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NAMKUM, RANCHI, BIHAR

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INDIAN COUNCIL OF AGRICULTURAL RESEARCH
NEW DELHI

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INTRODUCTION

The Indian Lac Research Institute came into existence as a result of the recommendation of a two-man enquiry committee (comprising of Mr. H. A. F. Lindsay and Mr. C. M. Harlow) appointed early in 1920 by the then Government of India to enquire into the conditions of the Indian Lac Trade and suggest measures for its all round improvement. The report of this Committee was published in 1921 in which they observed, *inter alia*, that the two major ills from which lac trade was then suffering, namely, liability to violent price fluctuations and adulteration in times of short supply, could be cured only by improved outturn. For this, they suggested that recourse should be taken to *intensive* cultivation by scientifically tested methods, rather than to *extensive* cultivation. In order to implement this suggestion, members engaged in the lac trade at the time constituted themselves into a private registered body under the name of the Indian Lac Association for Research. This Association set up the Indian Lac Research Institute in 1925.

In 1930, on the recommendation of the Royal Commission for Agriculture (1927), the Indian Lac Cess Act was passed by the Central Legislature. Under this Act, the Government of India constituted the Indian Lac Cess Committee which took over the Institute from the Lac Association in 1931. The Committee maintained the Institute till 31st March 1966. With the abolition of the Committee on this day, the Institute was taken over by the Indian Council of Agricultural Research with effect from 1st April 1966. The Institute is now functioning under this Council.

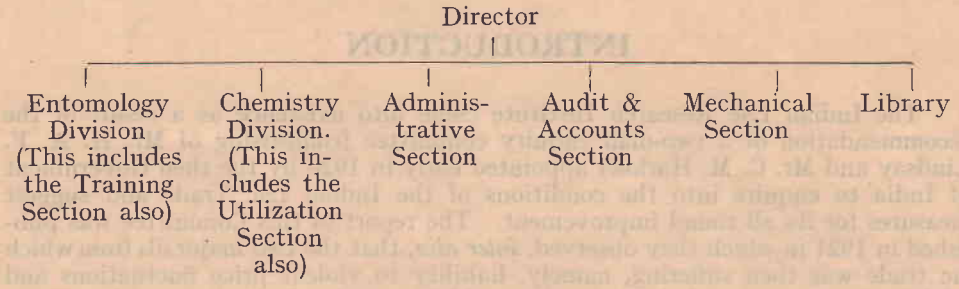
The Institute is situated at Namkum about nine kilometers east of Ranchi. The laboratories of the Institute consist of three fair sized separate buildings housing the Chemistry Laboratory, the Entomology Laboratory and the Experimental Factory. The Institute Library adjoins the Entomology building. The Administrative Section and Museum are housed in another block. The waterworks, workshop, gas plant etc. are located in small constructions between the Chemistry and Entomology Laboratories. Due to paucity of accommodation, the Audit and Accounts Section and one unit of the Administrative Section are temporarily accommodated in two small rooms adjoining the workshop.

Apart from these, the Institute also has an adjoining plot of over 35 hectares for use as an experimental plantation. The total estate of the Institute at Namkum including the plantation covers an area of about 49 hectares. For outstation experiments, areas/trees have been taken on long term lease.

The Institute is headed by the Director who also functions as Head of the Chemistry Division. The Head of the Division of Entomology is the Entomologist.

Objective and structure — The main objective of the Institute is to carry on research towards effecting improvements in the cultivation, processing, standardization and modification of lac through scientific research so as to intensify cultivation and extend utilization. In addition, the Institute is also to carry on publicity and maintain liaison with and provide technical service to the indigenous industries towards improving the quality of their products and increased utilization of lac.

Present structure of the Institute is indicated in the following plan:



Visitors — This Institute has always been a regular attraction to most visitors to Ranchi particularly scientists and technologists. During the period under report also, it received the usual complement of visitors including students and trainees from different colleges and institutions, officials and other VIPs.

Collaboration with other institutions — Apart from work within its own premises, the Institute has always sought to take advantage of technical know-how and facilities available in other institutions also for the furtherance of its objectives. A Research Project is being implemented since 1960 under which the constitution of lac is being studied simultaneously (i) at the Chemistry Laboratory of the Delhi University under the guidance of Prof. T. R. Seshadri, F.R.S. and (ii) at the National Chemical Laboratory, Poona under the guidance of Dr. Sukh Dev. In addition, the constitution of lac dye is also being investigated at the National Chemical Laboratory, Poona under the guidance of Prof. K. Venkataraman and development of shellac based leather finishes at the Central Leather Research Institute, Madras, both under separate schemes. Further, Shri A. H. Naqvi, Senior Research Assistant in the Entomology Division of this Institute was deputed for three months training on techniques of identification of micro-organisms and general micro-biological application in the Indian Agricultural Research Institute, New Delhi. He completed the training on the 26th of October.

The Institute is continuing to get cooperation from the Indian Institute of Technology, Kharagpur in its work on shellac rubber combinations as during the last two years.

The Institute also takes advantage of International Technical Co-operation Schemes to provide specialized knowledge to its employees. Six scientists of the Institute have so far been provided advanced training in various disciplines under the Colombo Plan, five in the United Kingdom and one in Canada.

The Institute continued to collaborate, as usual, with the Indian Standards Institution in the formulation of Indian standards for lac and lac products and allied materials. The scheme of co-operative research with the Jute Technological Research Laboratories, Calcutta, taken up during last year with a view to developing newer uses of lac in conjuction with jute, was continued.

