SCIENTIFIC ARTICLE

Microbial Enzyme Technology for pollution abatement in Leather Industry

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Abstract

It is well known that environmental pollution has been a major irritant to industrial development. Chemical and chemical based industries are the prime targets of environmentalists for their crusade against pollution and leather industry is not left out of the reckoning. The chemicals mainly responsible for pollution in pre-tanning processes are lime, sulphide and caustic soda apart from common salt and degreasing chemicals. In fact, one third of the pollution caused by leather industries results from the wastes generated during dehairing operations. The wastes are let out into the drains which in turn empty into the main sewerage causing hazard to those who use this water. Many tanneries have been forced to close down because of their noncompliance with the standards laid down. In a short span of time, Indian Leather Industry has faced serious challenges such as German ban on pentachlorophenate, certain azo dyes, formaldehyde etc. on one hand and court orders imposing strict compliance of environmental regulations on the other. The attention of tanners is focused towards revamping the processing methods, recovery systems and effluent treatment techniques to make leather processing ecofriendly. Intensive efforts have been taken up to use a viable alternative technology viz. microbial enzyme technology in pre-tanning processes and this could be one of the ways of solving the industrial pollution problems caused by tannery effluents.

Introduction

The raw skin goes through a series of chemical treatments before it turns into a flattering leather. This includes soaking, liming, dehairing, deliming, degreasing and pickling. During all these steps, the chemicals used are quite toxic. Naturally, these pre-tanning operations make leather processing one of the worst offenders of the environment.

Enzyme is a biological catalyst with clear cut specificity. An important enzyme used in pre-tanning processes belongs to the group of proteolytic enzymes, also known as proteases which act on proteins. Although enzymes from plant, animal and microbial sources have been used, large scale use of microbial enzymes received a boost only in 1960s following the introduction of fermentation technology. The enzymes or enzymatic formulations need not be pure but must be cheap as compared to that of commercial chemicals used in leather industry. Animal proteases and microbial proteases from bacteria and fungi are used in the pre-tanning processes of leather manufacture. The animal proteases are mixtures of trypsin, chymotrypsin and various peptidases which may contain amylase or lipase as secondary enzymes. Mainly for economic reasons, enzymes from microorganisms have come to play a significant role in recent years and enzymatic products of microbial origin are already being produced on a wide scale.

Use of microbial enzymes in pre-tanning processes

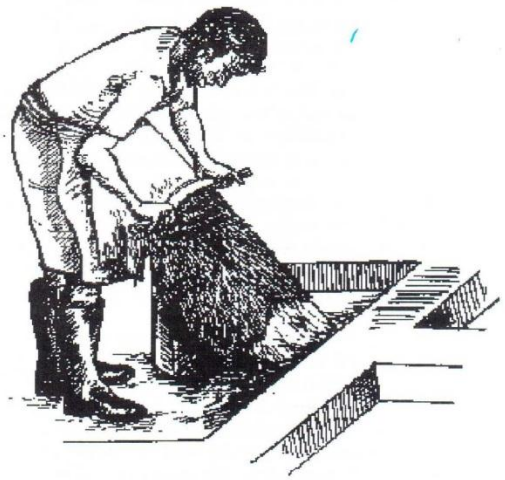
The important stages in which microbial enzymes used in pre-tanning processes are: soaking, dehairing, bating and degreasing. Soaking is the first operation in the tannery in which the skins are treated with water for making them clean and soft. Wet salted or freshly slaughtered skins do not require any chemical agent for their proper soaking. Soaking is necessary for solubilization and elimination of salts and globular proteins contained within the fibrous structure of skins. Soaking is carried out under alkaline conditions at low temperature in water containing sodium hypochlorite, sodium pentachlorophenate, formic acid etc. and it is accelerated by some of the nonionic detergents and additives such as sodium sulfide or sodium tetrasulfide.

The advantages of enzymatic soaking include loosening of the scud, initiation of the opening up of the fibre structure, production of leather with less wrinkled grain and a decrease in soaking time. Enzymes from *Aspergillus parasiticus*, *A. flavus*, *A. oryzae* and *Bacillus subtilis* are used alone or in mixtures. Soaking is usually performed with a combination of proteolytic enzymes that are optimally active in the neutral or alkaline pH range.

Dehairing of skins and hides using microbial enzymes

The most important operation in which enzyme is used in leather processing is dehairing. Five methods of dehairing are generally adopted viz.(i) Clipping process (ii) Scalding process (iii) Chemical process (iv) Sweating process and (v) enzymatic

process. The conventionally practiced method of dehairing is the chemical process using lime and sodium sulfide. However, the use of high concentration of lime and sodium sulphide creates an extremely alkaline environment resulting in the pulping of hair and its subsequent removal. While the efficacy of this process cannot be questioned, it has some major disadvantages. About 75% of the organic waste from a tannery comes from the pretanning yard and 70% of this waste is from hair which is rich in nitrogen. This illustrates the contribution made by the lime and sulphide process towards pollution. Sulphide is highly toxic and has an obnoxious odour and if left untreated, it can cause major problems in the sewers. The severe alkaline condition is a health hazard for the workers.

