Indian Leather Sector: A Need of Newer Process Technology

Leather is a valuable material provided by Nature. It is a unique commodity, which links the rural farmer to the fashion world. Hides and skins for leather making are primarily co-products from the meat industry, which depends on the agricultural industry. In order to the agricultural industry be sustainable, its secondary stream of co-products have to be utilized properly. Hence, processing of skins and hides, which are co-products of meat industry, into leather makes the Indian agricultural industry perpetual. Leather processing has also emerged as an important economic activity in several developing countries, which are dependent on an agricultural economy. Indian leather industry occupies a pride place in economy building through an employment generation of about 2.5 million jobs and an annual foreign exchange of about 9600 crores. Unfortunately, the intensive processing methodologies employed for leather manufacture has rendered tanning as an eco-constrained process. Conventional methods of pre-tanning and tanning have the largest discharges accounting for nearly 90% of the total pollution from a tannery.

Current Leather Processing: Environmental Brakes

Leather manufacturing involves chemical processing of a biological matrix, employing a range of engineering equipments. The rationale in leather processing is based on the removal of interfibrillar and unwanted matter through a series of pre-tanning operations, protection of the collagen matrix against microorganisms and imparting thermal stability by tanning and providing aesthetic value by means of post-tanning and finishing operations.
Liming–reliming processes are the vital steps in leather processing which are unavoidable and fulfills two major objectives.

(i) Removes the unwanted outer epidermal structures of skin or hide.

(ii) Removes much of the inter-fibrillary cementing substances in the corium and appreciably opens up the fibre bundles, fibres and fibrils.

These process liquors contribute to 50–70% of the total biochemical oxygen demand (BOD) and chemical oxygen demand (COD) load from tannery wastewater and 15–20% in the case of total solids (TS) load. Leather processing also results in emissions of noxious gases, such as ammonia, which is released during deliming, and hydrogen sulphide, which can possibly be released during mixing of liming and pickling wastewater. In addition, significant volumes of solid wastes are produced, which includes trimmings, lime sludge, flesh and hair from beam house processes. The disposal of lime-bearing sludge generated through conventional processing (a global estimate of 1.4 million tons per annum) causes both ecological and economic concerns. Throughout the world, the environmental impacts of tanning are a major concern and impediment to the tanning industry.

**A GREEN TAN–PATH THROUGH BIOCATALYSTS: A VISION FOR LEATHER INDUSTRY**

The process rationale designed is based on the avoidance of “Do-Undo” process logic followed in the conventional leather processing. In other words, in one of the operations, certain chemicals are added and physico-chemical changes in skin or hides are brought about through “Do” logic and in the next set of operations, the physico-chemical changes are reversed by way of “Undoing” what was done earlier. An approach to overcome the inefficiencies of the conventionally and commercially used process
logic through an integrated and path breaking bio-mediated alternative has been developed, where the “Do-Undo” principle is replaced by a “Do-Only” principle.

A biotechnological pathway without lime forms a green route for dehairing and fibre opening. Dehairing using commercially available enzyme formulation with or without sodium sulfide has been designed for cowhides, goat and sheepekins at an operational pH of 8.0 – 8.5. Hence, this method enjoys coupling of enzymatic opening up treatments that are capable of splitting fibres at pH 8.0 with enzymatic dehairing, thus provides an opportunity to avoid deliming. Enzyme based fibre opening is a new concept and acts as a fulcrum on causing a paradigm shift of the conventional chemical based leather processing to a bioprocessing. Lime based swelling removes the interfibrillary materials (protein-carbohydrate conjugates namely proteoglycans) through osmotic forces leading to the reduction in area and wrinkle formation. On the other hand, substrate specific enzymes such as α–amylase disintegrates the proteoglycans and makes the fibre matrix open thereby inducing swelling. This approach has been followed to obtain a clean pelt with desired fibre opening and at the same time without forming any lime sludge.

ENZYMES IN LEATHER PROCESSING: A REALITY

Conventional use of lime and sulfide leading to commercially viable methods of removal of hair and opening up of fibres in skin and hide has resulted in solid, liquid and gaseous discharges. The use of enzymes as alternatives to sulfide has been attempted before, but the process has defied application of enzyme-only methods for removal of hair and opening up of fibres. The methodology developed by Team-CLRI ensures potential increase in area, abatement of pollution and elimination of lime sludge. The lead gained
by the team using enzyme-only process represents a breakthrough, which has been well received [News Story in “Environmental Science and Technology Online Technology News” on a paper published in Environmental Science & Technology, 39, 2005, 3776-3783].

Conventional lime based fibre opening removes interfibrillary materials through osmotic forces for softening the fibres. It is possible to use substrate specific enzymes to replace lime in the softening step, where a protein carbohydrate blend called proteoglycan is stripped out of a hide to leave only a clean web of tangled fibres of the protein “collagen”. The team has shown that amylases, akin to those in saliva that turn carbohydrates into their component sugars, break down proteoglycan as effectively as lime does. The hides are as soft as limed pelts, and look the same under the microscope. The lead gained by the team using enzyme based fiber opening process has been well received by the scientific community [Editorial in Nature Science Update on a paper published in Environmental Science & Technology, 36, 2002, 4187-4194].

**BIOPROCESSING OF LEATHER: SUCCESS STORIES**

This new process involving enzyme based dehairing and fibre opening has been successfully demonstrated at M/s Shri Ramajayam Prime Tanners, Dindigul, M/s KAR Leathers (P) Ltd., Dindigul, M/s KKS Leather Processers Pvt. Ltd., Erode and M/s C Kalyanam & Co., Chennai on various substrates like goat, sheep, cow and buff calf.

The commercial viability of the technology has been proven for vegetable and chrome tanning. Enzyme based dehairing and fibre opening provides an area yield of about 3-5% and reduction in wrinkle formation. The methodology gains considerable merit by virtue of benefits in terms of reducing COD and TDS in the wastewaters. This methodology ensures reduction in chemicals, process time,
water, power and liquid wastes. Apart from this, formation of lime sludge and toxic gases are completely avoided. The direct and indirect benefits gained through this enzyme-driven tanning using commercial-grade enzymes make this technology economically viable.

TEAM-CLRI: NATIONAL RECOGNITION

A Team-CLRI comprising of Dr J Raghava Rao, Dr P Thanikaivelan, Mr S Saravanabhan, Mr S Ramalingam, Dr Balachandran Unni Nair and Dr T Ramasami have been involved in the development of a new millennium bio-driven leather process. The new biobased leather processing could revolutionize the leather processing from its traditional chemical base to biotechnological method for attaining clean and green environmental status. This work has been conferred with Biotech Product and Process Development Award 2005 from Department of Biotechnology, Government of India.