Achievements — It may be recalled that one of the major achievements in the field of lac cultivation in recent years is the identification of the bush *bhalia* (*Moghania macrophylla*) as a host for the superior *Kusmi* lac and that this bush is also suitable for lac cultivation of both *Kusmi* and *Rangeeni* lacs on plantation basis. As a result of further systematic study, it has now been determined

that the optimum spacing of this bush for a plantation is 1·22×1·22 metres (i.e. 4 ×4 ft) and that the yield of sticklac in such a plantation is 209 kg per acre in the *Aghani* crop. Further, farmyard manure (which is better than chemical fertilizers for this purpose) at 36 quintals per acre further improves the yield by about 77 per cent. It had earlier been determined that whereas *bhalia*, carrying lac, does not survive the summer months, *galwang* (*Albizzia lucida*) does. Therefore, a mixed plantation of *bhalia* for the *Aghani* crop and *galwang* for the *Jethwi* is the most suitable for sustained lac cultivation on plantation basis. A pilot scale trial is indicated. Other results worthy of mention are the isolation and identification, for the first time, of a few micro-organisms associated with the lac insect and the observation that the first detected mutation in lac insect, namely yellow, is more or less neutral with regard to the fitness of these insects as it does not appear to have any effect on the fertility and life period of the insects.

In the field of processing, experiments for the production of shellac directly from sticklac, instead of through the conventional seedlac, is the first attempt to eliminate lac containing by-products altogether. Apart from increasing yield of refined lac, this method also saves one step in the processing operation thereby effecting double economy, particularly for the production of dewaxed lac which is the material in increasing demand. Preliminary results are very encouraging. The reclamation of wax and dye from lac factory wastes has made further progress. The wax isolated in the pilot plant appears to need some improvement whereas the lac dye is ready for trial in bigger batches.

In the field of utilization, the most notable achievement during the year was the solution, the Institute found, to overcome the difficulty faced by the Heavy Machine Building Plant of the Heavy Engineering Corporation, Ranchi, for the efficient insulation of core plates (of transformer steel) of inductors for surface hardening. Two shellac compositions were recommended, one for application by the conventional dipping method and the other by the latest electrodeposition technique, both of which were found satisfactory, the latter yielding better results (vide Appendix).

The Corporation has since been taking small quantities of the composition for their further use.

Other notable successes, during the year, in fields promising of considerable shellac consumption potential are the development of a technique and compositions for the coating of urea fertilizer with shellac in order to reduce its caking tendency and leaching rate, shellac-rubber combinations and water based red oxide primers for steel. The first is ready for agronomical trials and the last for commercial assessment before taking up further studies at pilot plant levels.

Awards — Shri B. B. Khanna, Scientific Officer (Factory) was awarded the Ph.D. degree of the Punjab University on the basis of his thesis entitled " Chemistry and Technology of Bleaching of Lac ".

Shri C. P. Malhotra, Scientific Officer (Field Station) was awarded a Senior Fellowship of Indian Council of Agricultural Research with retrospective effect from October 1967. Shri N. Majumdar, Senior Research Assistant (Entomology) was awarded a Junior Fellowship of the Indian Council of Agricultural Research for his further studies in Kalyani University. Shri A. Kumar, Senior Research Assistant (Chemistry) received a Senior Fellowship from Indian Association for the Cultivation of Science, Calcutta, for research in their laboratory.

Advisory Services — The Institute provides technical assistance to all those interested in the cultivation, processing, grading and utilization of lac (see pages 58 to 61).

In addition, the Institute provides two courses of training of six months duration (i) on improved methods of lac cultivation and (ii) on industrial uses of lac. The training is usually given to deputees of Central and State Governments and industrial undertakings.

During the year, five candidates completed their training in "Improved methods of Lac Cultivation" of whom four were from Madhya Pradesh and one from Bihar. Three more candidates, two from Madhya Pradesh and one (private candidate) from West Bengal were receiving training on 31st December 1968, the former two on "Improved Methods of Lac Cultivation" and the latter on "Industrial Uses of Lac."

For the benefit of the trade and industry, the Institute also maintains Regional Analytical Laboratories in the major lac processing centres of the country. During the period under report, two laboratories were functioning, one at Namkum (Ranchi) and the other at Balarampur (Purulia District), West Bengal.

Publications and Patents: (a) *Publications* — The Institute used to publish its research findings in the form of bulletins, technical notes, research notes etc. Nowadays, these are generally first published in leading Scientific or Technical journals and re-issued in the form of bulletins, research notes etc. In addition, a few books and one monograph have also been published and some of these in Hindi and other Indian languages too.

The total number of publications as on 31st December 1968 are as below:

1. Bulletins		
i) Chemical	...	96
ii) Entomological	...	37
2. Technical notes	...	19
3. Research notes		
i) Chemical	...	58
ii) Entomological	...	18
4. Miscellaneous technical publications		
i) Physico-chemical	...	19
ii) Entomological	...	40
5. Books	...	14
6. Pamphlets and Leaflets	...	24
(b) *Patents*	...	15

A complete list of the Institute's publications together with those of a sister organization, the erstwhile London Shellac Research Bureau, is supplied free on request.

Library — The number of books and bound volumes of journals accessioned during the year was 334. This brought the total number of books and bound volumes of journals in the library as on 31st December 1968 to 12,710. One hundred and twentytwo periodicals were subscribed for in addition to a few received in exchange or as gift. Some miscellaneous publications and reports were also received.

The library also maintains an adequate stock of books and reprints of articles published by the Institute and by the erstwhile Indian Lac Cess Committee for sale/distribution to those interested.

Staff club — The Staff Club continued its activities as usual towards which the Institute made a recurring contribution of Rs. 459/- for 1968-69.

Finances — Since its inception, the Institute was being financed through a cess levied on all exports of lac. Since 1962-63, however, some grants were also received from the Government of India as the income from the cess was found inadequate. Since the takeover with effect from 1st April 1966, the Institute is being wholly financed by the Indian Council of Agricultural Research.

The revised budget estimates of the Institute for 1968-69 ammounted to Rs. 12,65,300/-. The actual expenditure during the same period was, however, only Rs. 11,65,663·52 p.

2. PROGRESS OF RESEARCH

(A) ENTOMOLOGY DIVISION

Work on the various problems continued as per Project Proposals submitted for the year 1968. The Staff position was somewhat easier than in preceding years. Three Research Assistants joined in the course of the year.

