The Central Leather Research Institute (CLRI), Chennai, a constituent laboratory of the Council of Scientific & Industrial Research (CSIR), New Delhi with its range and depth of core competence, a strong and interactive clientele base and support of the user industry as well as the Government, has emerged as one of the most empowered leather research centres of the world. The R&D programmes of the Institute are grouped as core, critical and support areas. Core area programmes relate directly to leather activities. Critical area programmes of R&D pertain to such science and technology activities in which CLRI having gained critical strength and viability already enjoys a niche status. Support area programmes provide logical support to technology extension, planning and other business and management related processes. A matrix type management structure which enables networking across a wide area of disciplines and specialisation has been evolved. CLRI has been playing a direct role in education and training in leather and related technologies through its academic and vocational training activities. The Institute has staff strength of 575 spanning a wide range of disciplines. The Institute has made important contributions to the areas of leather process and product technologies; environment technology; chemical, biological & physical sciences; chemical engineering; computational sciences and leather economics. The budget for the Institute for 2001-2002 was Rs.1538.70 lakh and the External Cash Flow Rs.650 lakh. CLRI has been engaged actively in generation, development and extension of knowledge along with efforts to assist the emergence of a Knowledge Society of the Indian leather sector. Some of the important contributions of CLRI to the leather sector during 2001-2002 have been highlighted in this Annual Report.
<table>
<thead>
<tr>
<th>Contents</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Director’s Report</td>
<td>3</td>
</tr>
<tr>
<td>Leather Processing Technology</td>
<td>5</td>
</tr>
<tr>
<td>Leather Product Technology</td>
<td>9</td>
</tr>
<tr>
<td>Environment Technology</td>
<td>17</td>
</tr>
<tr>
<td>Chemical Sciences</td>
<td>21</td>
</tr>
<tr>
<td>Engineering for Modernization</td>
<td>29</td>
</tr>
<tr>
<td>Biological Sciences</td>
<td>33</td>
</tr>
<tr>
<td>Physical Sciences</td>
<td>39</td>
</tr>
<tr>
<td>Specialized Expert Services</td>
<td>43</td>
</tr>
<tr>
<td>National Level Planning for Leather Sector</td>
<td>47</td>
</tr>
<tr>
<td>Human Resource Development</td>
<td>51</td>
</tr>
<tr>
<td>Performance Appraisal</td>
<td>55</td>
</tr>
<tr>
<td>Extension Activities</td>
<td>59</td>
</tr>
<tr>
<td>Budget</td>
<td>63</td>
</tr>
<tr>
<td>Patents</td>
<td>64</td>
</tr>
<tr>
<td>Staff Position</td>
<td>64</td>
</tr>
<tr>
<td>Publications</td>
<td>65</td>
</tr>
</tbody>
</table>
Institute Councils

Research Council Members
January 2001 – December 2003

Dr S Ramachandran – Chairman
No.1, Playground View Road
Nandanam, Chennai - 600 035

Shri Irshad Mirza
Chairman, Council for Leather Exports
Mirza Tanners Ltd
14/16, Civil Lines, Kanpur - 208 001

Shri Nari Kalwani
Managing Director
M/s. Asian Leather Ltd
19-A, Jawaharlal Nehru Road
“Leslie House”, Calcutta - 700 087

Shri M Mohammed Hashim
M A Khizar Hussain & Co.
2, Hunters Road, Chennai - 600 112

Dr K Dharmalingam
Head, School of Biotechnology
Madurai Kamaraj University, Madurai - 625 021

Shri M S Srinivasan, IAS
Joint Secretary, Industry Policy & Promotion
Ministry of Industry, Udyog Bhawan
New Delhi - 110 001

Dr R N Singh
Director, National Environmental Engineering
Research Institute, Nehru Nagar
Nagpur - 440 020

Dr T Ramasami
Director, Central Leather Research Institute
Chennai - 600 020

Dr G Vijay Nair
Director Grade Scientist (DG’s Nominee)
Regional Research Laboratory
Industrial Estate P.P., Trivandrum - 695 019

Management Council Members
July 2001 – June 2003

Dr T Ramasami
Director, CLRI

Dr T Krishna Reddy
Scientist G, IICT, Hyderabad

Dr A B Mandal
Scientist F

Dr (Mrs) S Amba
Scientist E-II

Dr (Mrs) A Amudeshwari
Head PME, Scientist E-I

Dr B Chandrasekaran
Scientist E-I

Shri K Giriappa
Technical Officer C

Mrs Malathy Jawahar
Scientist C

Shri D Lakshmanan
Sr Finance & Accounts Officer

Mrs Rama Mahadev
Controller of Administration
निदेशक का प्रतिवेदन

केन्द्रीय चर्म अनुसंधान संस्थान (केलरी) आज राष्ट्रीय चर्म के क्षेत्र में केन्द्र बिनो दु मा निम्न रहा है।

चर्म क्षेत्र में चर्म प्रौद्योगिकी के नवीनताओं का पूर्णांक करते हुए चर्म उद्योग के समस्त संपत्तियों को वाली चुनिन्दों का समापन करने के लिए यह संस्थान सदृश तत्त्व रहता है।

वर्ष 2001-02 के दौरान यह संस्थान केन्द्रीय चर्म अनुसंधान संस्थान और चर्म उद्योग दोनों के लिए ही दस्तावेज़ योजना के कार्यक्रम की रूपरेखा तैयार करने में मुख्यतः कारतूत रहा है। चर्म क्षेत्र के लिए तैयार की गई भारत की दस्तावेज़ योजना का कार्यक्रम अपने आप में एक विशेष महत्त्व रखता है। वर्ष 2002-07 तक की अवधि हेतु भारतीय चर्म क्षेत्र के लिए तैयार की गई योजना, वृद्धि, आधुनिकीकरण एवं विस्तार, उत्पादन आयाम (Strengthening of the production base through Augmentation, Modernization and Expansion (SAME)) के द्वारा समर्थन प्रदान करने की ओर लक्षित है। इस योजना में किसी भी उद्योग के लिए एक योजनाबद्ध विकास पद्धति का सुझाव दिया गया है।

केन्द्रीय चर्म अनुसंधान संस्थान ने देश की महत्वपूर्ण आवश्यकताओं के अनुकूल अपने अनुसंधान एवं विकास कार्यक्रमों का प्रारंभ बनाया है। वर्ष 2001-02 की अवधि में कई महत्वपूर्ण उत्पादियों प्राप्त हुई हैं तथा चर्म अनुसंधान के क्षेत्र में कई सीमा हम निराशित किए ए रूप से हैं। चर्म प्रौद्योगिकी, चर्म प्रौद्योगिकी, चर्म उत्पाद, प्रौद्योगिकी चर्म विज्ञान प्रौद्योगिकी, चर्म विज्ञान में दिखा जोड़क का प्रशिक्षण एवं विकास के क्षेत्रों में प्रतिस्पर्धात्मक रूप में इन्हें ग्रहित किया गया है।

यह पद्धतियों का पूर्ण रूप से विलीन होना Total Desolve Solid (TDS) और "नई सहस्राब्दी" में चर्म के लिए वैज्ञानिक प्रौद्योगिकी भारतीय प्रौद्योगिकी एवं मॉडर्नीज (Shumarram) न्यु मिलेनियम इंडियन टेक्नोलॉजी लीडरशिप इंिआटिव (NMITLI) कार्यक्रम कार्यन्वित किया गया जिससे कि प्रतिस्पर्धात्मक स्थान ऊँचाई रख सके। स्थायित्व से बहुत की जैव प्रौद्योगिकी के क्षेत्र में परिवर्तन के लिए कुछ लक्ष्य निर्धारित किए जा रहे हैं।

वर्ष 2001-02 केन्द्रीय चर्म अनुसंधान संस्थान के लिए वैज्ञानिक और प्रौद्योगिकी के क्षेत्र में उपलब्धियों का वर्ष कहा जा सकता है। संस्थान द्वारा किया गया विश्लेषण कार्यों को लेने वाले उद्योगपति ग्राहकों की संख्या बढ़ अधिक आंकी गई है। कई उद्योगपति ग्राहकों की मांग को ध्यान में रखते हुए दृष्टिकोण के लिए ग्राहकों की गई है, जिसमें कुश्तवेद और चर्म घटनाओं एवं अनुसंधान एवं विकास कार्य के लिए नया लक्ष्य निर्धारित किया गया है।

संवार के समाधान और जीव विज्ञान के कुछ क्षेत्रों में राष्ट्रीय स्तर का कार्य किया है। ये उपलब्धियों इस संस्थान के प्रकाशित अनुसंधान पत्रों में देखी जा सकती है।

अभिवृत्तीय चर्म स्थायि संस्था के जरिए प्रकाशित अनुसंधान पत्रों के प्रकाशन का वीस प्रतिशत भाग इस संस्थान के अनुसंधान पत्रों का है। केन्द्रीय चर्म अनुसंधान संस्थान चर्म क्षेत्र के बीचक उत्पाद (Intellectual Products in Leather) के क्षेत्र में महत्वपूर्ण सफलता प्राप्त कर रहा है। वर्ष 2001-02 में चर्म के क्षेत्र में विश्व स्तर पर आगाजी होने के लिए यह संस्थान कई महत्वपूर्ण कदम उठा रहा है। यह संस्थान चर्म अनुसंधान में एकता के लिए कंटब्लाड है। केन्द्रीय चर्म अनुसंधान संस्थान भारत के जीवन में महत्वपूर्ण भूमिका के लिए स्थायि रहता है, योजनाएँ बनाता है और संपूर्ण चर्म क्षेत्र के विकास के लिए कार्य करता है। वर्ष 2002-07 के लिए दिशाएं निर्धारित कर ली गई हैं। मार्च महीने का माह का शुभारंभ हो गया है सफलताओं स्वरुप अभिवृत्त विकास होगी।
Director’s Report

THE Central Leather Research Institute has attained the role of a central hub of the National Leather Sector. The Institute forecasts the technology trends in leather sector and strives to provide the industry with an advanced strategy of preparedness for meeting the emerging challenges.