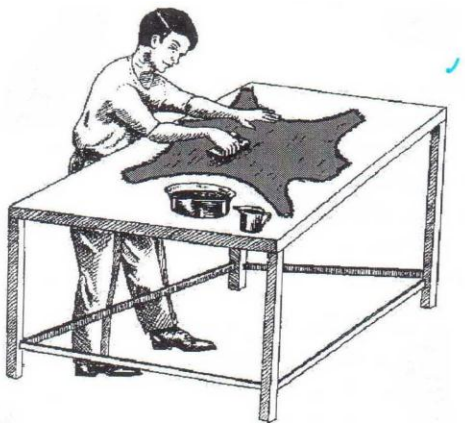


Conventional dehairing

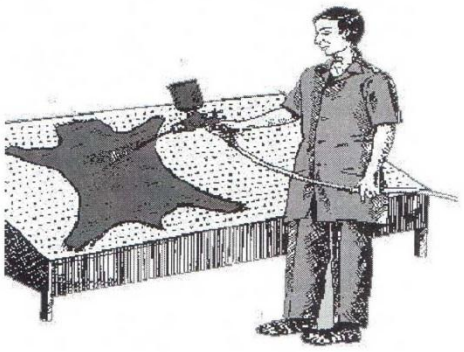
What are the advantages of enzymatic dehairing? Enzymatic dehairing is suggested as an environmentally friendly alternative to the conventional chemical process. Hair of good quality and strength with a good saleable value is recovered. An ecologically conducive atmosphere for the workers is created. A significant nature of the enzymatic dehairing process is the time factor involved. The lime-sulfide process takes about 16h whereas the enzymatic dehairing would be completed between 8h and 20h.

Proteolytic enzymes are of great commercial importance contributing to more than 40% of the world's commercially produced enzymes. Approximately 50% of the enzymes used as industrial process aids are proteolytic enzymes. Proteolytic enzymes are more efficient in enzymatic dehairing than amylolytic enzymes. Proteolytic enzymes from plant, animal and microbial sources are used for dehairing. Microbial proteases, because of their inherent advantages, are preferred in modern practice.

Three methods of application are commonly used in the enzymatic dehairing process: a) Paint method, b) dip method and c) drum method. In the paint method, the enzyme solution is mixed with an inert material like kaolin, made into a thin paste, adjusted to the required pH and applied on the flesh side of skins. In the dip method of enzymatic dehairing, the skins are kept immersed in the enzyme solution at the required pH in a pit or tub. In addition, drum method is also followed.



Application of enzymes by paint method



Application of enzymes by spraying technique

Bating using microbial enzymes

Another application of Microbial enzyme technology in pretanning process is known as bating. The concept of softening skins by treating them in a warm infusion of animal dung has been termed as "bating" and the product used for such process is known as a bate. The main object of bating is to remove some of the non leather forming proteinous materials such as albumins, globulins and mucoids from skins and to allow splitting of collagen fibres.

The principal materials which a bate contains are proteolytic enzymes, a suitable carrier for the enzyme and a deliming agent such as ammonium chloride or sulphate. Pancreatic enzymes are found to be the best for use in bating. Alternatively, microbial enzymes could be used for bating.

Degreasing using microbial enzymes

Another major operation where enzyme is used is known as degreasing and it is the process of removal of excess natural fat from greasy skins. The presence of natural grease in certain skins, especially woolly sheep skins, results in various defects. During the degreasing operation in the pretanning process, the fat or grease is removed from the interfibrillary spaces of the skins to facilitate the uniform penetration of tanning materials, fat liquors etc.

Degreasing is carried out after pickling and conventionally, it is carried out by either aqueous emulsification using detergents or by solvent extraction. It is well known that organic solvents like kerosene, petrol, perchlorethylene and trichloroethylene are highly unsafe and hazardous to the workers and heavily pollute the environment. The detergents, though not hazardous while handling and storing, cause serious pollution problems. These detergents and solvents add to the BOD (Biological Oxygen Demand) load of the pickling effluent and the chlorinated hydrocarbons and solvents add to the toxicity of the effluent.

Enzymatic degreasing is suggested as a viable alternative to combat the pollution problems caused by the use of solvents and detergents. Lipases catalyse the breakdown of fats and can be obtained from animal, microbial and plant sources. The advantages of using enzymes for degreasing are the elimination of solvents, reduction in surfactants and possible recovery of valuable byproducts.

Byproducts utilization

Microbial enzymes have a role in byproducts utilization. They could be used in the treatment of fleshings from the tannery. A combination of hydrolytic enzymes viz. proteases, carbohydrases and lipases might be ideal for this use.

Conclusion

Tanneries in future will use a combination of enzymatic and chemical processes. The potential for use of microbial enzyme technology in leather processing lies mainly in areas in which pollution causing chemicals such as sodium sulfide, lime and solvents are being used. Future might witness ecolabelled leather products emerging as niche products by the use of microbial enzyme technology and the experience gained by the Indian Leather Industry in this area might greatly help to emerge as a global leader.

References

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RESEARCH REPORTS

Gut microbes signal to the brain when they're full

Don't have room for dessert? The bacteria in your gut may be telling you something. Twenty minutes after a meal, gut microbes produce proteins that can suppress food intake in animals, reports a study published in *Cell Metabolism*. The researchers also show how these proteins injected into mice and rats act on the brain reducing appetite, suggesting that gut bacteria may help control when and how much we eat.

The new evidence coexists with current models of appetite control, which involve hormones from the gut signalling to brain circuits when we're hungry or done eating. The bacterial proteins--produced by mutualistic *E. coli* after they've been satiated--were found for the first time to influence the release of gut-brain signals (e.g., GLP-1 and PYY) as well as activate appetite-regulated neurons in the brain.

"There are so many studies now that look at microbiota composition in different pathological conditions but they do not explore the mechanisms behind these associations," says senior study author Sergueï Fetissov of Rouen University and INSERM's Nutrition, Gut & Brain Laboratory in France. "Our study shows that bacterial proteins from *E. coli* can be involved in the same molecular pathways that are used by the body to signal satiety, and now we need to know how an altered gut microbiome can affect this physiology."

Mealtime brings an influx of nutrients to the bacteria in your gut. In response, they divide and replace any members lost in the development of stool. The study raises an interesting