Abstract

Lac is a unique gift of nature to the mankind, especially to the people of India. It is the only natural resin of animal origin, secreted by a tiny lac insect on some trees. It mostly consists of a polyester type resin formed by fusion of hydroxyl fatty acids with sesquiterpene acids besides having some colouring matter, wax, etc. Lac is an important ingredient of several Ayurvedic and Unani formulations. Due to its wonderful characteristics, shellac, the product of commerce, has a wide range of applications in surface coating industries, electrical insulation, filling materials, adhesives, controlled release fertilizer and other agricultural formulations. Its recent uses include synthesis of bioactive and perfumery compounds. It not only provides livelihood to nearly three million poor people but also fetches foreign exchange through export.

Introduction

Lac is the only natural resin of animal origin, produced by a red coloured tiny lac insect, Laccifer lacca (Kerr) found throughout India. Fourteen species of the insect Laccifer are reported in India on a number of plants, both wild and cultivated in various regions. Host plants, viz. Schleicheria oleosa (Lour.) Oken. (Hindi — Kusum), Butea monosperma (Lam.) Kuntze (Hindi — Palas) and Ziziphus mauritiana Lam. (Hindi — Ber) are important ones. The word Lakh means hundred thousand, indicating the large number of insects involved in producing this resin. In fact, about 40,000 to 200,000 of these nearly 2 mm size insects are required to produce one kilogram of shellac, the lac of commerce. Lac, when secreted by the lac insect, with the purpose of making its nest around its body, is a viscous material, which quickly hardens after coming in contact with air. The insect completes its life cycle, inside the nest. The female insect after attaining maturity gets fertilized and gives birth to the next generation and then dies. The dead body of the mother is consumed by the newborns.

In India lac is known since Vedic period. Lac products were used as decorative materials even in 1200 B.C. During the 17th century, lac dye and shellac
were introduced to Europe then it became commercially important. Lac is therefore, interwoven with the cultural, social and technological evolution of our civilization.

Lac is more useful than all the other natural or synthetic resins and is an invaluable boon of nature to mankind. It has been conventionally used as filling material, protective, adhesive, binder and as insulating material, either alone or with other auxiliaries, involving wood, glass, metal, paper, leather, jute, stones etc. It has also been used in some indigenous drug formulations, especially for reduction of obesity and inflammations.

India alone produces about 65% of the total lac produced in the world. Myanmar (Burma), China, Nepal, Tibet and Vietnam also produce some lac. India and Thailand supply this commodity to nearly 100 user countries of the world. Nearly 85% of the total lac produced in India (average of the past few decades being 15,000 metric tonnes) involving about 3 million Adivasis or poor people inhabiting some of the most backward districts of Bihar, Jharkhand, Chhattisgarh, Madhya Pradesh, Orissa, Maharashtra, Uttar Pradesh and West Bengal. Bihar tops in lac production in India. From India it is exported to other countries valued about Rs. 20-100 crores annually.

**Lac Cultivation**

In India lac is cultivated mostly in Bihar, Madhya Pradesh, West Bengal, Assam, Orissa, Uttar Pradesh and at a small scale in Punjab, Karnataka and Chennai. Though the bulk of lac crop is obtained chiefly from Kusum, Ber and Palas other trees, viz. Acacia catechu Willd. (Hindi — Khair, Kattha), Acacia nilotica (Linn.) Delile (Hindi — Babool), Dalbergia sissoo Roxb. (Hindi — Sheesham), Ficus carica Linn. (Fig; Hindi — Anjeer), Ficus glornerata Roxb. (Hindi — Gular), Ficus religiosa Linn. (Hindi — Peepal), Mangifera indica Linn. (Mango; Hindi — Aam), and Shorea robusta Gaertn. f. (Hindi — Sal) also harbour the insect.

The insect thrives on tender shoots of the host tree, therefore, for cultivation the twigs carrying lac encrustation (broodlac) with larvae about to emerge from mother cells are cut, bundled and tied at different places on a fresh host plant, so that, the emerging larvae swarm and settle on nearby succulent shoots. After inoculation control of pests and predators of the lac insects is essential for ensuring good yield. Lac insects grow well on host plants which are grown in soil containing trace amount of copper.