During 2001-02, CLRI has been engaged in preparation of the Tenth Plan programmes of the Institute and the industry. The Tenth Plan of India for the sub-sector of leather is a plan with a difference. The Plan of Indian leather sector for the period 2002-07 aims at Strengthening of the production base through Augmentation, Modernization and Expansion (SAME). Planned development of footwear industry has also been focused.

The Institute has designed its R&D programmes to suit the emerging needs of the country. During 2001-02, there have been many milestones. Several landmarks in leather research have been reached during 2001-02. R & D programmes in core areas of leather technology viz. leather processing, leather products, environmental technology, leather science and technology and education and training have included competitive and comparative elements. Issues like urgent solutions of Total Dissolved Solids (TDS) have been addressed on one hand and a New Millennium Indian Technology Leadership Initiative (NMITLI) for ‘Biotechnology for Leather’ launched on the other, to gain a pre-competitive edge. A paradigm-shift from chemical to bio processing of leather has been targeted.

The year 2001-02 has been productive both in terms of scientific and technological outputs and acknowledgement by way of recognitions. An outcome analysis of CLRI by a large stakeholder base revealed a favourable position enjoyed by the Institute among its stakeholders. A future trajectory for CLRI, including R & D efforts in non-leather footwear components has been selected based on the feedback from several stakeholders. The Institute has made important advancements in the areas of leather processing technology, shoe design and development, innovative leather products, environmental technology and modernization of tanneries. CLRI has attained critical strength and national visibility in some select areas of chemical and biological sciences. These are reflected in the high impact factors of publications of CLRI in these frontier areas.

The Institute has carved for itself a dominant position in the Journal of American Leather Chemists Association (JALCA) with a 20% share of papers published. CLRI has been moving towards a critical strength in generation of intellectual properties in leather. Several measures have been taken during 2001-02 to gain global leadership. The Institute strives for and seeks excellence in leather research. CLRI dreams for India, plans for India and acts for the Indian leather sector as a whole. A path for 2002-07 has been paved. The March has begun. Success will ensue.
Leather Processing Technology
Leather Processing Technology

Less Salt Curing System
A curing system based on salt, boric acid and biocide has been developed. The quantity of salt used is only 5% compared to 35-40% (on raw weight) employed in the conventional curing system. The process has been investigated using goat skins and is being field tested in one of the tanneries at Ambur, having linkages with primary raw skin collection centres in Mumbai.

Lime-Free Fibre Opening
A process for lime free fibre opening based on the use of a bio-product has been developed. The technology is applicable to all substrates viz. goat, sheep, cow and buffalo. Finished leathers processed through such fibre opening technique were found comparable with conventional leathers in all aspects. When coupled with lime free unhairing, this technology offers possibilities of direct pickling without resorting to deliming after fleshing.

Pickle Free Chrome Tanning
A process for pickle free chrome tanning has been developed through modifications of the process technologies. The technology is versatile as it is applicable to both hides and skins. The technology, while eliminating use of salt, ensures uniformity in uptake and distribution of chromium in the leathers. The elimination of salt does not affect either the physical or chemical characteristics of the finished leathers. The technology does not involve use of any special processing equipment or chemicals.

TDS Reduction through In-Plant Measures
Various in-plant measures such as desalting, enzyme assisted hairsaving and unhairing, recycling of lime liquor, recycling of washing (deliming) liquor, acetic acid pickling (for vegetable tanning) and pickle liquor recycling (for chrome tanning) have been studied for their effectiveness in the reduction of TDS. Generic options for TDS reduction have also been standardized. Potential for reduction of TDS through these measures has been quantified.
Reduction of Total Dissolved Solids (TDS) through In-Plant Measures in a Tannery Cluster

A time bound project for reduction of TDS in tanneries connected to the effluent treatment plant at Pernambut has been completed.

The process flow and sources of TDS in each tanning unit have been profiled.

The generic, in-plant measures for reduction of TDS have been developed and fine-tuned for implementation to suit the process and production system of the individual units.

The efficacy of the devised methods has been assessed from the quality of the final leathers as well as the level of reduction of TDS. The devised measures have been standardized and validated.

Following audit of the effluent treatment system improvements in the end-of-the-pipe system were devised.

A management protocol for the sustainability and continuous improvement has been developed and presented to the tanners.
Leather Product Technology
Leather products form the major foreign exchange earning component in leather trade. However, recent trends and emphasis on non-leather materials have necessitated exploration of novel leather based products that enhance the value realization from leather. One approach has been to develop value added products from low value/grade leathers as well as new materials from wastes of leather industry. Artwork has been chosen as the upgradation and value addition tool. Revival of traditional painting technique on leather has been made realistic. Technological interventions have been developed to ensure commercial viability. New market avenues for the innovative leather based materials are being sought.

**Products from Alternative Materials (Eco Concept)**

Chrome shavings considered pollutant generated from tanneries, have been converted into value added products using an economically viable technology.

The new parchment-like material developed has also been tested for its effectivity in the fabrication of a range of products. After a careful study of its surface characteristics, the choice of products narrowed down to lampshade, wall mounting, lantern, fancy lighting, table top display, novel greeting cards all of which have been finished with eye catching, hand painted exotic artwork designs that are concomitants of traditional leather puppets.

**Artwork on Leather: A New Approach**

Traditionally artwork is accomplished on paper, wood, textile and other special materials. Although artwork on leather was performed in earlier centuries, it has completely waned in recent times. Leather as a material has many utilities. However low quality leathers do not find many applications. An attempt has been made to revisit the lower grade leathers for improving not only the quality but also the value of the end product through upgradation of the lower grade leathers by the application of artwork. Low grade E1/Semi-chrome
crust leathers have been chosen as raw materials. Several artworks based on a variety of themes such as “Unity in Diversity”, “Revival of Nature”, “Mankind Under One Tree” have been developed. As an initial trial, the artworks have been performed using Indian ink by hand. Studies are being undertaken to commercialize the process, using screen printing technology. Efforts have been made to match the depth of the colour achieved in hand painting. Tests on fastness of the colour to light, wet and dry rubbing will be carried out. At present, these leathers are targeted for interior decoration such as wall panelling, wall leathers / interior leathers, theme photo for showcasing, place mats, tablecloth, spreads.

SHOE DESIGN & DEVELOPMENT CENTRE (SDDC)

Productivity Improvement using Simulation Techniques and Optimization (Quest)

An indigenous software tool “QUEST” has been developed. This software enables optimization of productivity in real life systems and can be used for
- Accurate 3-D Modeling of the factory layout and
- Simulation of the actual work

The parameters of reduction of manufacturing time, reduction of buffer time and changing orientation of machines are considered to balance the time for source and output in each and every machine. The software provides a tool to investigate each situation and helps reduce operation time by selection of a suitable layout.
3D Visualisation: A Biomechanical Approach

3D Visualization concepts in foot sizing and last modeling have been worked out. In this approach, there are six sub modules viz. Image Pre-processing (image filtering, noise removal, object enhancements); Pattern Extraction (fetch various parameters from different views, store the parameters in the database); Reference Frame Transformation (common reference frame, mapping of different frames on common); Last Creation Module (edge detection module, contour generator module, mapping of contours in 3D, general last creator from parameters and 3D contour, storage and retrieval of lasts into a database); Last Editing Module (heel-height and toe-spring modifications, toe modifications, profile generation, search function); CNC Interface (modifying/developing of system level device drivers for CNC milling machine used, controlling CNC machine via computer interface, mapping of virtual dimensions of the last onto physical dimensions).

The approach has included scanning of the foot images and creating foot envelopes for later conversion to a shoe last conforming to the derived dimensions of the foot. A hardware device to gather data and software to analyse and develop a last modeling routine form parts of this programme.

A foot scanning equipment has been designed. A device with 5 cameras for grabbing the images from 5 different orthographic views has been built.

The figure explains how images are taken and passed on to the multiplexer. Cameras are fixed in a pre-defined position. A glass is placed on the slot inside the box. This glass is used as a base on which the foot is placed. The cameras and LEDs are placed in such a way so as to reduce glare. The device enables integration of images collected from various angles through the use of a multiplexer. The device is under close evaluation. Software for the utilisation of grabbed images of foot in the design and modeling of last is under development.

A New Test to Determine the Variation of Surface Frictional Resistance of Leather at Different Extensions

Presently the frictional resistance of leather is determined by two methods, (i) ratio between horizontal force required to move the sample over a standard platform and the normal force applied on the
sample (ii) tangent of angle at which the sample slips on an inclined plane of a standard platform. Since no study is available about the variation of frictional resistance of leather when it is under extension, an attempt has been made to study the variation of frictional resistance of leather at different elongations.

To validate, a test was setup, and it has been observed that, the frictional resistance of leather slightly increases with the elongation. This is due to formation of minor cracks on the surface of leather. A new formula has been derived for the new device and is given as $\mu = (f_2-f_1)/f_1$, where $\mu =$ coefficient of friction, $f_1 =$ initial force, $f_2 =$ maximum force. The measurement is fully automated, and the standard deviation of error in the experiment is found to be $S = 0.44$. The coefficient of friction is found to be independent of the speed of the operating system. This new test method also determines the coefficient of friction for films or binders that are applied on the grain surface of the leather. This test, unique in determining the friction at different elongations may also be applied to find the coefficient of friction for polymers, biomaterials, by-products, laces, elastic materials, rubber materials, which should be coated on leather.

A Study on Fatigue Resistance of Various Press Buttons

Press buttons widely used in leather garments, leather goods and footwear, are metallic or plastic. Fatigue resistance is one of the important properties, which determines the durability of the press button. An experiment has been conducted to study the fatigue resistance of press buttons made of steel, brass, aluminium with sizes 7 x 7 mm, 5 x 5 mm, 3 x 3 mm, 2 x 2 mm for ring and spring structures.