Shri N. Majumdar, Senior Research Assistant proceeded on study leave to join Kalyani University for the M.Sc. degree on a Junior Fellowship from the Indian Council of Agricultural Research. Shri C. P. Malhotra, Scientific Officer (Field Station) continued his study in the Indian Agricultural Research Institute for his Ph.D. degree and so was away from the Division for the whole of the year.

After a few years of drought, climatic conditions in lac growing areas were more favourable and all the studies could be carried out without any adverse effect due to climate.

Item-wise report of the various projects now follows.

(a) RESEARCHES COMPLETED

1. Determination of optimum density of larval settlement on *palas* in hot areas (at Kundri)

One of the most important factors for the economic use of available hosts for lac cultivation is the use of optimum quantity of broodlac for inoculation. Broodlac is a costly item and is often not available for purchase. Thus a considerable economy would also be achieved by determining the optimum rate. The study was, therefore, initiated in Kundri Orchard (a hot area) for *palas* (*Butea monosperma*) and has been in progress since 1963.

There were in all 14 sets (treatments A to N) with 10 trees in each. The sets A to H had been given " heavy " inoculation in October 1967 with brood rates ranging from 1·5 to 5·0 kg (for each set of 10 trees) with an increase of 0·5 kg from treatment to treatment. The sets I to N had been given " light " inoculation i.e. with 0·25 to 1·5 kg of broodlac (for 10 trees) with an increase of 0·25 kg from treatment to treatment. The crops in A to H were harvested as *ari* in April and sets I to N were left for self inoculation in June/July and were harvested completely in October/November, *i.e.* one year after inoculation. The average yields of sticklac in A to H were 1·25, 0·85, 1·00, 2·00, 2·50, 3·10, 3·10 and 5 kg respectively. Thus, the yield of sticklac was highest with the heaviest brood rate tried. The yields obtained from treatments I to N on final harvesting were 2·80, 2·70, 2·00, 1·90, 2·25 and 2·60 respectively. These are in conformity with the earlier findings that where self inoculation is allowed, the lightest inoculation serves just as well as the heavier inoculation as far as yield of sticklac is concerned. An additional advantage is that higher yields of broodlac are also obtained.

2. Spacing trials of *bhalia*

Bhalia is a recently discovered bushy host for the superior *Kusmi* strain and has the added advantage of suitability for cultivation of lac on a plantation basis. In the latter, the yield of lac per unit area would naturally depend upon the optimum number of these bushes which can be raised there for the purpose. Study had therefore been initiated six years back to determine the optimum spacing required for these bushes to maximize yield of lac.

Three spacings, namely, 1·83×1·83 (6 × 6 ft), 1·83×1·22 (6 × 4 ft) and 1·22×1·22 metres (4 × 4 ft) designated as treatments A, B and C respectively were tried in a three coupe system. The experiment was conducted on a randomized block design with 8 replications. The net size of each plot was 10·98×10·98 metres.

The *Aghani* 1967-68 crop in coupe III was harvested in February. Bushes in coupe II were inoculated to raise the *Jethwi* 1968 crop which was subsequently harvested in July. Unlike previous seasons, the *Jethwi* crop progressed satisfactorily. The results obtained are given in Table 1.

TABLE 1 — EFFECT OF SPACING ON GROWTH CHARACTERISTICS OF *bhalia*

Coupe No.	Month of coppicing/ harvesting	Treatments	Growth*-average — per bush			
			Height (cm)	Number of shoots	Total shoot length (cm)	Yields of sticklac per bush (g)
I	July 1967	A	124·0	14·2	718·2	Not in-
		B	134·5	13·8	720·6	oculated
		C	139·2	15·0	633·8	—
II	February 1967	A	146·2	11·0	946·0	40·5
		B	149·0	11·5	958·7	48·4
		C	137·0	9·5	871·0	48·2
III	July 1966	A	108·2	8·8	658·8	72·5
		B	123·0	9·6	863·7	85·0
		C	116·9	8·4	804·9	77·5

*Indicates final measurements of shoots taken just before inoculation.

It will be seen that, in all the coupes, the best growth of the bushes (as judged from total shoot length) was in treatment B. Nevertheless, in regard to yield of lac, there was not much of a difference between the three treatments, the yield being only slightly higher in B than in the other two. Therefore, treatment C

is to be preferred from lac cultivation stand point because yield of sticklac per acre (209 and 130 kg in *Aghani* and *Jethwi* crops) is highest in this spacing due to the larger number of the plants in this case (see Fig. 1A). These results are in conformity with the earlier findings during the past six crops. It can, therefore, be safely concluded that the optimum spacing between *bhalia* plants in a plantation for lac cultivation is $1{\cdot}22 \times 1{\cdot}22$ metres.

3. Effect of NPK on the yield of lac on *bhalia* (both with organic and inorganic manures)

Apart from spacing, manurial requirements of the bush were also investigated since 1965. The experiment was laid out on a randomised block design with the following five treatments and four replications. The plot was 24×18 metres with 200 bushes spaced at $1{\cdot}83 \times 1{\cdot}22$ metres.

Treatments:

A — NPK at 10, 20 and 20 kg/acre (Normal dose)

B — NPK at 20, 40 and 40 kg/acre (Double normal)

C — Farmyard manure at the rate of 18 quintals per acre (Normal dose)

D — Farmyard manure at the rate of 36 quintals per acre (Double normal dose)

E — No manure (Control)

NPK were supplied in the form of ammonium sulphate, superphosphate and muriate of potash respectively.

Aghani 1967-68 and *Jethwi* 1968 were raised during the period under report and performances were compared. It was found (see Fig. 1B) that there was substantial increase in the yield of lac when organic and inorganic manures were applied. The highest yields of lac were, however, obtained with the use of farmyard manure at the rate of 36 quintals per acre which were 76·6 and 94·2 per cent more than in the control in *Aghani* and *Jethwi* crops respectively. Further, crop yields during *Aghani* were always higher than in the case of *Jethwi*.

