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Dr. JITENDRA SINGH
Minister of State (Independent Charge)
of the Ministry of Science and Technology;
Minister of State (Independent Charge)
of the Ministry of Earth Sciences;
Minister of State in the Prime Minister's Office;
Minister of State in the Ministry of Personnel,
Public Grievances and Pensions;
Minister of State in the Department of Atomic Energy and
Minister of State in the Department of Space
Government of India

As the nation is observing Azadi Ka Amrit Mahotsav, CSIR-Central Leather Research Institute (CSIR-CLRI) is celebrating Platinum Jubilee year of its establishment. The foundation stone of the Institute was laid by Shri Syama Prasad Mukherjee on the 24th April 1948. It is more than a coincidence that National Leather Institute was established with in the first year of Nation’s independence on a day being observed as the National Panchayati Raj day. The Honourable Prime Minister on 24th April 2022 called for the development a concrete vision for bringing about positive changes in our villages through developmental programmes. The father of the nation pointed out that conversion of Indian raw materials into value added products could create employment for sensitive segments of the society. I am also aware that technological changes in Indian footwear industry has led to empowerment of women and those working in the fringes of the society. The Coffee Table Book is a photo story of a journey well performed. The path ahead is even more challenging. As CSIR-CLRI celebrates its Platinum jubilee, let me call upon all my colleagues and industrial leaders to make firm resolves to make tangible contributions to sustainable development of rural and semi urban India by making available right sized technologies for application in our villages. Let the path from Platinum to Centenary be studded with service to society through research led technological changes.

I wish CSIR-CLRI the very best in service to the Nation.

(Dr. Jitendra Singh)
MBBS (Stanley, Chennai)
MD Medicine, Fellowship (AIIMS, NDL)
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I am delighted to learn that the CSIR- Central Leather Research Institute will be completing 75 years soon. This has a happy coincidence with the 80 years of CSIR itself.

I am aware that the CSIR-CLRI was born out of a sheer need of our country to gain self-reliance in our footwear needs. The words of Mahatma that India needed the intelligentsia to turn hides and skins into leather and footwear were translated into action in 1948 itself. One of the remarkable aspects of CSIR-CLRI, which harmonizes especially well with that of the overall CSIR, is being an institution with an academy – research – industry linkage from the start. In this regard, I pleasantly note that CSIR-CLRI has slowly turned a trading industry into an S&T-driven industry and moved the industry from Rs. 0.3 Crores to 40000 Crores and employing over 40 lakh people. This coffee table book chronicles 75 technologies that have led to the technological prowess of the Indian leather sector. The institute has facilitated the growth of the industry and society as well. Technologies in leather product manufacture and the associated training that the institute has provided have taken artisanal products such as Kolhapuri Chappal to the international market. Similarly, through training and industry connections, the institution has created women's entrepreneurship in the country. In its march from 75 to 100, CSIR-CLRI is poised to further industrial growth in the country.

I wish CSIR-CLRI the very best for its future.

Shekhar C. Mande
I am delighted that CSIR-Central Leather Research Institute (CSIR-CLRI) is marching ahead in its 75th year at the time when I am part of the family of CSIR-CLRI as the Chairman of its Research Council. As a person who belongs to the leather fraternity and also having close interaction with the institute, I am aware of the rich contributions of the institute in shaping the Indian leather sector and the Nation. I am glad that this Coffee Table Book captures some of the key technologies developed by this institute since its inception and also the directions for future research.

In its early phase, the institute had played a pivotal role in moulding the industry from a mere exporter of raw hides and skins into export of finished leathers and products thereby not only creating employment but also providing great contribution to foreign exchange for the Nation. During its midway, the institute had provided critical technologies for the manufacture of synthetic tanning agents, fatliquors, finishing chemicals, speciality leathers, effluent treatment systems and various leather goods and products to the industry. In the past two decades, the institute has been providing Green chemistry based solutions to compliance and towards Sustainability of the industry both environmentally and economically. The institute has been a forerunner in handholding with industry and academia thereby fostering the Academy-Research-Industry trinity partnership. Today, the CSIR-CLRI leads the leather research globally by innovating game-changing technologies as well as partnering with several leather producing nations. This Coffee Table Book walks through all the aforementioned contributions in an effective manner.

I wish CSIR-CLRI a great success in its endeavours towards journey to Centenary!

Habib Hussain
Shri MM Hashim  
Chairman Emeritus, CEMCOT And Former Chairman, Council For Leather Exports  

I am immensely pleased to learn that the 75th Foundation Day of CSIR-Central Leather Research Institute (CSIR-CLRI) will be celebrated on 24 April 2022 and that the Hon'ble Minister for Science and Technology and Earth Sciences and Vice President of the Council of Scientific and Industrial Research will be inaugurating it.

In its long and inspiring journey of 75 years, CLRI has rendered unto the industry great services. The role of CSIR-CLRI in transforming the leather sector that was a rather primitive micro scale operation in the early years of independence into a vibrant, modern, diversified and environmentally sustainable industry cannot be overemphasised. In the early years of independence Indian leather sector was primarily an exporter of raw material and semi processed leather lacking in technology, financial resources and marketing knowledge. In those critical days, CLRI, by working closely with the pioneers of leather sector, not only transferred technology to the industry but also hand held them through their slow and painful transformation.

The industry had faced many a challenge in its journey of last 75 years after independence. In the seventies, it was in the process of equipping itself to make finished leather from the semi processed leather. In the 1980’s, the capacity to convert the finished leather into various products such as footwear, garments and assorted leather goods had been created on a vast scale in different parts of the country. In the 1990's the industry faced the challenge of environment protection. In every decade of its challenges, the industry had the unstinted support and cooperation of CSIR-CLRI. CSIR-CLRI had been blessed with distinguished scientists and remarkable leaders including Dr Y Nayudamma, Dr G Thyagarajan, Dr KV Raghavan, Dr T Ramasami, Dr AB Mandal and Dr KJ Sreeram, the present Director, who have contributed in strengthening the institution and taking its services not only to all nooks and corners of the country but also to many developing countries. Through its education and training programmes, CSIR-CLRI has enabled creating a large pool of technocrats who serve in the industry within and outside the country including in competitor countries like China.

My association with CSIR-CLRI dates back to the 1950’s and it continues to this day. I congratulate CSIR-CLRI for its long years of service to the industry and wish the very best for its future. I am sure that it will continue to serve and guide the industry in the years ahead.

MM Hashim
Message

Dr M Rafeeqe Ahmed
President, AISHTMA

I am glad CLRI would be Celebrating its 75th Foundation Day on the 24th of April 2022. Though leather processing was an ancient and village centred activity, it had an important role not only in preserving skin of the slaughtered animals but also in its utilization for footwear making, bag for baling water and for various other utilities at the village level.

From early 21st Century organized leather industry came to be formed and its growth and development since then is a valuable chapter in the industrial growth of the Country. The age old and traditional industry had developed into a highly scientific endeavour, thanks to CLRI. The growth and development of CLRI is indeed phenomenal. The hallmark of CLRI is not that it is an academic body continuing to research in its laboratories, but an institution which has extensive field contact and providing valuable guidance to Leather Industry and has grown into an Internationally recognized research centre and valuable service provider.

The institution had eminent leaders whose lifetime service will continue to be etched in golden letters. Without any contradiction, I may recall the outstanding contribution of Dr. Nayudamma not only for its global recognition but the field contact he established in the leather industry for its growth and development. His successors were no less famous and outstanding leather scientists, having made outstanding contribution to the growth and development of the leather industry. CSIR-CLRI always stood in front to help the MSME’s in transfer of new technology, abating pollution and finding new ways to minimize the pollution load in tanning process and also Leather Product including Footwear at reasonable cost, bearable to small tanners also. The use of treated salt from tannery Common Effluent Treatment Plants (CETPs) by other industries as raw material to their process with the help of CSIR-Central Salt and Marine Chemical Research Institute (CSMCRI) and CSIR-CLRI is really an achievement leading to total “Zero Waste Discharge.”

The hoary tradition is kept by the institution by its leaders and staff and the leather industry is indebted to CLRI for its international recognition and growth. It is my pleasure to feel that we in the leather industry is beheld to CLRI recognized as an excellent industry of international repute today and wish that the 75 years of leadership will develop into a limitless and perennial source for the growth of leather industry.

I hope the CSIR Laboratories will always stand in front to help the Leather Industry in future also.

M Rafeeqe Ahmed
Message

Shri Sanjay Leekha
Chairman, Council for Leather Exports

With its significant contribution to the overall development of Indian leather, leather products and footwear industry in the last 75 years, CSIR–CLRI has served the industry as one of its strongest pillars. The innovations and technologies created by CSIR–CLRI have helped the industry to surge ahead in many thrust areas namely leather processing, product design and development, capacity building, trend forecasting, skill development, environment management etc.,

The futuristic vision propelled by CSIR–CLRI has played a vital role in the transformation of the industry to a leading exporter of value-added products across the world.