Fatigue resistance of a press button is defined as the reduction in strength of opening the closed press buttons after a predefined number of opening and closing cycles. A device has been designed and fabricated in the laboratory to study the fatigue resistance of press buttons. The machine is operated at a speed of 60 ± 5 stokes/minute for opening and closing. The opening strength of the closed press button is determined by using the Universal Testing Machine at an operating speed of 50 mm/min. The relationship between the strength of opening the closed press button and the number of cycles for different press buttons is studied. From these studies, it is clear that the fatigue resistance decreases exponentially with the number of stressed periodic cycles. This decrease in opening strength of a closed press button is mainly due to abrasion of the button. From the curves generated, it is possible to standardize the number of cycles required to decrease the initial opening strength of a button by 10% or 20%, or 25% or any other value for different materials.
It has been observed that steel press buttons have very good fatigue resistance property as compared to brass and aluminium press buttons. It has also been observed that spring structure buttons are found to have better fatigue resistance property than the ring type structure buttons.

**Expansion of Activities**

At the invitation of the Sri Lankan - German private sector promotion project (PSP) a SDDC team visited Sri Lanka to assess the scope of CLRI's services to the footwear and leather sector in Sri Lanka and assist in setting up a training cum production centre.

The SDDC team had a meeting with the

- Industrial Development Board of Sri Lanka (IDB)
- Tertiary and Vocational Education Commission and the
- Ministry of Industrial Development

The team interacted and visited several small and medium scale companies in and around Colombo.

During the visit, PSP organized a workshop to inform the Sri Lankan leather industry about the range of services available from CLRI. Around 25 representatives of tanning, leather goods and footwear sector as well as the Ministry of Industrial Development and the Department of Tertiary and Vocational Training were present.

**Footprints: Shoe & Shoe Component Trends: Spring Summer 2003**

Footprints, the Shoe and Shoe Component Trends for the Spring Summer 2003 season was released on 2 February 2002 during the 17th India International Leather Fair (IILF) 2002. A new section “footnote” covering the various events in footwear and market reports was introduced.

**Showcase India: Theme pavilion at 17th IILF & 93rd GDS**

‘Showcase India’ is an effort to portray the “Best of India” at International Fairs and exhibitions through theme pavilions. Showcase India of the 17th IILF 2002 and the 93rd GDS featured

- Leathers/Colors for the Spring Summer 2003
- Leather & Material Trends for Autumn/Winter 02/03
- Shoes, Garments and Goods for Autumn/Winter 02/03

Trend presentations for the Spring Summer 2003 season covering

- Modeurop: Leather & Color Trends: Spring Summer 2003
- Footprints: Shoe & Shoe Component Trends: Spring Summer 2003
- Shoe Design & Retail Analysis: Autumn/Winter 02/03
- The Big Picture: Accessory Trends: Autumn/Winter 02/03

provided an informative visual feast.

**Design & Retail Analysis: Footwear Industries of America and Europe: A Statistical Analysis**

A snap shot of the market trends and significant changes in the
Footwear industry of America was presented on 1 February 2002 during the 17th IILF 2002. The presentation covered domestic production and imports of the U.S. non-rubber footwear industry during 1989-1999, consumption/retail markets and channels and segmentation, domestic production of footwear by product class, imports, price points.

Design & Retail Analysis Program (DRA) is a joint venture of CLRI & Indian Shoe Federation (ISF) under the aegis of National Leather Development Programme (NLDI) and supported by the Council for Leather Exports (CLE). DRA was launched in February 2001 during the India International Leather Fair 2001. The first edition addressed Spring Summer 2002 season and designs conceptualized and developed resulted in commercial interest at various International fora. The following reports have been prepared.

Revisit 2002: A snap shot guide to footwear retail trends, found very useful for manufacturers catering to niche fashion markets.

Return to Dressing up: A compilation of designs for SS 2002 developed using DRA inputs, which was a pride of the project.

While the first season addressed only men’s styles, the second season covered men’s, women’s, and children’s styles in the dress, casual and sportive categories. Yet another milestone was the compilation of the second volume of Revisit for Fall/Winter 2002/3, a Retail photo pack of designs.

Retail Flavours: Fall/Winter 2002/03

The inputs were collated and scientifically analyzed to help device a guideline for the Indian Footwear Manufacturers to forge the right combination of design, materials, components and construction to bring out the right product for the right market and season. These were further interpreted and categorized.

Dissemination to Industry

To disseminate the intelligence gathered and the scientifically analyzed and interpreted guidelines an outreach program was held at major footwear manufacturing centres of Agra, Delhi and Chennai. The seminars were very well attended by the top-notch footwear manufacturers of those regions.
Environment Technology
Environment Technology

New Approaches and Methodologies for Degradation and Utilization of Solid/Liquid Wastes towards Zero Discharge Concepts

Activated carbon is regarded as a porous non-sinterable matrix having widely separated energy gap. The application of activated carbon for catalytic oxidation and reduction of organics in wastewater is limited by the available electron in the conduction band. The flow of electron from valence band to conduction band is determined by the width of the energy gap. An attempt has been made to increase the Fermi level through doping of the activated carbon. The methodology for the measurement of fermi level in porous and non-sinterable matrix is reported to be nil. Hence, a new measuring device based on thermal and electrical conductivity was developed in this laboratory.

The doping of activated carbon is controlled by variables such as type of dopants used and the characteristic of the material. The characteristics of the material include the pore structure and its distribution. The distribution of the pores in the activated carbon is through proper heat treatment.

Heat treatment of carbon also brings about changes in the crystallites of the carbon matrix. One such phase with oxidation resistance up to 350-450°C was developed.

Development of Appropriate Technologies for Tannery Waste Treatment and Disposal

The treatment of post tanning effluents containing syntans, fat liquors, biocides, dyes, vegetable oils has become a major issue in leather industry.

The biodegradability study of post tonning leather auxiliaries has been investigated for phenolic syntan, acrylic syntan, melamine resin syntan, vegetable oil based tanning liquor and synthetic fat liquor, etc. The degradability of these chemicals in terms of COD and BOD, removal efficiencies has been studied.

Assessment was made of solid waste generation from Effluent Treatment Plants (ETPs) and other tanning clusters with a view to implementing biomethanation process for the treatment and disposal of solid wastes. Primary and secondary sludge samples were collected from various effluent treatment plants and characterized. Biomethanation studies were carried out for sludge samples with fleshing.

Studies on Liquefaction of Shavings for Biomethanation Using Bench Scale and Pilot Scale Reactor

Nearly 700,000 tonnes of hides and skins are processed every year.
Nearly 80% of them are processed as chrome tanned leather. Nearly 5600 tonnes of shavings are generated per annum.

Biological liquefaction of shavings was carried out by mixing treated wastewater from an Upflow Anaerobic Sludge Blanket (UASB) reactor. Shavings to wastewater proportion was optimized by mixing shavings with different proportions of anaerobically treated wastewater. Influence of pH on liquefaction was studied to determine optimum chrome precipitation. After separation of chromium, liquefied shavings was taken up for anaerobic biodegradation and biogas generation. Conversion of sulfate into sulfide, elemental sulphur and recovery through anaerobic route has been established for reduction of TDS. Anaerobic digestion of saline sludge and biomethanisation development has been taken up at laboratory and pilot scale.

Development of Appropriate Technologies for Biodegradation of Toxicants and Removal of Pathogens from the Wastewater

The main objective of the industrial/sewage treatment is that the treated wastewater should meet the prescribed Pollution Board standards depending upon the final mode of discharge. This includes mainly the removal of suspended solids, organic matter, nutrients and pathogens.

In order to treat the sewage and meet the standard prescribed for coliform bacteria in the treated effluent, various studies were carried out. The treatment formulation adopted for first phase in treating the sewage is UASB followed by 3 days stabilization pond.

For the purpose of determining the efficiency of organic pollutants and pathogens from wastewater, studies were carried out.
Development of New Mineral Tanning Agents

Chromium present in the residue generated by the chromite manufacturing process has been characterized. Speciation studies on the nature of chromium in the residue indicates the presence of about 8 - 9% chromium with about 15,000 - 18,000 ppm as extractable chromium (VI). While 10.5% of the total chromium was in the exchangeable phase, 3.7% was bound as carbonates 5.8% was reducible, 1.3% oxidisable and the remaining was residual chromium. Methods to recover chromium from such residues are currently being investigated. A sodium peroxide based oxidative extraction was found to enable the recovery of more than 90% of chromium present in the residue.

A non-lime opening up method based on sodium hydroxide has been developed. An optimum concentration of sodium hydroxide has been established for optimal opening up of fibre bundles. This has been substantiated through scanning electron microscopic, spent alkali liquor and pelt analysis, softness measurements and stratigraphic chrome distribution analysis. Physical and hand evaluation have shown the performance of the leathers are on par with conventionally treated leathers. The process also eliminates deliming process coupled with a 45% reduction in total solids load on environment.

A novel chromium-silica-based tanning agent has been prepared in the laboratory. The application studies showed that the leathers had acceptable shrinkage temperature and improved softness and fluffiness.

An eco-friendly synthetic chrome-tanning agent has been prepared for application at delimed stage without using formaldehyde. Among the three developed products, the syntan prepared using pre-made Basic Chromium Sulfate (BCS) powder and sulphonated aromatic hydrocarbon along with masking agents has been thoroughly studied for its technical applications, economic viability and environmental friendliness. The product has been upscaled to 100kg level. It is being evaluated commercially. The use of chrome shavings for the manufacture of BCS has been demonstrated.

Highlights of R & D in Industrial Chemistry

Synthesis and characterization of biodegradable copolymers based on ketals and acetals and distyryl ketone based copolymer for photoresist as well as crosslinking agent for making solid polymer supports for peptide synthesis has been carried out.

Emulsion terpolymer solutions of n-butyl acrylate (BA), styrene (STY) and methacrylic acid (MAA) were prepared at temperature 70°C by employing n-pentanol/n-butyl cellosolve as cosurfactant along with Sodium Lauryl Sulfate (SLS) as surfactant. Potassium persulfate was used as a free radical initiator in these experiments. These terpolymers were employed as retanning agents in retanning wet blue cow hides. The products showed better performance in retanning chrome tanned cow hides.