These results have been consistent for the six crops investigated.

4. Survey of lac enemies and their parasites: General survey — Qualitative

The survey of inimical insects of lac insects were continued for which *Aghani* and *Jethwi* crops were raised on *kusum* trees and *bhalia* bushes.

Emergence of predators and parasites were slightly more in the case of the crop raised on *bhalia* than on *kusum* (*Schleichera oleosa*). Among the predators, *Eublemma amabilis* Moore. was more than *Holcocera pulverea* Meyr. in both the crops. Among the parasites, *Tetrastichus purpureus* Cam. emerged in the largest number, the next by number being *Parechthrodryinus clavicornis* Cam. and *Coccophagus taschirchii* Mahd. Among the beneficial insects, *Pristomerus sulci* Mahd & Kolu. emerged in largest number. The number of these increased with the age of the crop.

The corresponding data for *Baisakhi* and *Katki* crops having been gathered earlier, the study was completed. The results are being compiled.

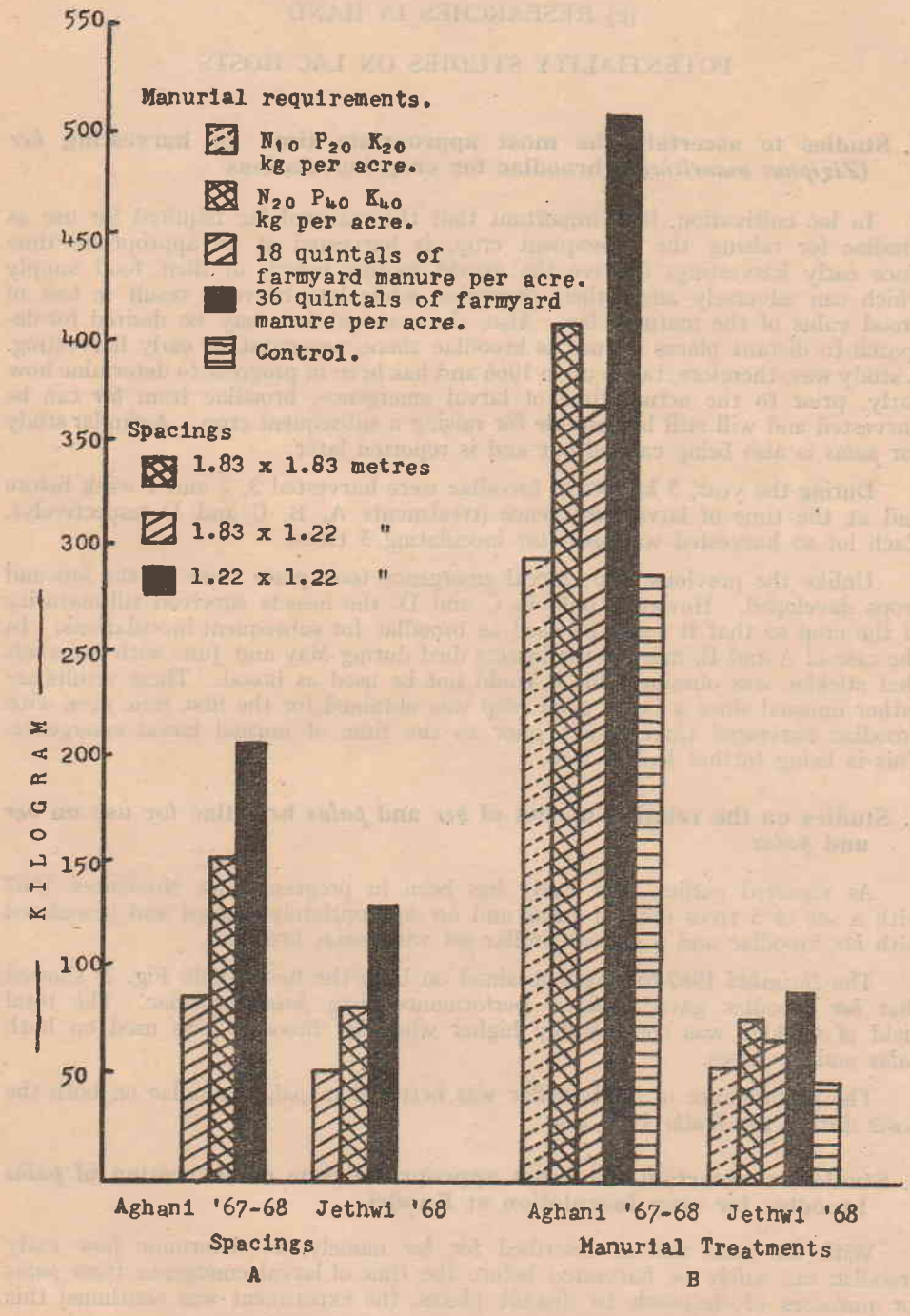


FIG. 1 — Sticklac yield per acre under different treatments

(b) RESEARCHES IN HAND

POTENTIALITY STUDIES ON LAC HOSTS

1. Studies to ascertain the most appropriate time for harvesting *ber* (*Ziziphus mauritiana*) broodlac for crop inoculations

In lac cultivation, it is important that the matured lac required for use as brodlac for raising the subsequent crop, is harvested at an appropriate time since early harvestings deprive the gravid mother insects of their food supply which can adversely affect their progenies, while late harvests result in loss of brood value of the matured lac. Also, the matured lac may be desired for despatch to distant places for use as broodlac there, necessitating early harvesting. A study was, therefore, taken up in 1966 and has been in progress to determine how early, prior to the actual time of larval emergence, broodlac from *ber* can be harvested and will still be suitable for raising a subsequent crop. A similar study for *palas* is also being carried out and is reported later.

During the year, 5 kg lots of broodlac were harvested 3, 2 and 1 week before and at the time of larval emergence (treatments A, B, C and D respectively). Each lot so harvested was used for inoculating 5 trees.