Recently researchers at the Indian Lac Research Institute, Namkum, Bihar have developed improvement in lac host plant propagation and lac pest management techniques. They have identified and developed promising lac insect lines. The institute also gave “In-house” and “On-farm” training to farmers on improved methods of lac cultivation, conducted certificate courses on "Improved Methods of Lac Cultivation" and "Industrial Uses of Lac" on a regular basis.

**Forms of Lac**

Based on the methods of collection and processing, various forms of lac known in commerce are as follows:

**Stick Lac** — It is raw lac, obtained by scraping the lac encrustation from the dry twigs, cut down before emergence of the new insect. It contains dead bodies of the lac insect, bark of the host plant, dried leaves, dust and other extraneous impurities.

**Seed Lac** — The semi-refined product obtained after crushing, sieving and winnowing of stick lac, followed by washing and drying is called seed lac. It contains impurities such as sand, insect debris, etc.

**Shellac** — It is the refined form of lac, available in the form of thin flakes. It is obtained by stretching the heat softened seed lac, freed from infusible materials. It is the lac of commerce and is graded based on its colour and wax content.

**Button Lac** — It is another form of heat-purified lac, where the molten resin is cast into button-shaped cakes instead of being drawn into sheets, as in

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the manufacture of shellac. The cakes are largely used for bonding mica splittings into micanite.

**Characteristics and Composition of Lac**

Shellac is a hard, brittle resinous solid, slightly heavier than water. On slow heating it softens and melts at 65-70°C. On strong heating it loses fluidity forming a rubber like mass, which is finally converted to an insoluble hard mass. Below 150°C, it behaves as a thermoplastic resin and at 150°C, it behaves as a thermosetting resin for nearly half an hour. It is tasteless and non-toxic to health.

Lac is soluble in organic and inorganic bases. It is soluble in caustic soda, sodium carbonate and borax solutions as well as in alcohol and acetic acid. It is insoluble in hydrocarbon solvents like petroleum ether, benzene, toluene, etc. and partially soluble in ethyl acetate, chloroform, ether and carbon disulphide.

Shellac forms very good protective and insulating film over a wide varieties of materials including metals, wood, glass, leather, etc. Its inherent gloss is remarkable and thus finds many applications in surface coating industry. Because of its non-toxic and biodegradable nature it has considerable advantage over the synthetic resin compositions.

When stored with moisture contents of more than 4%, lac tends to form lumps or hard blocks and loses various characters. Stick lac darkens and deteriorates with age. Seed lac can be stored without appreciable change up to 18 months. Flow values and rate of filtration are quite sensitive to ageing and possess a linear relationship. It is therefore, possible to determine the age of seed lac or shellac by simply determining the flow value.

Stick lac contains some water-soluble components such as lac dye (nearly 1%), sugar and albuminous matter. The water insoluble components constitute besides insect debris, sand and plant material, lac resin (60%), wax (6%), an odoriferous principle and a dye (0.5%). When the crushed stick lac is agitated with water, the water-soluble dye, consisting of atleast five closely related anthraquinone derivatives, called laccaic acids, come out in the effluent. Commercial seed lac owes its colour (pale yellow to red) to the water insoluble dye called erythrolaccin.

Shellac, the refined form of lac, is polyester type resin and consists mostly of aleuritic acid, other long chain hydroxy fatty acids, jalaric acid (10%) and other sesquiterpene acids. An average lac molecule contains five hydroxyl, one carboxyl and one aldehydic group along with a point of unsaturation.

**Applications and Uses**

Lac is used in the form of solution in some solvents or after blending with some other substances for numerous purposes.

**Electrical Industry** – Due to its very high dielectric strength, anti-tracking property and adhesion to a variety of substances, shellac is extensively used in electric industry to act as air-drying and baking-type insulating varnish, cement for various electrical sockets, protective coating for PCBs, anti-tracking insulating varnish, coating of spark plugs, various laminated sheets, tubes, etc.
**Feature**

**Varnish and Printing Industries** — The resistance to abrasion property of lac makes it useful as furniture polish (French polish), floor polish, heatproof and waterproof varnish, shellac red-oxide primer, sealers and in embossed printing.