The terpolymer emulsions of methyl acrylate (MA), n-butyl acrylate (BA) and acrylonitrile (AN) were made as medium soft binders (MSB), and the finishing applications were carried out on fullchrome and semichrome leathers. The visual assessment and physical testing were carried out on these finished leathers. The physical properties such as...
grain crack strength, tensile strength and tear strength show better performance compared to commercial resin (acrylic) binders.

Polymeric drug conjugates based on vinyl type and maleimide derivatives for in vitro antimicrobial activity and controlled drug release analysis, synthesis and characterization of new tetra functional epoxy resins, novel biodegradable ester-amides copolymers for leather applications, microbial degradation of polymers, binding of cholesterol by an allosteric receptor-cyclodextrin dimer with crown ether link have been studied.

Comb like polymeric amphiphiles providing control over energetic and structural modifications at interfaces and exhibiting solution structures varying from ionomer to polyelectrolytes have been synthesized and characterized.

Lubricants based on lipoprotein derivatives have been developed for impregnating and imparting water repellancy in garment and sophisticated leather.

**Synthesis of Phenanthridines**

The synthesis of phenanthridine derivatives by imino Diels-Alder reaction of Schiff's bases with dienes catalysed by indium trichloride has been initiated. Phenanthridine derivatives possess a wide range of biological activities such as non-steroidal inhibitors for steroid 5-reductase. Synthesis of novel cyclic compounds with potential antifungal properties has been undertaken.

**Development of Syntans from Vegetable Tannins**

Studies on the reaction of compounds like gallic acid, ellagic acid, catechin, plant polyphenols, phenol and naphthalene sulphonic acids with glyoxal were taken up and the optimization of the reaction conditions is under standardization for the production of syntans based on vegetable tannins as raw materials.

Studies are being continued to develop a suitable methodology to prevent development of intense colours in vegetable tannin infusions and vegetable tanned leather. The nature of compounds formed during auto oxidation of di, tri-hydroxy phenols and vegetable tannin precursors like flavan-3-ols and flavan-3,4-diols after exposure to atmosphere, sunlight and UV rays is under investigation.

Studies on the isolation and characterisation/preparation of value added fine chemicals like gums, dyes, pigments etc., from tanniferous plants have been initiated.

**Thermal Degradation Processes in Polysulfide Copolymers Investigated by Direct Pyrolysis Mass Spectrometry and Flash Pyrolysis-Gas Chromatography/Mass Spectrometry**

Random block polysulfide copolymers with varying number of repeating units in the copolymer backbone have been studied by direct pyrolysis mass spectrometry (DPMS), and pyrolysis-gas chromatography/mass spectrometry (Py-GC/MS). The homopolymers such as poly (ethylene sulfide) (PES), poly (styrene sulfide) (PSS), and two random copolymers viz. poly (ethylene sulfide-co-styrene sulfidey) [copolymer I (x = y = 0.5), copolymer II \((x = 0.74, y = 0.26)\)] were investigated by both DPMS, and Py-GC/MS techniques. In the case of copolymer I, the thermal degradation products of SE \(_1\), SE \(_2\), S \(_2\), and S \(_2\)E (S-styrene sulfide, E-ethylene sulfide) were detected in DPMS, whereas the formation of SE \(_2\) and SE \(_2\)E were observed by Py-GC/MS technique. But for copolymer II, SE \(_3\) was also found along with SE \(_1\), SE \(_2\), S \(_2\), and S \(_2\)E in DPMS. The formation of additional product (SE \(_3\)) observed in copolymer II has been attributed to an increase in the block length formed during copolymerization. Further, a comparative study on thermal degradation of PES, poly (ethylene disulfide) (PEDS), and poly (ethylene tetrasulfide) (PETS) were investigated by Py-GC/MS. The pyrolysis products detected by both DPMS and Py-GC/MS indicate that the thermal decomposition of these polymers yield cyclic sulfides through an intramolecular
exchange or by backbiting processes and the same is presented in Scheme 1. The linear products with thiol, and vinyl groups were also observed by Py-GC/MS along with the cyclic products via carbon hydrogen transfer reaction. The formation of heterocyclic compounds during thermal degradation is illustrated in Scheme 1b-1c.

**Novel Stimuli Responsive Polymers**

Azobenzene is a well-known photoresponsive chromophore and its photoinduced and thermal geometric isomerizations are accompanied by changes in physical properties. When incorporated as a photosensitive chromophore in the backbone of polymer chains, photoresponsive polymers are obtained. Photochromic poly (acylssemi-carbazides) have been synthesized by (i) reacting azobenzene containing diisocyanates with dihydrazides (ii) reacting azobenzene containing dihydrazide with various diisocyanates and poly (urethane acylsemi-carbazides) by (i) chain extending the azobenzene containing NCO terminated prepolymers with dihydrazides (ii) chain extending NCO terminated prepolymers with azobenzene containing dihydrazides. Both the unsegmented and segmented polymers exhibited photochromic behavior, studied with UV-vis spectrophotometer. A decrease in absorbance due to the $\pi \rightarrow \pi^*$ transition of the trans form and increase in absorption maximum due to the $n \rightarrow \pi^*$ transition of the cis form upon irradiation of solutions of the polymers in N,N'-dimethylacetamide with UV light was observed. Such stimuli responsive polymers have potential industrial applications.

**Synthesis and Characterization of Segmented Liquid Crystalline Polyurethanes**

A series of segmented polyurethanes of varying content of mesogenic unit were synthesized from the polyols (polyether / polyester type polyol) of various molecular weights, aliphatic and aromatic diisocyanates and 6 spacer high aspect ratio mesogenic diol as chain extender. The molar ratio of the diisocyanate to the dihydroxy compound was maintained at 1:1. The molar ratio of the diisocyanate was kept constant while that of the dihydroxy compound
(polyol / mesogenic diol) was varied. The content of the mesogenic unit in the polyurethanes was varied from 20-50 mol % in order to establish the minimum amount of mesogenic unit required to exhibit liquid crystalline property. The effect of the mesogen content, soft segment and diisocyanate on the LC properties was studied. The effect of partial replacement of the mesogenic unit by the polyol influenced the liquid crystalline properties of the polymers and the occurrence of the mesophase textures. In the polyester urethanes 20 mol% mesogen content was sufficient to impart LC properties while in the polyether urethanes, the mesogen content varied with the soft segment length. Grain and thread textures were observed depending on the molecular weight of the polyol, the mesogen content and the diisocyanate. Elastomic property could be studied only in the high molecular weight polyether based polyurethane.

Metal Induced Structural Changes in Macromolecules and Composite Materials

Chromium induced tyrosine phosphorylation in lymphocyte cell culture system followed by activation of pro-apoptotic signals viz. p56lck, p59fyn and p53/56lyn have been demonstrated in the presence of chromium (III), chromium (V) and chromium (VI). Expression of lymphocyte specific protein tyrosine kinases has been found to be time and concentration dependent. Activation of these kinases was blocked when lymphocytes were pretreated with kinase inhibitors.

Collagen like 9-mer peptide sequence was built by imposing the φ and ψ using the Ramachandran plot for collagen. Studies on the interaction of collagen-like peptides with various constituents of vegetable tannins were carried out. Most of these complexes exhibited hydrogen bonds between the collagen like peptide sequence and the polyphenolic molecules. Hydrogen bonded energies were found to be in the range of 6 – 15 kcal/mol.

Factors controlling reactivity of metal ions and the role of ligand environment on reactions of base metal complexes have been investigated.

Among the three chromium (III) complexes, \([Cr(salen)(H_2O)_2](ClO_4)_2\), \([Cr(EDTA)(H_2O)]Na\) and \([Cr(en)_3]Cl_3\), \([Cr(en)_3]Cl_3\) were found to induce structural transitions on interaction with pig gastric mucin from a native random coil to α-helix.

\([Cr(naphen)(H_2O)_2]^+\), \([Cr(dpzp)2Cl_2]^+\), \([Cr(bzimy)_2]^+\) have been synthesized and characterized and their interactions with DNA studied. The first two compounds bound with DNA through an intercalative mode while the third did bind through groove binding.

Studies on monolayers of novel amphiphilic Schiff bases, mixed monolayers of long chain alcohols and amines with novel ionomers have been carried out. These studies addressed basic issues of molecular organization in two dimensions and served to initiate design of new materials at interfaces.

The evidence of micelle formation of hydantoin drug, 5'- (α - Acetamido - α - benzyl) - 5'-methyl imidazolidine - 2, 4- dione and a bis-amide compound has been explored in aqueous and non-
aqueous media using UV-visible and fluorescence spectroscopic techniques. The aggregation numbers with the help of steady state and time resolved fluorescence spectroscopic techniques has been evaluated. Two-dimensional surface properties of the hydantoin and bis-amide have been investigated using a Langmuir Film Balance. Surface areas have been computed theoretically using a new Connolly method. Poly ethylene glycol based (PEG-PPG-PEG) triblock copolymers (Mol. wt = 1100 and 4400) have been characterized in the presence and absence of Sodium Dodecyl Sulfate (SDS) micelles using fluorescence and NMR spectroscopic methods. Transport studies have been performed in order to find out the hydrated volume of the copolymer micelles in the presence and absence of SDS. To explore the surface chemistry of these pluronics, monolayer experiments have also been carried out at the air / water interface. It has been planned to study the interaction of these triblock pluronics with peptides to establish the thermodynamic aspects of mixed systems. Monolayer experiments have been conducted on Poly (Styrene- co-Maleic anhydride) in the presence and absence of cetyl ester of maleic anhydride at different temperatures. Also, surface characteristics of fluoroacrylate compounds have been explored and it was observed that they showed monolayer properties with low surface pressure. In order to enhance the surface properties of fluoroacrylate compounds, they have been interacted with stearic acid. The objective was to investigate whether they have been incorporated in to the stearic acid matrix or not. It is believed, the enhancement of surface properties such as hydrophobicity, wetting and adhesive can be achieved by studying the effect of stearic acid with fluoro compounds.
Engineering for Modernization
Engineering for Modernization

In continuous pursuit of modernization of leather manufacturing process, several new techniques and methods have been evolved, bringing innovations in process and its conditions. Some of the achievements are listed below:

**Diffusion, Kinetics and Transport Phenomena in Leather Processing**

Application of Power Ultrasound to Tannery Process

**Leather Dyeing:** Preliminary cost analysis for the ultrasonic aided dyeing of wet blue leathers directly in the ultrasonic tank has shown that the savings in dye due to the use of ultrasound can compensate ultrasonic energy cost. Diffusion coefficient has been calculated for the optimum output power, 80 W with ultrasonic probe under given process conditions.