Unlike the previous year, larval emergence took place from all the lots and crops developed. However, only in C and D, the insects survived till maturity of the crop so that it could be used as broodlac for subsequent inoculations. In the case of A and B, most of the insects died during May and June with the result that sticklac was obtained but it could not be used as brood. These results are rather unusual since a fairly good crop was obtained for the first time even with broodlac harvested three weeks prior to the time of normal larval emergence. This is being further looked into.

2. Studies on the relative merits of *ber* and *palas* broodlac for use on *ber* and *palas*

As reported earlier, this study has been in progress since November 1967 with a set of 5 trees each of *palas* and *ber* appropriately pruned and inoculated with *ber* broodlac and a second similar set with *palas* broodlac.

The *Baisakhi* 1967-68 crops obtained on both the hosts (vide Fig. 2) showed that *ber* broodlac gave a better performance than *palas* broodlac. The total yield of sticklac was considerably higher when *ber* broodlac was used on both *palas* and *ber* trees.

The performance of *ber* broodlac was better than *palas* broodlac on both the hosts during the *Katki* 1968 also.

3. Studies to ascertain the most appropriate time of harvesting of *palas* broodlac for crop inoculation at Kundri

With the same aim as described for *ber* namely, to determine how early broodlac can safely be harvested before the time of larval emergence from *palas* for purposes of despatch to distant places, the experiment was continued this year also at Kundri.

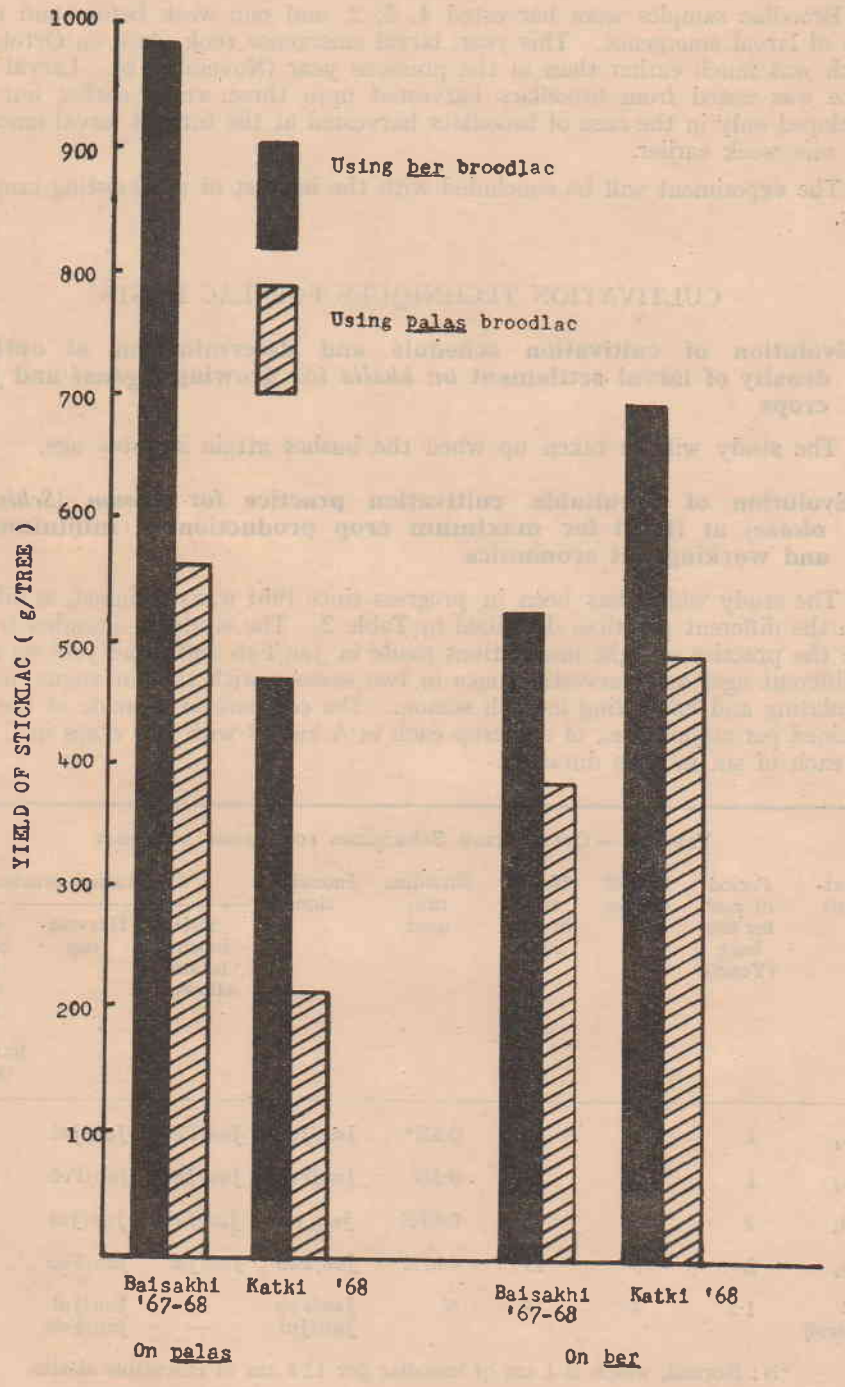


FIG. 2 — Relative merits of *Ber* and *Palas* Broodlac

Broodlac samples were harvested 4, 3, 2, and one week before and at the time of larval emergence. This year, larval emergence took place on October 12, which was much earlier than in the previous year (November 6). Larval emergence was noted from broodlacs harvested upto three weeks earlier but crops developed only in the case of broodlacs harvested at the time of larval emergence and one week earlier.

The experiment will be concluded with the harvest of the existing crop next year.

CULTIVATION TECHNIQUES FOR LAC HOSTS

4. Evolution of cultivation schedule and determination of optimum density of larval settlement on *bhalia* for growing *Aghani* and *Jethwi* crops

The study will be taken up when the bushes attain suitable age.