Smart manufacturing aided by innovations will define the success of penetration in the highly competitive global market. At a time when the entire world is looking at India as a global manufacturing hub, the leather, leather products and footwear industry is striving to achieve even greater milestones in the coming years both on the export front and in the domestic market. With the guidance of CSIR–CLRI, I am sure that our industry will be able to reach greater heights through optimum utilization of the emerging business opportunities.

I extend my best wishes to the entire CSIR–CLRI fraternity on the momentous occasion of 75th Foundation Day and wish CSIR–CLRI all success in future endeavors.

Sanjay Leekha
It is pleasure to know that CLRI is celebrating its 75th year foundation day. It is a milestone CLRI has achieved. This journey of CLRI is full of achievements of their commitment to the leather industry. This institute is backbone of our industry which took the leather sector to a pinnacle.

CLRI’s contribution to the Kanpur-Unnao Leather Cluster, to establish as a complete industry, cannot be forgotten. The institute’s role in implementation of IDLS scheme in this region is commendable. Some more activities like demonstration and implementation of waterless Chrome Tanning technology and other environment friendly technologies to mitigate pollution load needed for sustainable development of leather industry are worth mentioning. CLRI also participated in Third party inspection conducted by CPCB for compliance verification in Jajmau Leather Cluster Trade facilitation by daily inspection of export consignment.

CLRI has taken a step further to meet requirement of skilled workforce of this region by entering an agreement with Kanpur-Unnao Leather Cluster for conducting training programmes. In last 5 years about 2000 candidates completed their training in different fields. The signing of an MoU with KLC to run the testing laboratory in the KLC campus is a milestone which will fulfil the long term requirements of this region. This will be a boom for the industry in their endeavour to the growth of export.

My best wishes on this memorable day.

Mukhtarul Amin
On behalf of Punjab Leather Federation (PLF) and members of leather fraternity, it gives me immense pleasure to wish CSIR-CLRI on its 75th Foundation Day, which is celebrated on 06th May, 2022. We, wholeheartedly thank CSIR-CLRI for their great contributions in the development of Leather Complex, Jalandhar which was executed by Punjab State Development Corporation Ltd in the year 1987-88. Nevertheless, the regional centre of CSIR-CLRI situated in Leather Complex also supports the industry from time to time for betterment of production and to improve quality of leather & leather products through its technological interventions and innovations. Technical inputs and guidance for smooth functioning of Common Effluent Treatment Plant (CETP) of this leather complex is constantly being provided by CSIR-CLRI. We are really proud to have CSIR-CLRI with us for their kind cooperation and troubleshooting problems in the leather sector. On this special occasion. I wish the Director and the staff of CSIR-CLRI all the very best in all their future endeavors!

Hira Lal Verma
I am extremely pleased to note that Central Leather Research Institute (CSIR-CLRI) has turned 75 years and I take the opportunity to congratulate team CLRI for their valuable services to the growth and development of the leather industry. Calcutta Leather Complex Tanners’ Association and Central Leather Research Institute have a strong relationship and this has only grown stronger with time. CLRI has contributed immensely to the growth of the Kolkata Leather Sector and their handholding over the years is always cherished. CLRI has also contributed to introducing and adopting various technological changes in Calcutta Leather Complex.

On the occasion of the 75th Foundation Day of CSIR-CLRI, on behalf of the Calcutta Leather Complex Tanners’ Association and the entire Kolkata Leather Industry, I convey my warm greetings and best wishes.

Ramesh Juneja
Foreword

Dr KJ Sreeram
Director, CSIR-CLRI

Leather Science is an evolving area. Despite being fraught with challenges and hurdles, India's raw hides/skins trading industry has adopted technological advancements and progressed to a global leader in quality leather and leather product manufacture. Progress over the last 75 years is due to the presence of a research institution under the aegis of CSIR. The Central Leather Research Institute has remained the backbone of the leather industry. We chronicle the journey from 1948 to the present through this coffee table book. The period of 1950-54 was one of converting the traders of raw hides into tanners. The partnership with the University of Madras provided the technical education and training to transition from trader to manufacturer.

The Golden era of CLRI was 1954-70, where dynamism in industrial growth and the partnership with the academy grew. Institute introduced leather fairs, fashion shows, tanners' get-togethers, and international meets to attract business to Indian leather. Translational research took birth in this period. Between uncertainties and navigation to excellence, polymer science emerged during the 70s to 80s.

The later part of the 80s and the 90s saw the emergence of footwear research, environmental science, synthetic fatliquors, and industrial incubation. Institute focused attention on industrial modernization, automation, and computer-aided design. In the early 90s, a greater focus was on leather goods and garments alongside quality assurance. From 1996, industrial sustainability through do-ecology solutions, leading Indian leadership in best practices in environmental management was the focus. A paradigm shift from chemical to bioprocessing of leather was introduced in the new millennium. The S&T growth led CLRI to move its technology prowess to Africa, enabling the development of industrial activity in Ethiopia. Around 2017, CLRI introduced a waterless processing methodology. Focus moved towards zero liquid discharge and value addition to solid wastes. In 2020, the institute took up the assignment of developing a footwear sizing system for the country.

All these efforts have led to CSIR-CLRI enabling the growth of Indian leather and setting tall and ambitious targets for the future. The institute continues its journey in enriching India through technologies, entrepreneurship, women empowerment, and creating jobs for the lowest economic strata. We have a roadmap to 100.

While tracing back our history, this coffee table book is also the institute's commitment to national development through the leather sector.

KJ Sreeram
**Mandate**
To focus R&D towards the betterment of the leather and associated industries

**Vision**
To leverage core competencies and built-up strengths of CSIR-CLRI in aiding India gain technology enabled leadership in global leather and footwear trade

**Mission**
Economic, Environmental, and Social Sustainability of the Indian Leather and Footwear Industry, leading to its achieving USD 35 Billion Market share by 2030, is the Mission of CSIR-CLRI
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75 STORIES OF CSIR CLRI
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AISHTMA Project 1996: Rising to Occasion
Through Do-ecology Solutions

In 1996, about 600 tanneries in Tamil Nadu were closed under the orders of the Hon’ble Supreme Court of India for reasons of inadequate compliance to environmental discharge norms of the State. CSIR-CLRI in collaboration with CSIR-NEERI had undertaken the massive exercise of providing critical technological solutions to the vexed problem in a span of 15 months. The outcome of the implementation of technology plans developed and delivered by the two CSIR laboratories to the All India Skin and Hide Tanners and Merchants Association (AISHTMA) enabled the tanners of Tamil Nadu to comply with the environmental norms of the State.
1972- Seetharamaiah Committee – Trade Transformation

During 70s, the Indian leather industry was mostly exporting raw hides and skins and semi-finished leathers. Conscious of the need for higher unit value realization for export, Government of India had planned to change the pattern of export from semi-processed hides and skins to finished leather and leather products. A committee was appointed in July, 1972 under the Chairmanship of Dr. A. Seetharamaiah along with the experts from CSIR-CLRI to make a comprehensive study of the question of promoting Indian exports of leather manufacturers. The Seetharamaiah Committee suggested a number of measures for promoting export of leather manufactures such as restriction on export of semi-finished leather, cash subsidy to the extent of 15% against the exports of finished leather and creation of infrastructure, the investment required for setting up of the infrastructure including land, building and machinery for conversion of 75% of the exports of semi-processed hides and skins, etc.
Secure Chrome Management in Tanneries: A Technological Reality

A closed loop Alutan - BCS tanning methodology ensures near zero discharge of chromium. CSIR-CLRI has developed the process, designed and implemented Chrome Recovery Plants for recovery of chromium from spent chrome liquor. Batch, mobile and semi-continuous systems have been developed to suit the field conditions. Recovery of chromium more than 99% realized with a payback period of 1-2 years. Chrome recovery/reuse methods are simple and easy to adopt at all investment and capacity levels. More than 400 tanneries adopted in India, Nepal, Sri Lanka, Bangladesh and other Southeast Asian and African countries.
Leather Technology Mission (LTM) aimed at technology driven development grid integrating the needs of the decentralized as well as organized sectors. Major technology initiatives through LTM included 1) animal health care systems aimed at providing better quality skins for the leather sector, 2) implementation of cleaner technologies, 3) innovations in human resource development activities, and 4) new technology initiatives including chemo autotrophic wet air oxidation method and biomethanation. More than 250 tanneries throughout the country have benefited. Benefits accrued are reduction in BOD/COD by 35%, sulfide reduction by 50%, 20% reduction in hydraulic load, and 25-30% reduction in TDS levels in tannery waste water.
Customized Processes for Exotic Leathers and Fur