**Fatliquoring:** Experiments in fatliquoring have been carried out with ultrasound and compared with the control process. Presonication of vegetable fatliquor helps to get finer emulsion and better fat uptake. The strength properties of the final leather assessed and found to be improved for leathers fatliquored in presence of ultrasound.

**Extraction of Vegetable Tannin:** Ultrasound is employed to improve the efficiency of the solid-liquid tannin extraction process. There is a significant improvement in the amount of extract obtained due to the application of power ultrasound.

**Chrome Recovery Process:** Studies on the application of ultrasound in chrome recovery process using alkalis such as magnesium oxide showed that presonication of MgO slurry before mixing with spent chrome liquor helps to form more compact chromic hydroxide precipitate.

**Scale up and Process Development**

**Removal of Aroma from Activated Carbon**

Lab and bench scale trials for the extraction of aroma from activated carbon were tried at 5g and 40g levels. Hexane, 2-propanol / dichlormethane were used as solvents for extraction at 40-60°C depending upon the solvent's boiling point. Finally, the solvent was distilled off to obtain concentrated aroma.

**Preparation of Trichloro Acetic Acid from Acetic Acid**

Using acetic acid as the base material, chlorine was used to make trichloroacetic acid in the presence of a mixture of catalysts. A series of experiments were conducted at lab and bench-scale levels to standardize the process. The product level varied from 500g to 3kg.
Rationalization of Tannery Processes

*Clari Processor*

The prototype of a novel tanning drum has been fabricated. Its advantages reduction in time, saving in energy, water and chemicals for processing leather without affecting the quality of leather have been demonstrated. Efforts are on for commercialization of the processor design.

Standardization of Control & Processing System in Tannery Modernization Scheme

A project report on Continuous Chrome Treatment and Recovery System (Common Facility) at Kanpur has been prepared for the Central Pollution Control Board. This facility is expected to reduce the chrome content in the final treated effluent of the CETP in the Jajmau area of Kanpur.

Tannery Modernization Scheme

CLRI is represented as a technical member of Steering Committee for the Tannery Modernization Scheme. A revisit of the tannery modernization scheme has been prepared and submitted to Government of India.

Kolkata Leather Complex

Standard layout models for three typical tannery capacities of 1000-1500 kg/day, 2000-3000 kg/day and 7500-10000 kg/day of hides and skins were developed. A strategic plan has been developed for relocation of tanneries and presented to the tanners. The need for implementation of cleaner tanning technologies in the existing location as well as in the relocated site was explained and a large number of tanners have been enrolled into the programme.
Biological Sciences
Role of Extra Cellular Matrix Proteins (ECM) in the Regulation of Collagen Synthesis by Ito Cells in Liver Fibrosis

In liver fibrosis, the quiescent Ito cells undergo activation and transform into myofibroblast-like cells, which synthesize the excess ECM proteins. In the present study, Ito cells were isolated by the Portal Vein Perfusion method and characterized by the inherent autofluorescence and staining for Desmin and α-smooth muscle actin (α-SMA). Cell associated collagen was characterized qualitatively by immunofluorescence with type specific antibodies. Lipocytes bound themselves to antibodies to collagen types I, III, IV and smaller quantities of laminin but not to Type V collagen. Secretory collagen was quantitated by immuno-precipitation and ELISA. In the culture medium the major amount of collagen was Type III collagen and moderate intracellular Type III collagen staining and modest intracellular type IV collagen staining and weak laminin staining. On a Type IV collagen matrix, there were moderate intracellular staining of Types III and I collagen and weak laminin staining. Fibronecctin staining was also prominent. There was no Type V collagen detected.

Hepatoprotective Effect of Alcohol Extract of *Garcinia indica* in CCl$_4$ Induced Liver Fibrosis

It has been demonstrated that collagen plays a central role in fibrotic processes. An active association of free radicals and lipid peroxidation in tissue injury and fibrogenesis in fibrotic conditions suggests that as arteriosclerosis, fibrosis is also characterized as a disease of oxidative stress. The use of anti-inflammatory compounds and anti-oxidants as antifibrotic agents is suggestive of inhibiting collagen deposition in fibrosis. *Garcinia indica* has been acclaimed as a source of antioxidant and antiulcerogenic biomolecules.

The protective effect of *Garcinia indica* was evaluated against CCl$_4$ hepatotoxicity and the fibrosis induced therein. The profile of liver enzymes was assayed in serum. The activities of Alkaline Phosphatase (ALP), Gamma-Glutamyl Transpeptidase (GGTP), Glutamic Pyruvic Transaminase (GPT) Glutamic Oxaloacetate Transaminase (GOT) and Glucose-6-phosphatase (G6Pase) and bilirubin content were determined in serum. Lipid peroxidation and triglycerides (TG) contents were also measured in liver homogenates. Liver cirrhosis was evidenced by significant increase in liver collagen, lipid peroxidation, serum activities of alkaline phosphatase, GGTP, GPT, GOT, G6Pase, bilirubin content and liver triglycerides. Co-treatment with the alcohol
extract of the rind of the fruit partially prevented all the changes observed in CCl₄ cirrhotic rats. A significant reduction in the liver collagen content was also observed.

**Efficacy of Acalypha indica on Dermal Wound Healing in Rats**

The effect of plant products in wound healing has been investigated. The influence of Acalypha indica on skin wound healing was studied in rats. Full thickness excision wounds were made on the back of rats and Acalypha indica extract was administered orally and topically. The granulation tissue formed was used to estimate collagen, hexosamine, protein and DNA. The extract increased cellular proliferation and collagen synthesis at the wound site, as evidenced by increase in DNA, total protein and collagen content of granulation tissues. Quicker and better maturation and cross linking of collagen was observed in the extracts of treated rats, as shown by the high stability of acid soluble collagen and increase in aldehyde content and tensile strength. The extract treated wounds were found to epithelialise faster by a factor of 25% and the rate of contraction was higher as compared to the control wounds. The tensile strength of the wounds increased by 40% in topically treated wounds. The results substantiate that Acalypha indica produced beneficial effects on the various phases of wound repair.

**Molecular Mechanisms in Abnormal Wound Healing**

The differential regulation of keloid fibroblasts to growth factors viz., Epidermal growth factor (EGF) and platelet Derived Growth Factor (PDGF) in comparison with normal skin fibroblasts has been investigated in detail. PDGF induced cell migration and proliferation in keloid fibroblasts remarkably when compared to EGF. The expression of phospho ERK -MAP kinase in the signal transduction pathway showed variation by induction with growth factors. This study is expected to be of great importance in designing therapeutic interaction in abnormal healing situation.

**Healing of Infected Wounds**

Bovine type I collagen was succinylated and characterized. Succinylated collagen was converted into bilayer dressing. The bilayer dressing containing antibiotics like ciprofloxacin or cephalexin was tested in vitro against microorganisms. The microorganism selected for the study included Pseudomonas aeruginosa, strep.pyogenes and stap.aureus. The sensitivity of these organisms was tested using 25 drugs and it was found that ciprofloxacin has a broad range of antigenicity towards gram positive and gram negative organisms.

**Studies on Chronic Foot Ulcers in Diabetic Patients**

The factors modulating healing of foot ulcers of different severity were investigated with respect to the expression of Matrix Metallo Proteinases (MMPs) and lipid peroxidation. Increased free radical damage and over expression of MMPs in foot ulcers were proposed as causative factors for this pathogenesis in wound healing.
Evaluation of Active Proteins/Peptide Efficiency on Hair Growth

The protein/peptides (14 samples) received from a private firm have been evaluated for their potential for hair growth in in vitro and in vivo models. Albino rats were used as in vivo models for:
- Morphological observation of hair growth
- % hair population density
- Hair length measurements and
- Histological studies for Anagen/Telogen ratio

In vitro assessment was made on isolated hair follicles from rat neonates. Three formulations of the given 14 samples were found to promote hair growth.

Development of Animal Models for Alzheimer's Disease

A new animal model to study acute phase reactions in the brain has been established. Chronic systemic amyloidosis leads to neurological condition similar to Alzheimer's disease. It has been established that the liver metabolic damage could lead to crossing of Blood Brain Barrier by acute phase reactants like SAA and SAP proteins. These proteins aggregate to form non proteolytic fibrils in the brain. For the first time it has been established that enhanced levels of the GLN, GLU and GABA could be used as an index for the inflammatory condition in the brain.

Development of Peptide Incorporated Collagen Tubules for Nerve Regeneration

Cell growth promoting peptides incorporated collagen tubules for peripheral nerve regeneration have been developed and studied with the help of rat sciatic nerve model. This is a non-invasive method wherein a large number of collagen tubules can be prepared under sterile conditions. Apart from using as bridging graft for regenerating nerves, these tubules can also be used as implants for controlled release of drugs and as a supporting material for blood vessels as they allow the permeability of molecules like glucose and small molecular weight proteins and restrict the passage of heavy molecular weight substances like blue dextran.

