev.*, **2**(5):30-35.

El Sayed, H. , Hamed, R.R., Kantouch, A., Heine, E. and Hocker, H. (2002). Enzyme wool enzyme-based felt proofing of wool. *AATCC Rev.*, **2**(1):25-28.

Kondo, T., Sakai, C. and Karakawa, T. (2001). The process for modifying animal fibers, Eur.pat.Appl. 16pp EP 134267 A1850320.

Levene, R. and Shakkour, G. (1995). Wool fibers of enhanced luster obtained by enzymatic descaling, *J. Society for Dyers & Colorists*, **111** (11): 352-359.

Nostadt, K. and Zyschka, R. (1997). Softeners in the textile finishing industry, Colourage, January, pp. 53-58.

Sawada, K. and Ueda, N. (2001). Enzyme processing of textiles in reverse micellar solution. *J. Biotechnol.*, **89** : 263-269.

Shridhar, V.C., Khan, S. and Mehta, R.D. (1995). Effects of bio-finishing on cotton/wool blended fabrics. *Textile Res. J.*, **65** :564-569.

Zubay, G.I., Parson, W.W. and Vance, D.E. (1995). Principles of Biochemistry, Wm.C.Brown Publications, Oxford, pp.136-159.

Webliography :

http://www.wraindia.com/RD%20Projects.htm