Process technologies were developed and standardized for exotic raw materials by CSIR-CLRI. Leathers suited for specialty products were developed from reptiles, turtle, shark, frog, bandicoot rat, ostrich, emu, kangaroo and ray fish skins. Cost effective process technologies were also developed for fur skins.
Waterless Chrome Tanning Technology (WCTT)

Primary innovation of this technology is no use of water for chrome tanning, therefore, there is no chromium containing wastewater generated thereby providing a total solution for the chromium pollution. Apart from addressing the issue of chromium discharge, this technology also brings about the benefits of reduction in total dissolved solids load. The quality of leathers thus produced is also found to be better than the leather produced in the conventional manner. More than 100 leather manufacturers have obtained the license to adopt this technology in India and several of them have regularized their leather production employing WCTT. WCTT has bagged five prestigious awards namely CSIR Diamond Jubilee Technology Award (CDJTA) 2016, CSIR Technology Award for Innovation 2017, FICCI R&D Innovation Award 2017, NRDC National Meritorious Invention Award 2017 and SV Rao Excellence Award 2019 for Technologists.
Fallen Carcass Utilization: A Case of Successful Downsizing to Meet People’s Need

The disposal of fallen carcass is a major socio-economic problem faced in India where the usual practice of disposal is by mechanical burial of the dead cattle. The presence of intact hide, bone, horns and hooves hinders the decomposition of dead animals which leads to ground water contamination. A viable solution was provided by CSIR-CLRI by recovering the hides and rendering the animal for making protein for usable products for fertilizer or animal feed applications. Systematic collection of fallen animal was suggested especially in rural areas with installation of the necessary machineries and commissioning. The process includes lifting of fallen animals, flaying techniques, preservation of hides and skins, rendering (cooking) of the flayed carcass, preparation of meat meal, bone meal, tallow, besides treatment of effluent and utilization for agro-horticultural purposes and conversion of rumen contents into manure.
Stability, broad substrate specificity, high yields and rapid growth of microorganisms on inexpensive media made microbial enzymes as a choice for industrial needs. CSIR-CLRI developed processes for producing and upscaling commercially important enzymes for industrial applications. Unique protease secreting bacterial strain was identified and explored for enzyme production for its application in the unhairing of skins/hides. The enzyme formulation for rapid fibre opening of skin matrix developed by CSIR-CLRI has been awarded the CSIR Innovation Award for 2015. A team from CSIR-CLRI developed a process for the degradation of a mixture of aliphatic and aliphatic-aromatic polymers using yeast lipase. This process has been selected for the 10th National Awards for Technology Innovation under the category of “Innovation in Polymer Waste Management” for 2020.
Salt Less Preservation: A Sleepless Pursuit with Many Landmarks

Salt has been traditionally employed for curing of hides/skins. Quantity of salt used is 35-40% (on raw weight) in conventional curing systems. Alternatives to salt in curing have been developed. Less salt/salt less preservation methodologies have been assessed for the quality of leather produced. Some of the alternatives to salt in curing tested are neem oil, zinc chloride, silica gel, boric acid and parachlorometacresol. Newer initiatives include preservation-cum-unhairing, air drying, use of alkali silicates, combination of salt with biocides and other preservatives.
Moving Industry Forward through Technologies: Blond Lining

A process technology was developed for improving low grade, low yield vegetable tanned leathers. The technology created export avenues for leathers, which did not find an internal market. A boon for small scale tanners as it required no additional infrastructure. Significant value and utility enhancement was created. It is a simple, reproducible technology with good commercial acceptance. It is a technology still in practice.
Evolutions in Finishing Techniques:
A Never Ending Job

Newer finishing techniques have proved to be value engineering tools. Tie & dye effect, bathik effect, grain suede effect are landmarks. Novotone effect produced by transferring photographic print of selected pattern on suitably finished leathers. Xerofinis technology is one of the early forms of transfer coating, which won NRDC award for innovation. Seal sink technology, one of the versatile and simple technologies, led to breakthrough in finishing technologies for value addition in leather.
Odour released during leather processing owing to the nature of chemicals used and the chemical reactions occurring during the process is one of the problems that are mostly complained to the environmentalist. CSIR-CLRI designed an indigenous eco-friendly integrated technology for removal of odour from tannery using biofilter. In this technology, the odourous gas generated from the process is passed through vent and duct and is treated in the biofilter with a removal efficiency of about 90%. A prototype of odour abatement system has been developed and available for demonstration at (CSIR-CLRI). A commercial level technology is designed & commissioned at M/s. SA Abdul Aziz Tannery, Erode.
Wastewater treatment and disposal is one of the important key issues in any industrial process. CSIR-CLRI has developed a 'zero wastewater discharge technology' (ZWDT) based upon in-process measures. According to this technology, the waste streams of differing characteristics are segregated, treated following electro-oxidation and then reused. The electro-oxidation system developed is based on indirect oxidation where selected electrodes (specific metal oxides coated) are used. The technology has been standardized at pilot and commercial scale. The capital cost for the ZWDT is around 40% of the traditional wastewater treatment plant. Technology has been demonstrated at commercial scale in almost all the tanning clusters in India. The technology has been transferred to five tanneries in India. It is also demonstrated in three leather manufacturing units in Ethiopia.
India is endowed with more buffalo and goat based raw materials. CSIR-CLRI developed various types of leathers from Buffalo hides. The institute was the forerunner in developing technologies for making upper, upholstery, garment and glove leathers from buffalo hides. The technologies have been practically demonstrated to the tanners in various clusters throughout India. Technologies for making suede leathers from goat skins were also developed. CSIR-CLRI showcased goat leathers and leather products made using sustainable technologies at the Road Show organized to the tanning fraternity. Goat leathers were made employing the technologies of CSIR-CLRI such as salt-free curing, enzymatic unhairing, organic tanning system devoid of vegetable and glutaraldehyde, waterless chrome tanning technology and using liquid syntans and dyes.
Sustainability of Leather: End-to-End Solutions

Tannery specific sustainable leather processing solutions have been developed and transferred to several tanneries in India for the reduction of pollution loads such as BOD, COD, Cr, etc. In addition, suitable effluent treatment systems such as common effluent treatment plant (CETP) or individual effluent treatment plant (ETP) have also been designed and delivered to various tanneries and tannery clusters in India. The efforts have resulted not only in environmental benefits but also in economic benefits thereby resulting in the sustainable development of the leather sector in the country. The work has helped to achieve special recognition for CSIR-CLRI from Indian leather sector.
Ionic Liquids: Exploring Next Generation Technology for Leather Processing

Ionic liquids (ILs), well known as “task-specific”, “designer”, and “new age” materials are currently explored for leather processing applications. The effect of varying classes of ionic liquids viz., imidazolium, phosphonium, ammonium and choline salts on collagen has been studied at different hierarchical levels. Depending on the chaotrophicity and kosmotrophicity of ions, they influence the stabilization, denaturation and aggregation events in collagen. The swelling effect of ILs has been judiciously employed in the liming and unhairing process. Value added products from skin have also been extracted using ILs.
Machineries for Leather Making

A low float tanning device (CLaRI) was developed by CSIR-CLRI as an effort towards design innovation through engineering approach. The device is essentially a substantial improvement of design over existing wooden tanning drum used for leather processing. The major advantages being better capacity utilization, reduced power consumption, enhanced productivity and ease of operation. First of its kind prototype model with a processing capacity of 500 kgs was designed and fabricated at CSIR-CLRI. The special feature being the rocking action in addition to the conventional rotational movement, which ensures speedy and effective processing without compromising the quality of the hides/skins. An Enzyme applicator device ensures an improvisation over the application of processing agents like depilation paste, enzymes etc on hides and skins by providing, unlike the conventional manual method, enhancing the productivity of the process. The application also has automatic stirring of the liquid to be pasted providing better working environment, where manual operation is totally avoided. A Salt Separator removes the adhered salt from the salted hides/skins, thereby reducing the salt load in the soaking wastewater. The equipment consists of a perforated hollow light weight container with baffles fixed in the inner periphery, which aids in removal of salt.
Chicken feet skins, waste from poultry has been explored as a potential raw material for leather industry owing to its exotic grain pattern and the availability. A full chrome process, full veg process & semi-chrome processes were developed and standardized to turn chicken feet skins to leather products. Suitable post tanning methodologies were adopted to attain good substance, softness and strength characteristics. Value added exotic leather products such as wallets, hand bags, and footwear have been made from the chicken feet leather panels. The technology knowhow was licensed to M/s Shayoen Labs (Indian startup company) – A women entrepreneur exports chicken feet leather panels abroad.
Leather Products
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Foot Care Solutions: Transitions from Footwear to Foot Care