Crosslinking of Collagen Sheet with Glutaraldehyde (GTA)

In vitro studies were undertaken to find out toxicity limits for the usage of GTA as a cross-linking agent and an analytical method to find out the free GTA. It was found that GTA content in RCS was between 1.5 and 2.00 ppm within the safe limit of toxicity. Presence of minute amount of bound or even residual glutaraldehyde in the collagen prosthesis is considered beneficial. It has been well documented that glutaraldehyde is a powerful anti-microbial agent and serves therefore as a disinfectant and sterilant. It also has anti-fungal and anti-viral properties. These cytotoxic or bactericidal effects are manifest at concentrations of glutaraldehyde higher than 20 ppm.

Enzymes in Leather Processing

An alkaline protease produced during microbial hydrolysis of chrome shavings was isolated and purified to homogeneity by ion exchange and gel filtration chromatography. The biochemical properties are being characterized to optimally use the enzyme in leather processing.

Biomaterial Testing

A low cost indigenous apparatus/equipment to eliminate user dependency in measuring viscosity of different liquids has been developed. A new design has been conceived and fabricated for measuring the flow time in an Oswald viscometer with a high degree of accuracy and reproducibility using light sensors with display of time in seconds. This has also been interfaced with a computer.

Attempts were made to capture the variations in the biaxial stress-strain behaviour using a gridded sample by video monitoring the process of tensile fracture. Design and development of a two dimensional creep tester has also been carried out.
Biophysical Studies on Collagen

Three amino acids with aromatic side chains are fluorescent (1) tryptophan, (2) tyrosine and (3) phenylalanine. In the amino acid sequence of collagen there are only a few amounts of tyrosine residue (3 per molecule). In extremely dilute solutions triple helices are destroyed to produce random coils that are isolated by a large amount of water molecules, making it very hard for tyrosine to encounter. The quantum yield of phenylalanine is relatively low compared with that of tyrosine. The photo irradiation is a prerequisite for the tyrosine formation in collagen. Conformational changes can be observed when collagen solution is subjected to brief ultraviolet irradiation. Knowledge of the conformational change and dose effect of UV irradiation is important for biomedical and consumer application. Hence, the effect of UV irradiation on the conformational stability of purified collagen solution has been studied using fluorescence spectroscopy.

Urea induced unfolding of collagen solution is monitored by circular dichroism. The decrease in [θ]_222 (up to a critical concentration) indicates that the monomeric collagen treated with urea undergoes a cooperative unfolding transition that results in the loss of secondary structure. This transition is monitored by CD spectroscopy. The structural study of the denatured state of collagen at higher concentrations of denaturants has been limited partly because most of the proteins are folded or precipitated in such extreme denaturing conditions.

Comparative studies on the structure of rat tail tendon collagen and elastoidin spicules were carried out using Transmission Electron Microscopy (TEM) and Atomic Force Microscopy (AFM). Elastoidin is a fibrous and unusual type of intracellular structural protein that includes major collagen and minor non-collagenous proteins. Dorsal fin rays of unidentified shark species were used as source of elastoidin. Rat tail tendon collagen (RTTC) obtained from an Albino white rat and elastoidin spicules (ES) were negatively stained with aqueous phosphotungstic acid (PTA), pH 7 and examined in TEM. The unstained specimens of RTTC and ES were examined using AFM. The results demonstrate that the characteristic repeat banding pattern of RTTC observed in TEM was different from that of the repeat banding pattern of ES observed in TEM. The so-called single wet elastoidin fibre teased out from dorsal fins of a shark showed a number of microfilaments having 1440 – 1470 nm dia. with smooth and featureless surface morphology, whereas dry ES showed an aggregated appearance of these microfilaments with roughened surface features. AFM of tendon collagen fibril showed characteristic grooves and ridges, whereas, such ridges and grooves were not obtained in the case of elastoidin fibrils. This suggests that elastoidin fibre morphology has to be reinvestigated by removing non-collagenous materials from it. Surface morphology of reconstituted elastoidin is under investigation.
Physical Sciences
Physical Sciences

Electron Paramagnetic Resonance Imaging
An attempt has been made to image tanned leather treated with Chromium. Some preliminary studies have been carried out with Cr (V) hmbo complex smeared over the leather surface. Distribution of Cr (V) on leather with stable Cr (V) complexes like Cr (V) hmbo and Cr (V) ehba has been mapped in 2D EPR imaging. In this connection a basic design of Microwave Bridge Translation Module to facilitate linear movement in either X or Y direction has been proposed. This will enable 2D & 3D EPR imaging with ease. The basic module has been designed. This is one of the first translation modules designed and fabricated in the area of EPR Imaging.

Quantum Computation
The possibility of quantum computation with ensembles in pseudo pure states or even thermal states has been demonstrated in spin systems involving spin-1 nuclei. Specifically, the Deutsch-Jozsa algorithm has been implemented on a $^{13}$C-$^2$H coupled spin ensemble in solution state, as well as on an ensemble of deuterons in a lyotropic liquid crystalline phase with low order parameter. Cartesian operator calculations of the density matrix description of the experiment as well as experimental verifications on these model systems using a Bruker MSL 300 P NMR Spectrometer have been carried out.

Solid State CP/MAS Spectroscopy
Recently, solid state CP/MAS accessory has been installed for the MSL 300P multipurpose NMR spectrometer. As part of the activities, Solid State $^1$H, $^{31}$P and $^{13}$C measurement are being carried out periodically. In this connection, $^{13}$C CP/MAS has been used to investigate the miscibility and phase structures of melt blends. The melt blends of thermoplastic polyurethane (TPU) / polystyrene-co-acrylonitrile (SAN) of various compositions have been prepared by a two-roll mill at 220°C. $^{13}$C CPMAS at room temperature established the specific interaction responsible for the miscibility in the multi component polymer blends and the structure of the phase separated polymers. The blend ratio of TPU/SAN (70:30) showed miscibility as a consequence of hydrogen bonding and the carbonyl carbon appeared broad and shifted.

Solid State Stray-Field Imaging
Solid State Stray-Field imaging is one of the potential tools to map spatial distribution of various nuclei in rigid solids. So far proton ($^1$H) Stray Field imaging is relatively well known even though other nuclei are equally important. There are a few nuclei other than protons, viz., $^7$Li and $^{11}$B that have been investigated occasionally by Stray Field
imaging. The gyromagnetic ratios \( \gamma \)'s of the above nuclei are different from each other and also from the \( \gamma \)'s of proton and fluorine. Therefore imaging of the above nuclei does not place critical demands on isotope discrimination capability in the stray field. In case of \( ^{19}\text{F} \) and \( ^{1}\text{H} \), however, the \( \gamma \) values are close and as a result the resonance frequencies get perilously close to each other, especially at the relatively low fields that are typical at the magnet fringe. For selective detection of \( ^{19}\text{F} \) signals, static surface coil system has been adopted and designed. The main objective of the static resonator design, i.e., selective detection of \( ^{19}\text{F} \), is clearly accomplished. With this STRAFI static resonator simultaneous as well as selective imaging of \( ^{1}\text{H} \) and \( ^{19}\text{F} \) nuclei is possible.

**Micro-Imaging**

Preliminary micro-imaging studies on the embryonic growth cycle of a reptile egg have been attempted using single slice spin echo sequence. 1D spectrum of a wolf snake egg is also being measured with Bruker MSL 300 P Spectrometer.
Specialized Expert Services
Carcinogenic arylamines are used in large volumes to produce dyes and pigments. However, it is very relevant to identify the hazardous arylamine isomers from eco benign species so that the products based on carcinogenic species can be kept out of usage. Identification of carcinogenic isomers of arylamines employing Miceller Electro Kinetic Chromatography (MEKC), a mode of capillary electrophoresis, was taken up as it offered better scope for separation science. Success of this analytical method was proved by real sample analysis, which confirmed this as a promising technique for the arylamine species.

Risk Analysis of LPG Bottling Plants
Risk Analysis of LPG Bottling Plants is one of the specialities of CISRA. Different locations and different types of operation techniques, storage and transfer operations decide the risk of the plant. Reports were submitted for the new plants and for expansion programs in the following LPG bottling plants:

- The Indian Oil Corporation (IOC) Belgaum; Chingleput, Coimbatore
- The Bharat Petroleum Corporation Ltd (BPCL), Dharwad and Kochi

Risk Analysis of CPCL
CISRA had carried out detailed Risk Analysis and Hazop studies for the units of the Chennai Petroleum Corporation Limited (CPCL), Manali in 1995. However, CPCL again assigned the work of Risk Analysis for their additions and modifications with reference to the population changes. Hazop for some of the selected units of addition...
and modifications were carried out. The new Safeti-Micro software was used for this purpose.

**Environmental Management Systems**

As a part of the ongoing joint programme of Carl Duisberg Gesellschaft, Germany, and the CLRI in the field of environmental positioning of the Indian leather industry, the propagation of Environmental Management Systems (EMS) as per ISO 14000 and similar standards has been identified as one of focal areas. As a part of this project, it was planned to assist interested leather companies, both from leather manufacturing and conversion sectors, in implementing an EMS/OHSMS in their companies and in preparing for certification under ISO 14001 and OHSAS 18001. As a first step, a team, consisting of German and Indian experts, visited 30 leather companies in 8 different clusters of India, and assessed the existing environmental management practices on site and based on the assessment provided practical guidance to them. In addition 20 representatives of CLRI and Industry were trained as associate EMS auditors.

**Thermochemical Investigations**

Thermochemical Studies form an important aspect of process safety. Studies on the process parameters and safe preparation of Triamino Trinitro Benzene (TATB) were completed and results passed on to the High Energy Materials Laboratory (HEMRL) Pune of the Defence Research & Development Organization (DRDO).
National Level Planning for Leather Sector
National Level Planning for Leather Sector

Pre-Investment Feasibility Study for the Potential Development of Leather Sector in the North Eastern Region

At the instance of the North East Development Finance Corporation (NEDFi), Guwahati, an extensive field survey was organised in the North Eastern States of Assam, Meghalaya, Tripura, Mizoram, Manipur, Nagaland and Arunachal Pradesh for assessing the potential for development of leather sector in the region. Based on the field survey, a comprehensive “Pre-investment Feasibility report for Potential Development of Leather Sector” was prepared and submitted to NEDFi. The report covered livestock trends, slaughter and mortality rates, reasons for sickness of existing tanneries, demand for leather products like footwear, leather goods and garments. An exclusive Tanning Complex for Tanneries and Product Units was suggested for the entire North East in Silchar. The findings of the report has been disseminated to the potential entrepreneurs, policy makers in the region. The report has been well received. Efforts are being made to establish a tannery for processing 3000 skins and a leather garment unit in Jorhat.