5. Evolution of a suitable cultivation practice for *kusum* (*Schleichera oleosa*) at Hesal for maximum crop production at minimum cost and working out economics

The study which has been in progress since 1961 was continued, as hitherto, with the different practices described in Table 2. The study is intended to compare the practice of light inoculations made in Jan/Feb and June/July on shoots of different ages and harvesting once in two seasons with that in vogue, namely, inoculating and harvesting in each season. The comparison is made of the crops obtained per annum, i.e., of one crop each in A and B with two crops in C which are each of six months duration.

TABLE 2 — CULTIVATION SCHEDULES FOR *kusum* AT HESAL

Treatment	Period of rest for the host (Years)	No. of coupes	No. of trees in each coupe	Broodlac rate used	Inoculation	Cultivation practice		
						Self inoculation allowed	Harvesting	Period between initial inoculation and harvesting (Months)
A_1	1	2	15	0·5N*	Jun/Jul	Jan/Feb	Jun/Jul	12
A_2	1	2	15	0·5N	Jan/Feb	Jun/Jul	Jan/Feb	12
B_1	2	3	15	0·67N	Jun/Jul	Jan/Feb	Jun/Jul	12
B_2	2	3	15	0·67N	Jan/Feb	Jun/Jul	Jan/Feb	12
C (Control)	1·5	4	15	N	Jan/Feb Jun/Jul	— —	Jun/Jul Jan/Feb	6 6

*N: Normal, which is 1 cm of broodlac per 12·5 cm of inoculable shoots.

The crop data for the year under report were as follows:

	Yield of sticklac — kg		*Crop ratio* †	
	1*	2**	1*	2**
A	101·70	257·30	1 : 4·4	1 : 9·93
B	183·70	300·10	1 : 7·4	1 : 9·17
C††	291·40	352·80	1 : 2·75	1 : 9·17

*Crop inoculation in Jun/Jul and harvested 12 months later.

**Crop inoculation in Jan/Feb and harvested 12 months later.

†The number of times the weight of sticklac of the crop increased over that in broodlac used for inoculation.

††The data given are for the two crops harvested during the corresponding period.

The results obtained are consistent with those found in the previous years. It is clear that much higher crop ratios (brood used to total yield of sticklac) are obtained when harvested once a year. The inoculation for the following crop was carried out again and the study will be concluded with the ultimate harvest in July 1969 after obtaining a further confirmation. The economics will also be worked out.

6. Studies on the proper time of harvesting cum coppicing *bhalia*

It has been fairly established that this bush does not sustain a normal lac crop through the summer months upto July (*Jethwi crop*) nor does it show proper growth after crop harvests in July. A study was, therefore, initiated during the year to see if the bush can be used to raise a crop which can be harvested as *ari* in May or whether it will sustain at least a partial or light crop to brood stage in July.

The following four practices were therefore tried.

(A) Heavy inoculation (400 g/bush) and complete harvesting as *ari* in May, (B) medium inoculation (200 g/bush) with partial harvesting as *ari* in May and complete harvesting in Jan/Feb next, (C) medium light inoculation (100 g/bush) and otherwise the same as in B and (D) light inoculation (50 g/bush) with complete harvesting after one year in Jan/Feb. Inoculations were thus always made during Jan/Feb. Crop from A was harvested completely and those from B and C partially in May as per schedule. The crop is progressing fairly satisfactorily in B where it is better than those in other practices.

These will be harvested in January/February next year.

7. Permanent field experiment for working out economics of cultivation of *Kusmi* lac on *bhalia* under different conditions of manuring and irrigation

The experiment was restarted in 1968 when irrigation facilities were available and was conducted under irrigated and non-irrigated conditions and with

varying conditions of manuring on a split plot design with the following treatments with 4 replications.

(a) *Main plot treatments*:

a_1	—	Irrigation
a_2	—	No irrigation

(b) *Sub-plot treatments*:

b_1	—	Control (No manure)
b_2	—	Organic manure
b_3	—	Inorganic manure
b_4	—	Combination of inorganic and organic manures

Inorganic manures as ammonium sulphate, superphosphate and muriate of potash were applied to the bushes just after inoculation in February 1968 (for the *Jethwi* crop) and organic manure as farmyard manure two months before inoculation.

Although yields of lac have not been very satisfactory, treatment differences were quite evident. Highest yield was recorded under irrigated condition with the use of farmyard manure at the rate of 18 quintals per acre.

ARBORICULTURAL/SYLVICULTURAL STUDIES

8. Studies on training of major lac hosts, e.g. *palas*, *ber*, *kusum*, *galwang* and rain tree (*Samania saman*) into bushes

Attempts were continued to train the above host trees into bushes and to investigate the possibility of exploiting such bushes for lac cultivation with a view to reduce the cost of cultivation operations and to facilitate agronomical treatments to maximize yield of lac.

(a) *Training into bushes*:

Galwang and *ber*, as reported earlier, had already been successfully trained and were used for lac cultivation. *Palas* and *kusum* were still in the process of training.

Palas — It was seen that, as reported last year, in *palas* trees which were coppiced during February 1967 and April 1967, the primaries did not attain further growth but that these produced secondaries from April onwards. Total length of secondaries developed from February and April coppicings were 662·5 and 497·6 cm respectively per bush.

Kusum — (i) The first set of *kusum* trees which was initially coppiced in July 1966 was again coppiced in January 1968. Average number of shoots and total shoot length attained per plant were 10·3 and 583·3 cm respectively by December 1968. (ii) In another set, which was coppiced in January 1967, the primaries did not show further growth during the year. However, secondaries started appearing in March/April 1968 and continued to grow till June 1968 and attained a total shoot length of 304·0 cm per plant. These plants were again coppiced in July 1968 and shoot growth has taken place from these. (iii) The third set which was coppiced in July 1967 showed second phase of growth in the primaries from March 1968 onwards and these attained a total shoot length of

474·5 cm per plant by December. Some of these primaries also produced secondaries which are developing satisfactorily.