CSIR-CLRI in collaboration with M/s MV Diabetes Hospital and Diabetes Research Centre developed ‘special footwear’ which would go a long way to help reduce diabetic foot complications and ensure a better quality of life with enhanced productivity for these patients. The footwear developed, called “DIASTEP”, is a therapeutic open footwear for the diabetic patients with risk of foot problems. The footwear is designed to provide for better shock absorption, reduced friction, better comfort and wear properties and most importantly helps in redistributing pressure uniformly on the plantar surface of the foot. Brand named as DIASTEP: an off-the-shelf footwear for low-risk Diabetic patients. It is a matter of great pleasure and pride that “DIASTEP” technology has been transferred by CSIR-CLRI to M/s M V Health Care Pvt. Ltd. India and is now available commercially.
Leap Frogging in the World of Fashion Forecasting

CSIR-CLRI Design & Fashion Studio has played the role of a catalyst in the growth of the Indian Leather Industry. A lot of attention would have to be paid to honing ‘Design’ capabilities, introduce technologically advanced tools to aid in the ‘design process’ and to develop ‘merchandising’ expertise amongst our product design teams in the footwear companies. MODEUROP is an International Institution founded in 1960 in Zurich / Switzerland by the most important institutions of the leather and footwear industry. It forecasts fashion and trends in Leathers, Colours and Materials for the International market, three seasons ahead. The official MODEUROP Colour Cards are now ‘Made in India’ with suitable acknowledgements to the contribution of CSIR-CLRI/CLE as well as to the contributing tanners; thereby enhancing the marketability of Indian Leather in International markets. CSIR-CLRI’s ‘success clock’ ticks at Colour Meetings of MODEUROP and FASHION TREND POOL, Germany with metronomic thoroughness and brings the Indian Leather and Leather Products Industry to astonishing and durable success.
Since the Children’s feet grow at a rapid rate thus mandating a frequent change in footwear to accommodate this foot growth, CSIR-CLRI felt that in order to provide correct fitting shoes for them it is essential to gather reliable foot dimensions of children and statistically analyze the data to derive the dimensions of the “lasts” which would fit the children – both Boys and Girls, perfectly providing for a Comfortable Footwear. Accordingly, the Children’s (both Boys and Girls) foot dimensions were reliably captured through a unique ‘3D Digital Capture’ of the foot images. Sophisticated Statistical technique, led us to compress the foot data captured and resulted in the optimization of the complete children’s (both Boys and Girls) size range into only 5 Groups, which helped in minimizing the size range to be manufactured. The newly developed sizing system covered children having different foot sizes comfortably, accommodated the foot growth in children and also reduced the frequency of footwear change.
GAIT and Motion Analysis for Corrective Footwear

In combination of 3D foot scanners, that help in arriving last parameters, the GAIT analysis system helps in the study of walking patterns and gait of a person. Changes in gait owing to foot disorders and understanding of pressure patterns, helps in design of customized footwear for offloading of the pressure and thus progress towards corrective gait and footwear design. This has led to CSIR-CLRI developing children footwear and comfort footwear.
Kolhapuri: Reviving Traditional Wisdom through Knowledge Back-up

The Kolhapuri footwear is ethnically designed footwear traditionally crafted by the artisans’ at rural villages namely: Athani, Nippani, Madhubavi, Kolhapur and other places located at Karnataka and Maharashtra state in our country. There is a necessity and need felt for the design and development of Kolhapuri footwear and thereby improving the socio-economic status of the artisans who have been depending on this traditional wisdom from their ancestors. CSIR-CLRI evolved an appropriate module on “technology of kolhapuri making” specific for the artisans’ community. The artisans acquired Design Innovation skills through the training programs and workshop conducted by CSIR-CLRI. The technological interventions from CSIR-CLRI have been impetus for the overall development of the rural clusters transition from traditional practice to modern concepts of footwear manufacture.
CSIR-CLRI investigated the Structural, Mechanical and Thermal Properties of banana fabrics and analyzed the compatibility with leather for making combination products. Three types of banana fabrics have been chosen for the above analysis with buffalo leathers. The results of this study suggest that the identified banana fabrics can be used for making a variety of products in combination with leather for several applications. Since the findings are favourable about their compatibility, a range of products (20 designs) were made based on trend forecast and novelty. A brochure encompassing the above designs was prepared and the same was released on the occasion of 78th Foundation Day celebrations of Council of Scientific & Industrial Research (CSIR). As part of dissemination activity "Banana fabric and leather combination Products" were exhibited at India Leather & Accessories Fair (ILAF) held at Kolkata. A design package consisting of 6 designs was transferred to M/s ROPE International Pvt. Ltd.
Ethnic Design for Leather Products – North East India

Due to non-availability of employment, the younger population of north east India moves to other parts of the country in search of better opportunity. The other negative impact is that the development in that particular region is reduced and traditional artisanal work is affected. Marketability and Quality enhancement of the products that are being currently developed by the local artisans needed to be supported by systematic intervention. Hence, it was planned for Design and Development of Innovative leather lifestyle products in combination with ethnic textile material and natural fibres of North Eastern Region (NER) of India for the self-sustainability and socio economic development of rural population in those regions. CSIR-CLRI conducted training programs to women population through Self-Help Group (SHG) on the design and development of combination products.
Computer Aided Design (CAD) for Leather Products

From its advent way back in the 80’s to the present time, Computer Aided Designing has been making tremendous impact both in the design and manufacture of footwear, garment and goods. To help the Indian leather products industry take advantage of this technology and stay a step ahead of competition, the CSIR-CLRI through its Shoe and Product Design Centre is offering specialized CAD services and courses for this industry. With the available facility, CSIR-CLRI provides technical services to number of industries making footwear, garment and goods to enhance the linkage between Institute and Industry, and imparts training to entrepreneurs and industry personnel.
Leather Puppet

It is a unique art practiced as shadow play – a Rural entertainment supported by narration and music. Leather puppets are used traditionally in Folk Plays and Home Decorative works/Lamp shades. Goat parchment leather is specially processed for puppet making. Machineries/Equipment required to make leather puppet are Tables, Cuddapah slab with Teflon sheet, mallets, hand punches, painting tools, wooden frame with screen and bamboo sticks to perform the folk art. The technology status comes under tradition products. The total investment depends upon the art of puppet. The market potential exists in interior decorations and lamp shade items. Marketability for the product is highly potential in both Domestic and International.
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Adapting Upflow Anaerobic Sludge Blanket to Tannery Wastewater: A Forward Step

Upflow Anaerobic Sludge Blanket (UASB) technology for the treatment of tannery wastewaters was first implemented at Kanpur under Indo-Dutch program. Despite the advantages such as low sludge production and less requirement of energy as well as area, there is a major constraint of using this technology for treating tannery waste water because of the high sulfate content, which results in generation of methane gas. An improved system has therefore been developed whereby the sulfate is completely removed as elemental sulfur and the treatment of the tannery wastewater is carried out in conventional UASB reactor, thereby generating energy. This system ensures removal of COD and sulfate TDS by 60% and 90% respectively, whereby the sulfur can be recovered. A number of plants have been established based on this CSIR-CLRI Technology. This represents a forward step in UASB application for leather sector.
Sequential Oxic-Anoxic Bioreactor (SOABR)  
Technology for Wastewater Treatment

The SOABR technology from CSIR-CLRI has only investment cost, which is almost equivalent to build conventional system, but it doesn’t use any addition of chemicals and thus operational cost is very minimum compared to the available conventional technology. This technology completely avoids primary chemical sludge. SOABR was demonstrated to various industrial representatives in India and abroad and also in several occasions to achieve commercialization. The efficiency of SOABR was tested for sewage as well as various types of industrial effluent such as post tanning wastewater, soak liquor, pharmaceutical wastewater, evaporate condensate water from pharmaceuticals, fish and prawn processed wastewater.
Phenolic derivatives and Naphthalene derivatives are used by many industries such as tanneries, petroleum industries and chemical industries. These types of compounds bind effectively to the soil particles and get accumulated in plants as well as in people who consume them. Due to the relative stability of these aromatic hydrocarbons, soil ultimately acts as a major sink for these compounds. Thus, the in situ removal of aromatic hydrocarbon from the soil is a challenging one. CSIR-CLRI developed a technology, which addresses in situ bioremediation of aromatic compounds contaminated soil using aromaticity enhanced immobilized bio surfactants without affecting the fertility of the soil. Since the organic contaminants can induce a number of detrimental biological effects, such as mutagenic, carcinogenic, and teratogenic effects, the developed technology/process helps to remove these type of contaminants, which in turn improves the health and safety of living beings.
Biogas from Co-digestion of Tannery Solid Waste