Statistical Bulletin on India’s Foreign Trade in Leather and Allied Products (1996-2001)

The Statistical Bulletin on India’s Foreign Trade in Leather and Allied Products for the years 1996-97 to 2000-01 was released during the Leather Research Industry Get-Together - 2002. The voluminous data compiled from the Monthly Statistics of Foreign Trade of India (Published by the Directorate General of Commercial Intelligence and Statistics, Ministry of Commerce, Government of India) has been processed into a “ready-to-use” form for the benefit of planners, policy makers, researchers and others connected with the leather industry and trade. The year-wise data were supported by time series tables on India’s overall exports in different categories, diagrammatic and graphic presentations has been submitted.

Tenth Plan for Leather Sector

CLRI played a key role in the preparation of the report of the Working Group for the Tenth Plan of Indian leather sector for the Government of India. The Indian leather industry is poised for a planned development during the next ten years. The country needs to gain a leadership status in global leather trade by gaining 10-14% of the share in value terms. This calls for an integrated and a holistic development of the sector for meeting the demands of both export and domestic markets. Major action planned by the sector during the next ten years included eleven priorities as follows.

- Employment oriented policy promotion
- Readjustments to Dereservation
- Readjustments to Quantitative Restrictions (QR) Removal
- Promotional Measures For Compliance To WTO Regimes
- Modernization of all Sub Segments
- HRD Mission
- Environmental Mission
- R&D back up and Support
• Foreign Direct and Large Domestic Investments
• Readjustments to WTO Framework
• Aggressive Marketing Strategies

CLRI plans for an ambitious role and responsibility for itself in the Indian leather sector during the Tenth Plan period. The Institute plans to deliver on a Mission mode Human Resource Development and Environmental Actions Programme during 2002-2007 with the support of the Government of India and the leather industry.
Human Resource Development
Human Resource Development

The activities of the Centre for Human Organisational & Resource Development (CHORD) are basically continuous in nature with the objective of catering to the human resource needs of the Indian leather and leather product sector by conducting various academic/vocational/short-term and specialized training programmes, strengthening curriculum and course design for various courses conducted, expanding synergies with various universities, industrial associations and national centers for excellence, expanding value addition for various courses, designing, developing and conducting distance education and international training programmes in leather and leather product sectors.

**Academic Programmes**

B.Tech., (Full time as well as Part time), M.Tech. and Ph.D. programmes in Leather & Footwear Technology were conducted in collaboration with the Anna University. Doctoral research in various fields of science was also taken up.

**Vocational Programmes**

CHORD conducts and co-ordinates the courses involving core competence to meet the specialized training needs of the leather and leather products industry. Various long term, short term and executive training programmes has been conducted. During 2001-2002, various executive training programmes in footwear manufacture, leather processing were conducted for officials from Mangalore Chemicals & Fertilizers Ltd., Bangalore, Taurus Leathers Ltd., Performa I.D., Kerala, Tata Johnson Controls, SISI, etc.

**International Training Programmes**

Three candidates from Sri Lanka and five candidates from Leather and Leather Products Technology Institute (LLPTI), Addis Ababa, Ethiopia were imparted training in chemical testing, CAD for footwear and leather & leather Products manufacture. Four candidates from LLPTI are continuing their training programme.

**Distance Education Programme**

The Tannery Workers Vocational Qualification (TWVQ) organized by CLRI and the Indira Gandhi National Open University (IGNOU) has received encouraging response. TWVQ for Beam House Operation has been successfully implemented and 68 workers have undergone the skill and supervisory development training suited to industry.

Training of workforce in leather processing (Tanning and Post Tanning Operations) and footwear units through open learning and distance education for improved job performance in respect of productivity and quality is proposed to be organized in collaboration with IGNOU.

Distance education in the form of web technologies is proposed to be organized in various fields of leather processing. Preparation of learning material and web technology implementation is being carried out.
New Millennium Indian Technology Leadership Initiative – Biotechnology for Leather

A new scheme NEW MILLENNIUM INDIAN TECHNOLOGY LEADERSHIP INITIATIVE (NMITLI) has been launched by CSIR to realize the Vision of developed India in S&T. This farsighted new initiative seeks to look beyond today and support innovations centered technology development as a vehicle to attain for the country a global leadership position in a few selected niche areas. The Scheme envisages participation of all constituents in the innovation chain viz. academia, publicly funded institutions as well as industry.

In a true TEAM INDIA effort, CSIR had initiated widespread national consultations through letters, workshops, and media followed by expert assessment and evaluation to identify the potential niche areas. The responses received were then screened through an elaborate mechanism and several research areas were identified for further consideration. Amongst these ‘Biotechnology for Leather’, is one.

Leather manufacture has remained one of chemical processing of a biological matrix skin, world over. A paradigm shift in leather sector would call for a bioprocessing of skin at beam house stages. This is likely to render leather processing much cleaner. Salt-less and cleaner preservation, enzyme dehairing and defleshing and removal of growth marks by selective digestion of glycated conjugates and microbial consortia for reduction of sulfate in tannery wastewaters to elemental sulfur, are challenging demands. The project envisages proving the concepts of feasibility of rendering skin preservation and processing up to tanning stage bioproduct based. Three important components for the project viz. (i) Micro flora in skin – (a) identification and (b) chemical and biocontrol; (ii) enzymes in leather processing; (iii) environmental biotechnology have been identified. ‘BIOTECHNOLOGY FOR LEATHER’ networks 12 institutions, one industrial research foundation and an industrial trade association of users of technologies, organically and synergically. The proposal envisages enthusiastic partnership of additional scientific groups as the project develops further. In one of the recently held sessions on Biotechnology at the turn of the New Millennium, the presentation of the concept attracted enthusiasm. The project is expected to generate more than 10 globally competitive knowledge products of potential and commercial value. Bio- and ambient preservation of skin enzyme dehairing and defleshing and enzyme regulated management of sulfide bearing wastewater streams are likely to earn for India a special niche status. It is expected that leveraging of the intellectual products through partnerships with industries will develop with knowledge products emerging usable and useful products after revalidation and further resource addition. It is targeted that industrial partners as shareholders will be attracted to join after some critical leads have been obtained.
Performance Appraisal

Performance Appraisal: Measuring Stakeholder Value of CLRI


The stakeholder base of CLRI has been sub grouped as (a) Students (b) Academia (c) Scientists (d) Technologists (e) Third Generation (innovation driven) industry (f) Second Generation (technology driven) industry (g) First Generation (market driven) industry (h) Decentralised (material driven) industry, (i) Government and (j) The people of India. Special questionnaires were designed and stakeholder value of CLRI was assessed on a 1-10 scale. Around 180 stakeholders were contacted. Based on the response of stakeholders and statistical analysis, a stakeholder value profile has been developed. A weighting scheme proportional to the inputs and investments for work relating to each of the 10 groups of stakeholders has been adopted. The weighting scheme of stakeholder base of CLRI was linked to deployment of institutional resources for meeting the stated and unstated perceptions of stakeholders. The pilot study on stakeholder value of CLRI is presented in the figure.

The stakeholders have assessed and accorded values ranging from 6.9 out of 10 by the decentralized sector group to 9.0 of 10 by the Governmental agencies. The major stakeholder has been the industrial segment. They have accorded values to CLRI of 7.5, 8.0, 7.5 out of 10 for market, technology and innovation driven segments of industry. A notable point is that the industrial sector has accorded 15-20% higher stakeholder values to CLRI than they may give for themselves.

CLRI has carved for itself on institutional vision in alignment with the leather vision of Indian leather sector and the country. A beginning has been made. The tremendous partnership established with industry to relate science to society has been acknowledged by PAB.
Extension Activities
LEATHER RESEARCH INDUSTRY GET-TOGETHER
KOLKATA CHAPTER
Organised by: CENTRAL LEATHER RESEARCH INSTITUTE
Sponsored by: COUNCIL FOR LEATHER EXPORTS
INdIAN LEATHER TECHNOLOGISTS' ASSOCIATION
Date: 8th MARCH 2002
Venue: INDIAN SCIENCE CONGRESS ASSOCIATION AUDITORIUM
Extension Activities

The Regional Centers of CLRI at Ahmedabad, Jalandhar, Kanpur, Kolkata & Mumbai provide a vital role by linking the CLRI to the local industry.

Regional Centre for Extension & Development, Mumbai
Provided testing services for testing of leather chemicals. Training programme on leather goods and shoe upper manufacture continued.

Regional Centre for Extension & Development, Ahmedabad
Regional Center for Extension and Development, Ahmedabad has carried out testing and evaluation services and conducted training programmes in leather and leather product manufacture.

Field Training-cum-demonstration Programme
During the year 136 rural artisans have been trained by RCED.

RCED organised and conducted the 3rd Training-cum-Demonstration Programme at Tanner's Colony, SUIJANGARH (Dist: Churu) (Raj) from 1.4.2001 to 26.4.2001 which has been sponsored by RUDA, Jaipur/ LTM, Chennai.

The following Processes have been demonstrated:
- Improved method of Bag Tanning
- E.I. Tanning
- Simple chrome tanning with finishing
- Hair-on Tanning

About 35 rural tanners participated and derived benefits from the practical demonstration.

The 4th Training-cum-Demonstration Programme at Tanner's Colony, Sirohi (Dist : Sirohi) was conducted during 6.8.2001 to 3.9.2001.