**Adhesive Industry** — Its good binding and adhesive nature make shellac useful as gasket cement, optical cement, sealing wax, hot-melt adhesive, adhesive for Si-chips and solar cells, for making grinding wheel, polymer adhesive and coating of leather for adhering metal and plastic foils.

**Food Industry** — The non-toxic nature coupled with its adhesive character is suitable for its application in coating of fruits, chocolates, lozenges, coffee beans, etc. for increasing the shelf life, for internal can coating and for making non-toxic ink of marking food stuffs.

**Pharmaceutical Industry** — Lac has also been extensively used in pharmaceutical industry for coating of tablets, microencapsulation of vitamins and coating of medicines for slow release in the body.

It is also used in the preparation of some Ayurvedic and Unani formulations prescribed for diseases of bile, fevers, osteitis, osteomyelitis, dropsy, obesity, and as diuretic and anti-inflammatory agent. In these formulations lac is used as decoction or as refined resinous fraction.

**Cosmetic Industry** — Because of its non-toxic nature and good binding property, lac is used in hair sprays and lacquers, eye shadows, microencapsulated perfumes, lipsticks, nail polishes, mascara, etc.

**Other Uses** — Lac is also used by the goldsmiths for filling the ornaments and for fixing gold sheet on a wooden log for embossing artistic designs. Lac bangles with jewels on the surface are extensively used. It is also used in polishing stones, sharpening stones, encapsulation of fertilizers and pesticides for their slow release and in the synthesis of perfumes and bio-active compounds like insect sex pheromones and plant growth regulators.

**By-products of Lac**

**Lac Dye** — Lac contains a water-soluble red dye and an alkali and spirit soluble yellow dye. It is obtained by extracting stick lac with water and sodium carbonate solution and precipitating with lime. Before the advent of synthetic dyes, in the late 19th and early 20th century, lac dye was the main item of this industry. With the advent of synthetic dyes, the lac dye went into oblivion. There is now a reversed interest for this dye. It is being used in some developed countries as colouring material in food and beverages. The dye is also regaining ground in textile printing for its fast shades of pink, violet, crimson, brown, etc. on wool and silk, when different mordant are used.

**Lac Wax** — Lac wax is mainly obtained from stick lac and various grades of lac contain 4-6% wax. It resembles carnauba wax and practically insoluble in alcohol but fairly soluble in xylene. It is used mainly in shoe, car and floor polishes, glass marking crayons, lipsticks, etc.

**Kiri** — It is the infusible dark coloured material left out within the cloth bag during processing of shellac from seed lac, used for making sticks of sealing wax.

**Research and Development**

In 1925, realizing the importance of researches on cultivation and development of lac, lac merchants organised themselves into a private registered association, leading to constituting of the Indian Lac Research Institute (ILRI) at Ranchi. In 1931, the then Royal Government took over the Institute, maintained the London Shellac Research Bureau at United Kingdom from 1933 to 1947 and the Shellac Research Bureau at the Polytechnic Institute of Brooklyn, USA from 1934 to 1939. Researches carried out at these centres contributed to the development of several lac applications.
The Indian Lac Research Institute, Ranchi has done work on the genetics, breeding and management of lac insects and lac hosts, control of pests, development of technologies for better production, processing and utilization of lac, and its by-products. The ILRI also synthesized a number of fine chemicals from chief constituents of lac (Aleuritic acid) to give perfumery compounds, sex pheromones, pharmaceuticals, insecticides besides developing multipurpose adhesives, paints, lacquers, varnishes, marking inks, etc. It also extended training and extension services to the entrepreneurs and transferred new technologies to the industry.

Besides ILRI and SEPC (Shellac Export Promotion Council) the BISCOLAMF (Bihar State Co-operative Lac Marketing Federation) of the Government of Bihar at Ranchi also sponsored various research projects on the production and development of lac and its products, which gave fruitful results.