This technology uses tannery solid wastes (i.e., fleshings and waste activated sludge generated from effluent treatment plant) as substrates for biogas generation. After size reduction of fleshings, it was mixed with sludge in an optimized mix ratio and fed into the anaerobic digester fitted with gas collection system. A daily feed of 750 kg of mixed waste on wet weight basis resulted in biogas production of about 12-15 m³/day. The methane content in the biogas was 65 to 70%. To protect the environment and to generate green energy, the produced biogas is being converted into electrical energy using a biogas genset, which makes the plant self-sufficient in terms of energy requirement. The technology was demonstrated at Calcutta Leather Complex, Kolkata and to the Tanners at CLCTA, MSME&T Officials. The plant is operated and maintained by CLCTA, Kolkata.
Immobilized Oxidation Reactors (IOR) for Wastewater Treatment

IOR technology can treat wastewater discharged from industrial and domestic sectors with minimum sludge production compared to conventional technology. It requires low foot print requirement and no odour emission. The other advantages are no odour emission and minimum sludge production. IOR technologies were implemented to many industries with maximum volume of 2000 m³/day. Beneficiaries of the technology includes Sri Chamundi Leather, Kolappakkam, Chennai; M/s Shameel Tanners, Andhra Pradesh; M/s. Orchid chemicals & Pharmaceuticals, Chennai; M/s Nalco Indonesia, Indonesia; M/s. Cosmos Sea Foods Co. Ltd., Tema, Ghana; M/s Analytica Technology and Chemical Supply Pvt. Ltd., Namibia; and M/s, Renolux Engineering Sdn. Bhd., Malaysia.
Establishment of Secure Landfill System

CSIR-CLRI has designed and patented “Secure Landfill”. In this design, Reinforced Cement Concrete (RCC) based secure landfill structure with High Density Poly Ethylene (HDPE) liners drainage arrangement has been incorporated. Based on the patented design of secure landfill approved by the regulatory authorities, this approved secure landfill has been implemented at different tannery clusters in Tamilnadu.
Leather Chemicals
Reversing Flow of Technologies in Syntans

In this technology, syntans for retanning purpose were developed using raw materials such as phenol and/or naphthalene, sodium sulfite, sulfuric acid, formaldehyde and urea since fixation of aldehydes into collagen affected by modification of basic groups. Using this technology, CSIR-CLRI has enabled public sector unit to capture large market share. This syntan technology was exported to USA in 60s and 70s from CSIR-CLRI.
During 1970s, India was completely dependent on imports of fatliquors. A series of synthetic fatliquors derived from sulphochlorinated paraffins and natural oils were developed for leather industry applications. Still, technologies based on easily available raw materials that enables production of leathers with extraordinary level of softness and other special properties are needed. For the first time, CSIR-CLRI employed photosulfochlorination to impart water emulsifiable properties to paraffinic hydrocarbons. Around 60-80% of synthetic fatliquor needs of India were met through these CSIR-CLRI technologies, which enabled CSIR-CLRI to achieve Aatmanirbhartha in the field of fatliquors.
Firsts in the World of Mineral Syntans

Two mineral syntans with no International equivalents were designed, developed and delivered during 1984-86. In the following years, many novel mineral syntans have been developed, and the technologies were transferred. CSIR-CLRI developed several mineral-based syntans marketed as Balsyn ACE, Balsyn AL, Alutan, Alcrotan, Cleartan AL, Ecosyn, Ecochrome, Clarichrome, Claritan AL and Seltan CM. Balsyn ACE and Balsyn AL made a turnover of 7 crores per annum and Alutan in combination with BCS made zero waste tanning a reality. The products exhibit higher chrome uptake and also ensure reduction in wet finishing chemicals, and enable dyeing of leathers to rich shades. These products are marketed by M/s. Balmer Lawrie & Co. Ltd., Kolkata, M/s Quinn Group of Companies, Hyderabad and M/s. Sellam Chemicals Pvt. Ltd., Chennai.
Pentachlorophenol (PCP) is a banned substance. In the early 90s, CSIR-CLRI began the search for alternatives for PCP. Dual active preservatives such as PCP were rare and biocide cocktails were preferred. CSIR-CLRI prepared PCP substitutes such as 2-(thiocyanomethylthio)-benzothiazole (TCMTB) and 2-Octyl- 3(2H)-isothiazolone (OITZ). TCMTB was found to inhibit the fungi effectively that were found even in watch straps. With recommendation on continuous usage restrictions on TCMTB, CSIR-CLRI is working on the development of plant and plant-derived products as antifungal agents.
Protein-based Retanning Agents: Crostan EA and Dermatan RT

Most of the retanning agents used in the conventional post-tanning are hard for biodegradation. In addition to that, the presence of free formaldehyde is a major concern. The solid waste generated from leather industry, such as raw trimmings, contains two important biopolymers, namely collagen and keratin. These polymers have been hydrolysed into poly-peptide and further modified with additives. The modified poly-peptides are used as syntan in leather processing. The products developed are suitable for all types of leathers. The advantages: 1) excellent exhaustion of dye, 2) gives light, heat and migration fastness, 3) improves belly-filling and 4) provides softness and uniform color.
Retanning Agent: Protan KH

Protan KH is a polymeric syntan, containing protein hydrolysate of hair from tannery. The products developed are suitable for all types of leathers and compatible with all the auxiliaries used in leather processing. Protan KH is free of APEO, AOX and does not contain free formaldehyde. It enhances dye uptake and improves roundness and grain tightness of leather.
Retanning is a very critical and important step to fill up the void spaces. Though vegetable tannins, and synthetic tanning agents such as aromatics, acrylics and aldehydes are used as retanning agent, they are associated with several constraints like heaviiness of leather and cost. The product is formulated with inorganic filler (nanoparticles), monomers and various additives and used as a retanning agent in leather processing. It is a nano polymeric retanning agent that brings about fine and smooth grain with excellent fullness. In about 3-5 years, the Indian leather industry would depend on this product at least to the extent of 10 – 20% of their total requirement of retanning agents.
CSIR-CLRI has developed first of its kind product which is single organic product having a twin benefit of preserving and hair loosening. This product eliminates the salt and toxic sodium sulfide usage in leather industries, reduces the pollution load (TDS) in wastewater and in-turn eliminates the need for sophisticated end-of-pipe treatment system, and reduces the quantum of water requirement as well as wastewater discharge. Implementation of this technology is expected to save 500 kg of salt, 40 kg of sodium sulphide and 600 liters of water per ton of raw hide and skin. In about 3-5 years, the Indian leather industry would depend on this product at least to the extent of 20 – 30% of their total requirement of preservation and unhairing agents.
Water Free Dry Tanning Technology –
A Revolution in Leather Making

The tanning effluent containing common salt, unabsorbed chromium along with other unutilized chemicals poses serious environmental constraint for which, no cost-effective and viable treatment system has emerged so far. The present invention deals with development of a dispersing agent, which replaces completely “Water” employed as medium for tanning and mineral acids. First of its kind product, which does not contain any carcinogenic or toxic ingredients. The technology knowhow was licensed to M/s NS Eco Solution Pvt. Ltd (Indian company). Product was launched into the market in the name of DT ECOSAVE.
Lignin-based Retanning Agent

Black liquor from the paper and pulp industry, which predominantly contains modified lignin as a good source of aromatics have been employed for the development of retanning agent. This product does not use petroleum byproducts and formaldehyde. The indigenous manufacture of the niche product provides technological solution for single pot lubrication and filling. It can be used for retanning of all types of leathers.
Retanning cum Lubricant Agent - RELUB-17

Development of a lubricating agent for use in leather manufacturing process with the ability of providing retanning effect is the white space addressed through this technology. CSIR-CLRI developed an eco-friendly and readily biodegradable vegetable oil based retanning cum fatliquoring agent that incorporates excellent fullness and softness properties to leather. Its diversified nature provides the leather with improved softness, suppleness, roundness with a fine grain pattern. This product addresses the long time need of the industry where a single product can replace multiple products from various classes of compounds.
Grafting of Acrylic Monomers on Collagen and Leather: Path Breaking