About 25 rural tanners participated in the training-cum-demonstration Programme and derived benefits.

Training Programme in Leather Processing
3 months duration training programme in leather processing for 10 candidates sponsored by Gujarat Rural Industries Marketing Corporation Limited (GRIMCO), Gandhinagar has been organized from 9.4.2001 to 8.7.2001.

Regional Centre for Extension & Development, Jalandhar
RCED, Jalandhar continued to provide job work services, testing and evaluation of leather and leather chemicals and training programmes.

The major activities of the center have been

B.Tech (Leather Technology) Programme
Theory and Practical classes of B.Tech. (Leather Technology) students of Dr B.R. Ambedkar Regional Engineering College, Jalandhar were conducted by the Centre.

Effluent Pre-treatment Plants for Tanneries in Leather Complex
An agreement was signed between Punjab Leather Federation (PLF) and CLRI for providing designs of pre-treatment plants to forty member tanneries of the PLF at Leather Complex, Jalandhar. The designs have been provided to the tanneries for construction of the same.

Leather Garments/Goods Training Programme
The Centre continued to provide modular training programmes in Leather Product Manufacture. Five trainees successfully completed
part time Diploma Course in Leather Garments Manufacture. An orientation training programme for Government Tanning Institute, Jalandhar was also conducted.

Testing Facilities under CIBS
A state-of-the-art testing laboratory for physical & chemical testing of leathers & leather chemicals as well as testing of eco-sensitive chemicals in leathers & leather chemicals was set up at the Centre under Critical Infrastructure Balancing Scheme (CIBS), of Ministry of Commerce. The testing facility was commissioned on 08.08.2001.

Waste Minimization Circles
A Waste Minimization Circle was formed with five tanneries of Leather Complex. The activity has been sponsored by National Productivity Council, New Delhi. Activities/Meetings of the circle have been coordinated by the Centre.

Regional Centre for Extension & Development, Kanpur
RCED continued providing technical support to local leather industry and analytical services for leather & leather auxiliaries, footwear pattern grading, finished leather certification for export, verification of samples/inputs in the samples of leather, leather auxiliaries, shoes/boots, Saddlery & harness goods.

MINI-LERIG Kanpur Chapter

Chrome Recovery and Reuse System
Provided know-how package for the establishment of Chrome Recovery & Reuse System to M/s Mirza Tannery, Unnao and M/s Rahman Corporation, Unnao. The systems were also demonstrated to both the tanneries and training was provided for the operation of the system.

Common Chrome Recovery Plant
Feasibility report for the establishment of Common Continuous Chrome Recovery Plant for the small tanneries at Kanpur was prepared and presentation was made by CLRI team before representatives of State Government, Pollution Control Board and tanners.

Regional Centre for Extension & Development, Kolkata
The Regional Centre, Kolkata of CLRI has been continuing its activities in physical and chemical testing, microbiological testing. Job service facility also provided to the leather and leather product sector of the region. Training Programme on Leather Processing and leather goods making has been conducted at the Centre.

For the first time LERIG 2002, Kolkata Chapter was organized which was well attended by the tanners, product manufacturers, scientists and Govt. officials. Entrepreneurship Development Programme organized at the Centre with SISI, Kolkata.

The Centre has been involved in the development of Kolkata Leather Complex for providing technical assistance for establishment of continuous common Chrome Recovery System.
## Budget

### Budget Head

<table>
<thead>
<tr>
<th>A. RECURRING</th>
<th>2001-2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salaries P1, P2, P3</td>
<td>988.000</td>
</tr>
<tr>
<td>Contingencies P4</td>
<td>152.000</td>
</tr>
<tr>
<td>HRD</td>
<td>6.000</td>
</tr>
<tr>
<td>Maintenance P6</td>
<td>47.000</td>
</tr>
<tr>
<td>Chemical &amp; Consumables P7</td>
<td>165.500</td>
</tr>
<tr>
<td><strong>Total Recurring (A)</strong></td>
<td><strong>1358.500</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B. CAPITAL</th>
<th>2001-2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>Works &amp; Services P5 (2)</td>
<td>10.700</td>
</tr>
<tr>
<td>App. &amp; Equipment P5 (3)</td>
<td>109.625</td>
</tr>
<tr>
<td>Office Equipment P5 (13)</td>
<td>1.740</td>
</tr>
<tr>
<td>Furniture &amp; Fittings P5 (9)</td>
<td>2.135</td>
</tr>
<tr>
<td>Library Books P5 (12)</td>
<td>56.000</td>
</tr>
<tr>
<td><strong>Total Capital (B)</strong></td>
<td><strong>180.200</strong></td>
</tr>
<tr>
<td><strong>Grand Total (A + B)</strong></td>
<td><strong>1538.700</strong></td>
</tr>
</tbody>
</table>

### Extra Budgetary Resources

<table>
<thead>
<tr>
<th>I. External Cash Flow (ECF) (Rs. in Lakhs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Job Work</td>
</tr>
<tr>
<td>Testing</td>
</tr>
<tr>
<td>Sponsored Research</td>
</tr>
<tr>
<td>Consultancy Programmes</td>
</tr>
<tr>
<td>Others</td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>II. CSIR Revenue Budget (Rs. in Lakhs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EBR AS % Revenue Expenditure</td>
</tr>
<tr>
<td><strong>1358.500</strong></td>
</tr>
</tbody>
</table>
Indian Patents filed by CLRI during 2001-02

1. A process for the preparation of plant based acrylate composite.
3. A process for the purification of Escherichia coli contaminated water for reusable option.
4. An improved device for leather processing.
5. A process for the preparation of plant based reconstituted collagen substratum.
7. An improved process for making chrome tanned leathers.
9. Formulation for preparation of a material for making impression of an object (Provisional specification).

Staff Position as on 31.3.2002

<table>
<thead>
<tr>
<th>Category</th>
<th>Nos.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group IV Scientific</td>
<td>130</td>
</tr>
<tr>
<td>Group III Technical</td>
<td>86</td>
</tr>
<tr>
<td>Group II Technical</td>
<td>105</td>
</tr>
<tr>
<td>Group I Technical</td>
<td>83</td>
</tr>
<tr>
<td>Administrative</td>
<td>99</td>
</tr>
<tr>
<td>Group D Non-Technical</td>
<td>51</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>554</strong></td>
</tr>
</tbody>
</table>
Select Papers Published in International Journals

Acta Crystallographica
2001, Vol E57 PP474-476

Biochemical Biophysical Research Communication,
2001, Vol. 283 PP. 229-235

Bioprocess and Bio Engineering Systems
2001, Vol. 24, PP. 211-217

Burns
2001, Vol. 27, PP. 309-317
2001, Vol. 27, PP. 35-39
2001, Vol. 27, PP. 534-544


Chemical Physics Letters
2001, Vol. 334, PP. 245-249
2001, Vol. 335, PP. 489-495
2001, Vol. 342, PP. 603-609
2001, Vol. 344, PP.40-48
2001, Vol. 348, PP. 395-405

Colloid & Surfaces, 2001, Vol. 181, PP.115-121
Comparative Biochemistry and Physiology Part B,
2001, Vol. 128, PP. 81-90

CPS, Chemweb, July 2001
Experimental Eye Research, 2001, Vol. 72, PP. 301-310

2001, PP. 27-
2001, Vol. 96, PP. 127-132
2001, Vol. 96, PP. 157-161
2001, Vol. 96, PP. 222-233
2001, Vol. 96, PP. 290-304
2001, Vol. 96, PP. 343-349
2001, Vol. 96, PP. 444-450
April 2001, PP. 120-126


Journal of Applied Polymer Science
2001, Vol. 80, PP. 1870-1879
2001, Vol. 81, PP. 1567-1571
2001, Vol. 82, PP. 847-853


Journal of Cleaner Production
2001, Vol. 9, PP. 261-268
2001, Vol.9, PP 25-33
2001, Vol.9, PP 483-491
Journal of Society of Leather Technologists & Chemists
2001, Vol. 85, PP. 175-178
Journal of the American Oil Chemists Society
2001, Vol. 78, PP. 897-902
Liquid Crystals, 2001, Vol. 28, PP. 1475-1481
Macromolecular Chemistry and Physics, 2001, Vol. 202, PP. 2538-2546
New Library World (UK), 2001, Vol. 102, PP. 325-331
OSH & Development Journal, Swedish International Development Co-operation Agency (SIDA), April 2001
2001, Vol. 31, PP. 2199-2202
2001, Vol. 57, PP. 3465-3469
Toxicology 2, 2001, Vol.156(2-3), PP. 129-138
Transition Metal Chemistry 26 2001 333-338
Work study (UK), 2001, Vol. 50, PP. 222-228
Work Study (UK), 2001, Vol. 50(6), PP. 247-256

Publications Statistics

National Journals 26
National Conferences 31
International Journals 98
International Conferences 80
Awards / Honours / Recognitions

- John Arthur Wilson Memorial Lecture Award to Dr T Ramasami (2001)
- Chemical Research Society of India Medal to Dr B U Nair (2001)
- Honorary Fellowship to Dr T Ramasami to the Indian Institute of Chemical Engineers (2001)
- Om Prakash Bhasin Award for Engineering Technology to Dr T Ramasami
- Membership of Dr T Ramasami to the Science Advisory Committee to the Cabinet (SAC-C)
- Membership of Dr T Ramasami to the Society, Advisory Board and Governing Body of CSIR
- Dr K S V Srinivasan elected as Fellow of Tamil Nadu Academy of Science
- Honorary Membership of Jawaharlal Nehru Centre for Advanced Scientific Research to Dr T Ramasami
- Council for Leather Exports (CLE) Design Award for Leather Apparel for year 2001 to CLRI
- At the instance of Ministry of Industry, Government of India, CLRI prepared a major Working Group Document for the planned development of Indian Leather Sector during Tenth Plan period (2002-2007)
- Ms Lalitha Chellappa and Ms Malathy Chandrababu won the SSB Tournament in Carom (Doubles) held at Nagpur in February 2002