(b) *Lac cultivation on trained bushes*

(i) *Lac yields — Galwang* and *ber* bushes were put to use for cultivation of lac. Since, however, these two hosts are particularly suited for summer and winter seasons, lac was grown alternately on *galwang* and *ber* bushes in the *Baisakhi* and *Katki* seasons respectively. The yield data set out in Table 3 show that the trained bushes of *galwang* and *ber* recorded yields of 186·7 g and 172·5 g sticklac per bush respectively. These results agree well with the earlier findings.

(ii) *Response to coppicing — Galwang* bushes from which a lac crop was harvested in July 1967, were coppiced in February. The shoots which appeared showed satisfactory growth till October recording a total length of 2678·0 cm for primaries and 3420·7 cm for secondaries.

The primaries from the harvested *ber* bushes have shown satisfactory growth and a total shoot length of 1015·1 cm was recorded. They also produced a large number of secondaries. The total shoot length of these was 2076·5 cm.

9. Finding out alternate hosts for *Kusmi* and *Rangeeni* strains of lac insects and conducting cultivation experiments on them

(i) *For Kusmi strain*

Galwang continued to be under trial as an alternate host to and also in alternation with *kusum*.

(a) In alternation with *kusum*, the respective yields on *kusum* and *galwang* in the *Aghani* and *Jethwi* seasons were 1·6 kg and 1·7 kg per kg broodlac used. These results are in agreement with those of the previous seasons.

(b) As an alternate host to *kusum*, *galwang* failed to produce the *Aghani* 1967-68 crop (*Annual. Report.* 1967) and therefore subsequent inoculation in the *Jethwi* could not be carried out on this host. However, the trials were resumed with the onset of *Aghani* 1968-69 season. The crop has again progressed rather poorly.

(ii) *For Rangeeni strain*

A similar study to find out alternate hosts for *Rangeeni* lac has been initiated with the start of the *Baisakhi* 1968-69 season.

Albizzia richardiana, *siran* (*A. chinensis*), *siris* (*A. lebbek*), *putkul* (*Ficus glabella*) and *gular* (*F. racemosa*) were inoculated both with *palas* and *ber* broodlacs. All the larvae on the first three hosts died soon after settlement. Although there was a crop on the remaining two, this was also very poor.

10. Finding out a suitable technique to induce drought resistance in *bhalia*

As mentioned already, *bhalia* is a successful alternate host for the superior *Kusmi* lac in the *Aghani* season but does not behave so in the *Jethwi* because these bushes cannot sustain themselves and the lac insects during the drought condition of the summer months. A study was, therefore, taken up beginning from March 1968 to examine the possibility of inducing drought resistance in

TABLE 3 — LAC CULTIVATION ON TRAINED BUSHES

Host	Month of coppicing/ harvesting	No. of bushes	Shoot measurement data per bush; average				Crop	Average yield data per bush	
			Primaries		Secondaries				
			Number of shoots	Total length (cm)	Number of shoots	Total length (cm)		Broodlac yield (g)	Total yield in sticklac (g)
Galwang	Jul 1966	67	12·7	1543·6	31·3	2067·8	*Baisakhi* 1967-68	383·3	186·7
	Feb 1968	60	16·4	2678·0	49·8	3420·7	Inoculated for *Baisakhi* 1968-69		
Ber	May 1967	50	17·3	1316·0	48·3	1774·6	*Katki* 1968	296·0	172·5
	May 1968	50	11·9	1015·1	34·5	2076·5	To be inoculated for *Katki* 1969		

this host by exposing its seeds to high temperatures, namely 40°, 45° and 50°C for a period of 24 hours (Treatments t_2, t_3 and t_4).

These seeds together with those not subjected to any heat treatment (t_1) were sown in nursery beds in March. Highest percentage (73·0 per cent) of germination was recorded in seeds exposed to 50°C and lowest (61·5 per cent) in the control.

Further investigations were carried out under (i) field conditions and (ii) on potted plants. Seedlings raised from the treated and control seeds were transplanted in the field as well as in the pots during the month of July.

(i) *Under field conditions*

The four treatments were replicated six times with 9 plants in each treatment. The plants which had grown satisfactorily, however, suffered adversely due to severe frost in the third week of December.

(ii) *Under potted condition*

Here, the temperature effects are being studied in relation to the restricted water supply provided at 4, 8, 12 and 16 day intervals. The plants have grown satisfactorily and will be brought under restricted water supply after lac inoculation in February 1969.

11. Artificial induction of polyploidy in *bhalia* by colchicine treatment

With a view to developing polyploid varieties of *bhalia* and studying their performance as lac host, *bhalia* seeds were treated with 0·10, 0·15, 0·20, 0·25 and 0·30 per cent colchicine solutions for 16 hours and were sown in earthen pots along with those receiving no colchicine treatment. Seedlings from the treated seeds were again treated with 0·25, 0·50, 0·75 per cent colchicine solutions for 6 hours. The seedlings are growing satisfactorily.