The new graft water-based acrylic copolymers nanocomposites developed by CSIR-CLRI are path breaking due to high temperature stability, better reinforcement and shelf-life for use as a post-tanning agent. The product based on collagen grafted copolymer post tanning agents exhibit excellent grain tightness properties, especially in the belly region and the loosely structured parts of the skin or hide. These products were demonstrated to the various industries namely M/s Vijayam Biocytes Pvt Ltd. and M/s Ultra Tile Pvt. Ltd, as superplasticizers, to reduce the water uptake in the admixtures.
The CHILLS project of CSIR-CLRI focuses on a major lacuna in the availability of appropriate indigenous technologies for the manufacture of leather clothing for use in temperature conditions in the range of -30 to -10 °C and extendable to -50 °C specifically for strategic sector applications. This project addresses the technology gap for chemicals/combination materials employed for filling, lubrication, adhesion, flame retardance, weight and impact for making leather gloves.
The process of dyeing is influenced by charge, and condition such as pH, and presence of other auxiliaries like fixatives, leveling agent, penetrating agents of the dyes. The conventional dyeing methods are associated with some disadvantages such as reversibility, difficulty to achieve high colour intensities and high colour stabilities, low wet- and perspiration fastness. In order to overcome the disadvantages, CSIR-CLRI prepared encapsulated nanocolourant for leather dyeing application. The advantages of the product are 1) complete elimination of dye leveling agent, cationic fixing agent, dye penetrators, dye fixing agent like acid and alkali, and 2) avoidance of colored discharge from dyeing process, less burden to wastewater treatment.
Leather Science
Identification of New Crosslinks in Collagen

Fixation of aldehydes into collagen generally effects by modification of basic groups. Thus, new L-glutamyl peptide linkages in collagen and elastin were evidenced from this study. Influence of side chain amino acids on the properties of collagen revealed through chemical modification. Lysinoalanine crosslinks in heat-treated collagen and alkali-treated collagen identified. Tyrosine mediated cross-links such as dityrosine and monoiodotyrosine, and diiodotyrosine stabilizing collagen of Mytilus edulis, and elastoidin in shark fish has been identified. Oxidation of collagen by lipid peroxides and Fenton-like mechanisms responsible for the formation of advanced glycation end products (AGE) cross-links collagen, a possible consequence in the complication of diabetes were evidenced. Through this knowledge, CSIR-CLRI has made a mark in collagen research.
Directional frictional effect (DFE) in collagen fiber was first proposed. DFE in collagen fibre attributes to the saw-toothed appearance of the surface of collagen fibres as seen in transmission electron microscopy. The treatment of collagen fibres with vegetable tannins results in the filling up of the saw-toothed spaces thus nullifying DFE. This scheme is reported for the first time- the occurrence of ‘Stick-Slip’ phenomenon, which includes static, dynamic and kinetic coefficient of friction when determining inter-leather surface friction. The stick-slip phenomenon correlates with surface morphology of leathers obtained from scanning electron microscopy.
Catching Attention through Chromium

Special features of chromium chemistry were first proposed from CSIR-CLRI. The achievements are as follows; Demonstration of kinetic lability of Cr(III) with ground state structural distortion during 1980-85. Stabilization of unusual oxidation (Cr(IV)/Cr(V)) states during 1980-86. New hypothesis for role of Cr(III) in control of diabetes during 1989. Cr(III) induced apoptosis during 1995-99. Mechanistic insight into Cr(III)/(V)/(VI)-induced carcinogenesis during 2000-02. Cr(III)-DNA interactions during 1996-2020. Cr(III)-induced molecular assemblies during 1990-99. Those unique studies on chromium chemistry resulted in special place for CSIR-CLRI in world map and earned Bhatnagar Prize for CSIR-CLRI.
Two Dimensional Tester: First to Build

Bidirectional testing for viscoelastic and anisotropic materials such as leather was first proposed by CSIR-CLRI. Unidirectional testing is unrealistic for viscoelastic anisotropic sheet materials including leather (high Possion's ratio). Two dimensional tensile testing is imperative to get in situ simulation property of the material. A two dimensional stress relaxation testing device has been designed and patented (US 6,247,370) by CSIR-CLRI. A new template for 2D test samples developed to concentrate the stress applied to the centre of the sample has potential applications in several fields such as, shoe uppers from leather, textile materials, plastics and polymers (anisotropic) space and aerospace. Industry related composites (reinforced) bidirectional testing for viscoelastic and anisotropic materials such as leather was first proposed.
Bi-functional Magnetic and Conducting Leathers

The technology incorporates smart functionalities such as electrical conductivity and magnetism in leather for smart product applications. The technology aims to find new application avenues to leather for high unit value realization. Bimetallic nanoparticles are coated on the surface of the leather matrix by simple coating technique to provide both the electrical conductivity and magnetic properties. Depending on the choice of chemicals, leathers with satisfactory electrical conductivity and magnetic behaviour with different colour shades can be obtained. This technology has potential for applications in smart/interactive clothing, EMI shielding, adhesive-free wall covering and energy harvesting. First to report by CSIR-CLRI, the bi-functional properties such as electrical conductivity and magnetism in leather
Development of blended fabrics and products from leather wastes as raw materials was evidenced by CSIR-CLRI. Leather fibres were extracted from leather solid wastes and they were mixed with various proportions of natural (cotton) and synthetic (polyester) fibres to prepare composite fibers. These composites were further processed into leather blended yarns and leather blended fabrics. Blended fabrics made from cotton or polyester blended fibers were of good quality with smooth finish. A novel concept of fabric manufacture is explored, which is energy efficient, eco-friendly and cost effective. Preparation of blended fabrics using natural or synthetic fibres would result in low cost fabrics based on wealth from waste approach and would create opportunity for small scale leather and product industries. Value added blended fabrics and products were made from leather wastes as raw materials through this CSIR-CLRI technology.
CSIR-CLRI and Dr. Umayalpuram K. Sivaraman, an exponent of Mridangam, have been interested in the use of scientific methodologies for standardization and fabrication of the unique instrument. The research presents some objective parameters and criteria for the choice and selection of materials for construction of the instrument. Fast Fourier Transform technique has been employed for tonal characterization with ease. This research presents some useful methods for optimizing the conditions for application of black patch and leads for rendering the instrument more user- and transport friendly. It is now eminently plausible to fabricate instruments capable of complying with strict phytosanitary laws of some island countries.
Innovations in Formulating
Leather Finishes: Early Gains

Process techniques for the manufacture of soft, medium soft and hard acrylic emulsion binders for pigment fixing onto leathers were developed. Indigenous monomers and chemicals find use in the binders developed. Technologies were demonstrated at 3500 kg/batch levels. As an off-shoot of binder preparations, technologies for polyacrylate dispersion for enteric coating application, printing ink, pressure sensitive adhesives were also developed. Nitrocellulose lacquer and lacquer emulsions produced and supplied during the years of industrial transformation.
Antiviral Face Mask and Lab-coat

The growing threats from infectious diseases in the hospital and community, especially the COVID-19 pandemic, have been recognized by all the countries across the globe. Respirator mask is one of the personal protective equipment (PPE) to minimize contact transmission onto face or inhalation of airborne pathogenic microbes. CSIR-CLRI envisaged a scheme to develop an antiviral fabric that could bind and inactivate an aliquot of virus present in air-droplets under normal/hospital conditions. The team has succeeded in anchoring a potent antiviral and antibacterial agent, to cotton fabric and sponge. In this method, the cotton sponge or cotton fabric was synthetically modified such that either an antibiotic or an antiviral agent could be covalently attached. This modified cotton contains reactive functional groups, which aid in a strong binding to virus or bacteria. Attachment of drug onto the cotton fabric can be scaled up to manufacturing levels. The outcome of this research permits development of cost-effective commercial manufacture of face masks, lab-coats and other cotton based pharmaceutical products with antiviral potential.
The concept of simulated counter-current technique to extract the tannins from vegetable material has been successfully tested on a pilot plant scale rig. A micro-processor based technology is a breakthrough in this traditional area. This process has several advantages over the conventional vegetable tannin extraction technology with reference to productivity, operational efficiency and process control. The technology has been commercialized by M/s Rallis India Limited and M/s Quinn International Ltd. This microprocessor controlled vegetable tannin extraction technology was the first of its kind in the world. The test facility can be used in other areas of solid liquid extraction such as coffee, spices etc.
Tannery Waste to Wealth
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75 STORIES OF CSIR CLRI
Turning Fleshing Waste into Soles for Shoes

About 0.5 million tons of fleshing waste generated globally every year. Disposal of this huge quantity of fleshing waste is a major challenge faced by tanners worldwide. Present methods of fleshing utilization involve high capital and operational costs and are energy intensive. CSIR-CLRI developed a technology where limed fleshing was taken as source for the preparation of activated carbon. Activated carbon prepared from limed fleshing waste was used as a replacement for carbon black, which is used as filler in rubber compounding. Thus, this technology can be used by any rubber compounding industry for applications like rubber sole and tyre manufacturing. A technology providing dual solution to both fleshing waste problem of tanning industries and the carcinogenic filler replacement of rubber industries.
Preparation of Compost from Animal Hair Waste