Clinical research has been carried out at Ajmal Khan Tibbiya College of Aligarh Muslim University and Industrial Toxicology Research Centre of Lucknow has undertaken pharmacological research on toxicity/safety of lac.

Production, Marketing and Export

Production of lac is subjected largely to the variations of climate, weather conditions like annual rainfall, distribution of rainfall over the year, recurrence of hailstorm and frost and incidence of pests damage. Because of these factors lac production has always shown great fluctuations. During 1956-57 the total lac production in India was nearly 49 thousand tonnes whereas in 1978-79 it was only 9,119 tonnes. It rose to 20,340 tonnes in 1986-87 but came down to 14,800 tonnes in 1987-88 because of excessive heat during May and rains immediately after inoculation. Another important factor, which has a bearing on the production and fluctuation of prices of lac, is the middleman. Owing to technical and marketing system coupled with the natural calamities, lac has been suffering from unstable and unpredictable prices since very inception of this industry. When the poor growers do not get enough remuneration for their labour they lose their enthusiasm for lac cultivation. Andhra Pradesh, Assam, Karnataka and Punjab, which were producing lac in the forties, due to non-availability of proper market for their produce as well as prevalence for poor price for a long spell of time have almost stopped lac cultivation since decades.

Lac on Calliandra haematocephala Hassk. in NISCAIR campus

Government of India in 1949 formed the Shellac Export Promotion Council (SEPC) at Kolkata which initiated introduction of minimum export price for various grades of lac with a control on the quality, implementation of a code of conduct for domestic traders, publicizing various aspects of lac production among the farmers, distribution of brood lac to needy growers through the state governments of Bihar, Madhya Pradesh and West Bengal, evaluation of non-toxic nature of lac dye at USA and establishment of usefulness of lac coated urea. These activities had important bearing on restoration of confidence among the growers and on the quantum of production and export. After the introduction of synthetic resins, from 1956 onwards, Indian lac industry suffered a lot. However, India fetched more than Rs. 44 crores through export of lac and its dye in 1994-95. There is now a renewed global consciousness towards use of safer natural products. The total world demand of lac and its products have increased by several thousand tonnes in recent years.

Future of Lac Industry

Lac and lac dye have been important export commodities of our country for the past several centuries and there is not yet a complete synthetic substitute for shellac. Besides, the health and environmental hazards created by the synthetic resins, dyes and their industries, there is strong hope that the versatile eco-friendly lac products would regain their past glory. The growth of lac and its industries would sustain the economic development of our country especially the
tribals and the weaker sections of the lac producing regions. Production and supply of quality lac is likely to meet the future world demand and could earn foreign exchange.

**For Further Reading**


**Effect of shellac coating on chilling injury of Grapefruit cultivars**

In today's modern age oranges, lemons, apples and peppers are coated by using shellac to extend the shelf life of the product and giving it a shine which other natural products cannot. Recently, Dr H. Dou at Florida Department of Citrus, Citrus Research and Education Center, United States has done a study on the effect of coating application on chilling injury of Grapefruit (*Citrus paradisi Macf.*) cultivars and examined coating type on chilling injury (CI) incidence.

The results revealed that the shellac coating widely used for exported citrus fruits result in the lowest CI incidence in white 'Marsh' grapefruit stored for 2 months at 4°C and 92% ± 3% relative humidity compared with nonwaxed fruit or fruit waxed with either carnauba or polyethylene waxes. The order of coating performance for reducing CI was shellac > carnauba > polyethylene > nonwaxed fruit. For cv 'Flame' little difference of coating type on CI was detected after 2 months of storage. Overall, CI incidence was high in fruits of the cultivars harvested from September to December, low in February, and high again after March but was generally higher in white 'Marsh' seedless grapefruit than 'Ruby Red', 'Rio Red' and 'Flame'.

However, little difference of cultivar on CI incidence was found among the 'Ruby Red', 'Rio Red' and 'Flame' grapefruit except the October harvest in which CI was higher in 'Ruby Red' than in 'Rio Red' and 'Flame' grapefruit. Thus the coating and cultivar should be considered in the post-harvest management of CI in commercial packing [Dou, *Hort Sci.*, 2004, 39 (3), 558-561].