About 50 tons of hair waste is generated from the tanning industries on processing of every 1000 tons of hides/skins. The disposal of hair wastes results in many significant negative environmental impacts. CSIR-CLRI developed a bioprocess technology for efficient degradation of hair using a novel bacterial strain, Brevibacterium luteolum MTCC 5982 in liquid medium containing salts and animal hair. The resulting fermentation liquor was used for the manufacturing of organic compost and the efficacy of the product has been tested at field level. The compost could serve as an effective organic fertilizer and increase the yield of paddy by 20±5% and horticultural crops of bhendi, chilli and amaranthus by 25±5%. This is an exemplary model of circular economy as the waste of the leather industry serves as an organic fertilizer of the agricultural industry.
Leather industry wastes were converted into conducting nanocarbons for high-value applications. Most of the methods employ expensive precursors and stringent process conditions, which pose significant challenges for synthesis of nanocarbons. A simple high temperature treatment of pristine collagen wastes to yield conducting carbon nanostructures was developed by CSIR-CLRI. Nanocarbons derived from the raw trimming waste have a partially graphitized structure and are naturally doped with nitrogen and oxygen, resulting in multifunctional properties including electrical conductivity. Nanocarbon derived from leather wastes has potential for applications in battery, catalyst in fuel cells and EMI shielding. CSIR-CLRI made the first report on the synthesis of self-doped carbon nanostructure products from collagen wastes.
Healthcare
Collagen Surgical Sutures

Collagen being the strongest research points of CSIR-CLRI, has been explored for the development of healthcare products. Collagen extraction from mammalian intestine (cattle, goat, sheep) has been developed. Laboratory investigations like selection of raw material, preservation, cleaning, bleaching, tubing, sterilization was carried out thoroughly in order to prepare the catgut. The extracted collagen was tested for in vitro and in vivo studies. CSIR-CLRI developed a process for manufacture of absorbable sutures and marketed. The invention relates to suture material, essentially collagenous, useful for wound healing and internal as well as external surgical applications. The unique feature of the suture is that it exhibits tensile strength as high as 65 – 85 MPa that is retained for as long as six-month period.
Advanced Biomaterials for Wound Healing

Collagen based biomaterials are researched for drug delivery systems. Nanocomposites prepared using collagenous materials are used for skin, cardiac, bone and dental tissue regeneration. Extracellular matrix mimicking scaffolds were prepared by CSIR-CLRI for wound healing. Collagen in the form of sponge, sheet, powder and cream for sustained and targeted delivery of drugs/phytochemicals were evidenced by CSIR-CLRI. Collagen sheet incorporated with silver sulphadiazene loaded microspheres was transferred to Eucare Pharmaceutical Pvt. Ltd. The brands Kollagen, Neuskin and Seeskin are very familiar names in the wound care sector based on CSIR-CLRI licensed technologies. Some of the other products are available at lab scale and awaiting higher clinical trials.
High-value Collagenous Products from Raw Trimmings

A complete utilization of raw trimmings waste into pure collagen, high-grade gelatin and collagen hydrolysate has been developed by CSIR-CLRI. Holistic and a closed-loop process for the extraction of high-grade gelatin with the gel strength of >250 g, enabling the application of gelatin in food and pharmaceutical applications. Process demonstration for making Gelatin/Collagen hydrolysate was made at pilot scale level (TRL 7) for the developed technology, and it was exclusively licensed to M/s. Anigel Pvt. Ltd. A new Start-Up company M/s. Derma Proteins Pvt. Ltd. incubated at CSIR-CLRI for making collagen was created. The endeavor is made for value realization and employment creation through the “Startup India and Standup India” opportunity.
Demineralized Bone Matrix

Bovine femur/tibial bones were used for the preparation of demineralized bone matrix. Demineralization of bones were carried out using several sequential methods like removal of soft tissues, chemical and enzymatic defatting/degreasing etc. The demineralized bone pieces are pulverized and freeze dried. The lyophilized samples are stored at room temperature till further use. Demineralization was considered adequate when calcium content was less than 1%. This technology was transferred to several industries.
Galpro-cream: Collagen-based Cream for Burn Wound Management

Collagen based cream for burn wound management, infected wounds, oxidative stress in wounds has been developed by CSIR-CLRI with extremely potential properties comparable with commercial products available in the market. The prototype of the developed product is available for ready commercialization. It is an indigenous cost effective burn dressing material.
The role of Dermatopontin in wound repair was elucidated. It is proved that the high levels of proteases in Chronic Cutaneous Wounds (CCW) are responsible for the observed diminished levels of DPT in CCW, thus skewing the ECM balance and halting the healing trajectory. The influence of keloid collagen on the behaviour of fibroblasts with reference to cell adhesion, spreading and growth that translates the adhesion mediated signalling response in keloid pathogenesis has been demonstrated for the first time. Down regulation of antiangiogenic moiety endostatin (C-terminal end of Collagen XVIII) and upregulation of vascular endothelial growth factor in the tissue and sera of keloid patients disrupting the balance has been identified, which provides scope for keloid therapeutics.
Hybrid collagen scaffolds can be widely applied for burns and chronic wounds, and tissue engineering applications. It promotes rapid tissue regeneration and wound repair at the implanted site. In CSIR-CLRI, biomimetic hybrid collagen scaffolds with the combination of plant derived modified polysaccharides and bioactive molecules are prepared by a simple technique and it provides rapid tissue regeneration and wound repair at in vivo open excision wound model in Wistar albino rats. This lab scale accomplishment attracts healthcare and advanced wound care products industries.
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Global Outreach
Ministry of Trade and Industry (MoTI) of Federal Democratic Republic of Ethiopia (FDRE) had enrolled the services of the CSIR-CLRI by invitation for the Bench Marking Program aimed at the Technology Upgradation of Selected Seven Ethiopian tanneries. The Primary objective was to transform the Ethiopian Tanning Sector through capacity building to enable them to produce finished leathers for International Market by improving the efficiency and effectiveness of these units. A 4-party Agreement was signed among CSIR-CLRI, MoTI, MoCS and ELLPTI, Govt of Ethiopia on 21st January 2010 in Addis Ababa, Ethiopia. The then Director of CSIR-CLRI, Prof. Dr. A.B. Mandal, signed the agreement on behalf of CSIR-CLRI. The total cost of the project was US $ 0.5 million for a duration of 6 months. Team comprising 20 experts drawn from CSIR-CLRI and the Industry worked in the selected tanneries and made technological interventions. The progress of the project was monitored at the highest level in the Ministry of Industry and Trade and the reports on the Project submitted to the Prime Minister of Ethiopia. The project has successfully been completed and the success of this project fetched another similar project (Phase II) with a total cost of US$ 1 million for the benefit of a greater number of Ethiopian tanneries.
Twinning Programme for the Leather Industry Development Institute (LIDI), Ethiopia

The main objective of the Twinning programme is capacity building of the Leather Industry Development Institute (LIDI), Ethiopia leading to self-sustainability in terms of competence building in the areas of research & development, technical upgradation, creating and providing intellectual and skilled manpower to cater to the requirements of the industry, providing technical support in all the spheres of leather and leather product sectors, providing services to the industry such as testing, certification and establishing norms or standards, forecasting the global market dynamics and preparing the Ethiopian leather and leather products sectors to meet the changing requirements, creating functional tripartite linkage among the industry, R&D/laboratories and industry to start real time activities in research and training during the twinning period. The consultancy project has been commissioned with a total cost of US$ 5 million with involvement of more than 40 experts in the assignment over a period of three years starting from June 2011. Based on the success of the 1st phase twinning, second phase twinning was signed between the institutes on during May 2015 for a total cost of US$ 3 million.
Global Presence of CSIR-CLRI

The institute is turning into a global hub for leather S&T. CSIR-CLRI played significant role in the establishment of leather research institutes at Turkey, Iran, Nigeria and Sudan. Major technology dissemination and demonstration programs for Nepal, Sri Lanka and Bangladesh resulted in long term relationships. Today, the institute is the most sought-after organization for global benchmarking of the leather industry and also capacity building. The Twinning program that the institute is currently running with Leather Industry Development Institute of Ethiopia has led Ethiopia into a development path with leather as a major export earning for that nation. National Industrial Research & Development Agency (NIRDA) of Rwanda under the Indo – Rwanda Innovation Growth Programme signed the MoU in the presence of Prime Minister of India in July 2018 with CSIR-CLRI for collaborations in supporting the growth transformation of Leather Value Chain in Rwanda.
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75 STORIES OF CSIR CLRI

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Quality Assurance Systems
Eco-testing and Accreditation

CSIR-CLRI has established Centre for Analysis, Testing, Evaluation and Reporting Services (CATERS), a highly modernized and equipped laboratory to meet the industrial needs in the certification and testing of finished leather, leather products, leather chemicals, non-leather products, textile and footwear components to meet the various Eco regulations like Registration, Evaluation, Authorization and Restriction of Chemicals (REACH), Substance of Very High Concern (SVHC) and Zero Discharge of Hazardous Chemicals (ZDHC). The laboratory is capable of issuing REACH compliance certificate according to SVHC 223 list of chemicals. The laboratory has expertise to develop new test protocols to test these chemicals. CATERS is the designated laboratory for Finished Leather Certification (FLC) program under the provisions of DGFT norms under which the leathers are scrutinized for compliance before export. The laboratory is accredited by National Accreditation Board for Testing and Calibration Laboratories (NABL) for 257 test methods of ISO, IS and SATRA.
CSIR-CLRI has National Testing Facility (NTF), which provides advanced instrumentation services to researchers from colleges, universities, industries and research institutions to carry out their compound and material characterization. NTF @ CSIR-CLRI housed with more than 20 equipments and several advanced equipment like solution & solid state Nuclear Magnetic Resonance (NMR) Spectrometers, Electron Paramagnetic Resonance (EPR) spectrometer, Raman Spectrometer, Small Angle X-ray Scattering (SAXS), Liquid Chromatography Mass Spectrometer (LC-MS), etc. In continuation of adding advanced equipment to NTF, recently, CSIR-CLRI added high resolution electron microscope namely Field-Emission Scanning Electron Microscope (FESEM) and powder X-ray diffractometer (pXRD) to NTF, which provides greater opportunity for researchers to perform both fundamental and applied research.
Societal Outreach
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CSIR-CLRI strongly felt that the need of adequate information on tanning sector to come up with suitable intervention for sustainability & development of leather sector. CSIR-CLRI formed a survey team has been formed with a vision to carry out feasibility study, situational analysis, demand forecasting, employment pattern, production capacity and developing forecast models, development of Statistical model to predict trade forecast, market information report on tanning industry, leather footwear industry. Survey conducted National and International wide with the support of several leather sectors and the state Governments. From the survey, CSIR-CLRI team strongly believe that output and outcome of survey has the potential to address the challenges faced by tanning industry such as sourcing of raw materials, HRD, difficulty in exporting, and losses due to pandemic situation. These survey reports provide support for policy makers in decision making to provide appropriate schemes / programmes /recommendations for the development of tanning industry. Moreover, it provides additional inputs to the policy makers for preparation of various strategies/policies for the sustainability and development of Indian Leather Sector.
Skill Development Programs - Pan India

CSIR-CLRI attracted length and breadth of the globe for leather education and training programs especially Caribbean, South America, Africa, Middle East, South Asia and South East Asia. CSIR-CLRI has been in the forefront in devising novel training and skill development models to train manpower at the primary, secondary and tertiary levels. CSIR-CLRI also hosts executive training programs that belong to the advanced level of training. CSIR-CLRI has been instrumental in imparting skill training to more than 9000 artisans pan India till date in various leather trades sponsored by organizations like National Scheduled Castes Finance and Development Corporation (NSFDC) and Gujarat Rural Industries Marketing Corporation Limited (GRIMCO). CSIR-CLRI has successfully registered the Qualification Pack (QP) and National Occupational Standards (NOS) for its following Skill Development Programs (SDPs) – Diploma and short-term courses. CSIR-CLRI can now issue National Skill Development Corporation (NSDC)/ National Skill Development Agency (NSDA) accredited skill certificates to its trainees. CSIR-CLRI hosts a strong expertise in creation of an international skill ecosystem for the leather sector of the countries across the globe which has benefitted participants from over 27 countries. CSIR has brought all its skill initiatives under a single umbrella called as the CSIR Integrated Skill Initiative where CSIR-CLRI has become the model laboratory for skill development for all labs pan CSIR to stimulate the labs to work towards carving a skilling ecosystem integrating science and technology.
Photocatalysis is another area of research where important chemical transformations can be achieved in presence of a photocatalyst which can absorb solar energy. The examples include generations of hydrogen gas as green energy source by the photocatalytic splitting of water, photocatalytic degradation of polluting dyes etc. At CSIR-CLRI, research efforts have been directed towards development of photovoltaic devices or photocatalytic materials using polymeric substrates. We have synthesized various conjugated heterocyclic polymers in solution and immobilized to surfaces. Some of them have been used as donor materials in photovoltaic device fabrications. Various Fullerene-based materials have been functionalized with designer molecules in CSIR-CLRI for application as acceptors for photovoltaic devices and for photocatalysis. Very recently it was observed that the materials of photovoltaic devices can be used very effectively as reusable and recyclable photocatalytic surfaces under natural sunlight.
CSIR-CLRI's Journey from 75 to 80
Leather-like Materials: Much of Muchness

With the growing demand for leather and the cost associated with high quality leather, a number of materials have been made recently specifically from plant sources to resemble leathers for different applications. Vegan leather-like material is a new market-attractive product commercially made by several start-ups, although not much scientific literature is available. These are considered vegan alternatives owing to the use of natural fibres of plant origin. Some of the known materials in this category are paper, cork, waxed cotton, tree barks, apple peels, pineapple leaves, mushrooms, cactus and coffee plants. CSIR-CLRI has initiated an attempt to develop leather-like materials utilizing the plant wastes of agricultural industry for applications in lifestyle products. Efforts are made to develop hybrid sheet materials from various biological resources such as plants (agricultural wastes and cactus), fruits or vegetable wastes, fungi (mycelium/mushroom), bacteria and leather/textile wastes. Preliminary experiments conducted suggest the possibility of converting most of the selected agro wastes into a leather-like material, however, further process optimization and characterization of the materials are underway. The developed hybrid leather-like materials are expected to open up new avenues for Indian market in the area of sustainable leather-like materials from non-edible parts of plants.
Skin from Laboratory

Creating a power house of cell factory for production of bio-fabricated leather-like material from laboratory is a grand challenge. Recombinantly, a durable and flexible leather-like materials will be prepared by CSIR-CLRI as an alternative to animal rawhide and skin, with minimized pre and post tanning process. We will stabilize leather protein matrix through revitalize research to explore structural and molecular biology to create or mimic leather-like material from lab. This project is funded by CSIR under Focused Basic Research (FBR) Scheme.
Indian Foot Sizing System

CSIR-CLRI under the aegis of Department for Promotion of Industry and Internal Trade, Government of India, Ministry of Commerce to conduct a nationwide survey for reliable data on foot dimensions of the Indian population using 3D Digital Imaging technique to establish the Indian Footwear Sizing System. This Project is also known as the REVISION of NORMS of the IS 1638:1969 "Standard for Specification for Sizes and Fittings of Footwear". National Sample Survey Office (NSSO), Ministry of Statistics and Programme Implementation, Government of India has advised the ‘sampling locations for the foot measurement survey’ covering seventy-nine locations pan India with a total of 1,01,880 measurements in five zones. The 3D Foot Scanners (for Digital Image capture of the Feet) have been procured and hands-on training on the setting up of the equipment, calibration, image capture, file saving, checking of data coherence and data transfer has been completed for all team members across the country. To help in efficient data capture and analysis, the zones are further sub-divided into age and gender groups and the teams have been mandated to carry out foot measurement surveys at various locations in schools, colleges, factories and housing societies pan India. ‘Field work’ completed with 28 teams fanning out to the 79 locations identified pan India.
Metal-free and Deforestation-free Polymeric Tanning Agent

The tanning agent based on metals or plant polyphenols finds a prominent place in leather making and today 95-98% of the World’s leather production is based on metals/polyphenols-based tanning systems. However, the ecological concern and consumers’ awareness on metal toxicity and deforestation urge the leather fraternity to develop metal-free tanning agents. As per ISO definition, the total tanning metal content (Cr, Al, Zr, Fe and Ti) in metal-free leather should be less than or equal to 1000 ppm. Therefore, CSIR-CLRI strive towards developing metal-free and deforestation-free tanning agent with a focus on the selection of alternative elements that are safer and subsequently coupling with suitable polymeric matrix. Further, it is targeted to develop economically and commercially viable metal-free tanning agents with improved filling characteristics.
Precise self-assembly of collagen is a spontaneous, entropy-driven process, driven mainly by the molecular interactions of the residues in the X- and Y- positions. There is considerable concern and diversified hypothesis of collagen fibrillar formation. Our approach is to explore the fibrillar collagen through creating multiple variants with N- and C telopeptide, foldan and nucleation domain along with identical triple-helical sequence units, etc. We expect that mutual stagger of collagen domain sequence unit with N or C terminal or either termini or foldan variant region responsible for fibril formation in human collagen will be explored. This project is funded by CSIR under Fundamental and Innovative Research in Science of Tomorrow (FIRST) Scheme.
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