PHYSIOLOGICAL STUDIES

12. Amino acid and sugar contents of lac insect body at different developmental stages

The study has been taken up with a view to compare the amino acids and sugar contents of the lac insect body at its different stages of development with those of the plant sap which had been determined earlier. The body extracts, after freeing from proteins and dye, were subjected to two dimensional paper chromatography. The following solvent systems were tried:

	First dimension	*Second dimension*
1.	Methanol : water : pyridine (80 : 20 : 4 v/v/v)	*ter*-butanol : methyl ethyl ketone: water : diethyl amine (110 : 10 : 5 : 1 v/v/v/w)
2.	*n*-butanol : acetic acid : water (4: 1 : 5 v/v/v)	*m*-cresol : phenol : water (3 : 3 : 1 w/w/w)
3.	*n*-butanol : 3% ammonia (150 : 60 v/v)	*n*-butanol : formic acid : water (150 : 30 : 20 v/v/v)
4.	Phenol : water (74 : 26 w/v)	2,4,6-collidine saturated with water
5.	Phenol : water (80 : 20 w/v)	*n*-butanol : acetic acid : water (30 : 6 : 14 v/v/v)

However, the best separation was obtained from the last solvent system. All further studies were therefore carried out using this system. Amino acids of the insect body extract at early stages, i.e., crawling and after first moulting were identified. No difference in the number of the amino acids were observed at these two stages. The amino acids identified were proline/hydroxyproline, histidine, tyrosine, valine and lysine in the insect of the *Rangeeni* strain. Subsequently, separation was also carried out of the free amino acids present in the body extract of the insects of the *Kusmi* strain at their different stages, as moving larvae, settled larvae and fertilized females. Only six to seven free amino acids namely, proline/hydroxyproline, glycine, histidine, tyrosine, valine and lysine were identified in the moving and settled larval stages of the insect. Seven to eight amino acids proline/hydroxypyroline, glycine, histidine, tyrosine, valine, lysine and methionine were identified in the fertilized female (just after fertilization). Besides, at least two or three more ninhydrin positive spots were found which remain to be identified.

13. Studies on the relation of host to the fecundity and resin secretion efficiency of the *Rangeeni*/*Kusmi* strains of lac insect

Majority of the cultures of the *Rangeeni* strain raised on *bhalia*, *galwang*, *sandan* (*Ougeinia oojeinensis*), *ber* and *palas* as reported earlier were lost in *Katki* 1968 due to drying up of the host plants. Fresh cultures have, therefore, been started in the *Baisakhi* 1968-69 season.

14. Microbiological studies on lac insects

Four of the six microorganisms isolated from the body of lac insects (*A. Rep.* 1967) were subjected to various biochemical and other tests and the results are indicated in Table 4.

BREEDING AND GENETICAL STUDIES

15. Evolution of a high quality strain for lac cultivation on *palas*

As reported earlier, in order to boost up production of better quality lac, the possibility of adapting the superior *Kusmi* strain of lac insects to breed on the more abundantly available host of otherwise little economic value, namely, *palas* is being examined since 1966 by inoculating *palas* with *Kusmi* broodlac and using the rare survivors to continue their subsequent generations on *palas*. The *Kusmi* strain which had been reared in each successive generation continuously on *palas* had survived up to the fourth generation and had so far shown improvement in survival rate from generation to generation (*A. Rep.* 1967). The fifth generation which got started in March 1968 suffered unexpectedly and almost all the insects died. There was thus no broodlac available for continuing the progeny. However, another culture of the same *Kusmi* stock, started a generation later and reared similarly on *palas* was carried through the fourth generation during *Jethwi* 1968 producing a thick and continuous lac encrustation resembling *Kusmi* lac. The resulting fifth generation is again being raised on *palas* in *Aghani* season and has progressed very satisfactorily. The lac produced was compared with pure *Kusmi* and *Rangeeni* lacs and was found (vide Table 5) to retain the *Kusmi* characteristics with regard to colour index, life and flow.

TABLE 4 — RESULTS OF ROUTINE TESTS* FOR IDENTIFICATION OF MICROORGANISMS ISOLATED FROM THE INDIAN LAC INSECT

Serial No.	Morphological characteristics	Cultures																			
		L_1					L_2					L_3					L_4				
1	Gram's characteristics	(−)					(−)					(−)					(−)				
2	Flagella	(−)					(−)					(−)					(+)				
3	Capsules	(+)					(+)					(−)					(−)				
4	Spores	(−)					(−)					(−)					(+)				
5	Motility	(−)					(−)					(−)					(+)				
6	Shape	Cocci					Cocci					Coccoid					Rods				
7	Size, μ	1·98×1·85					2·66×2·18					2·0×2·5					2·6×1·6				
	Cultural characteristics																				
1	Colonies on agar plate	Shining yellow small round					Dull yellow small round					White slimy, small round					Dull white medium round				
2	Colonies on agar stroke	Effuse					Effuse					Rhixoid					Beaded				
3	Growth in nutrient broth	Membranous					Membranous					Flocculent					Flocculent				
4	Growth on potato plug	Flourishing					Flourishing					Flourishing					Flourishing				
5	Pigmentation on potato plug	Yellow					Yellow					Greyish white					Whitish				
6	Growth on deep agar	Upper surface					Upper surface					Bottom					Upper surface slightly below				
	Physiological characteristics																				
1	Reduction of nitrates to nitrites	(−)					(−)					(+)					(+)				
2	Reduction of nitrates to ammonia	(−)					(−)					(+)					(+)				
3	Indole production	(−)					(−)					(−)					(−)				
4	Production of hydrogen sulphide	(+)					(+)					(−)					(+)				
5	Relation to free oxygen	(+) (aerobic)					(+) (aerobic)					(−) (anaerobic)					(+) (aerobic)				
6	Liquefaction of gelatin	(−)					(−)					(+)					(+)				
7	Action on carbohydrates**	Gl	Su	La	Ma	Gy	Gl	Su	La	Ma	Gy	Gl	Su	La	Ma	Gy	Gl	Su	La	Ma	Gy
	i) Growth	M	L	M	M	M	M	L	M	L	M	L	M	M	M	L	M	M	M	M	M
	ii) Turbidity	H	L	M	M	M	H	M	M	L	M	L	L	L	M	N	H	M	M	M	M
	iii) Gas production	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	iv) Pellicle formation	N	N	N	N	N	N	N	N	F	F	F	F	F	F	F	N	N	F	N	N
	v) Acidity	N	N	N	N	N	N	F	N	N	N	F	M	N	N	N	M	M	N	N	M
	vi) Alkalinity	M	L	M	M	M	M	N	L	L	M	N	N	L	L	L	N	N	L	M	N

TABLE 4 (contd.) — RESULTS OF ROUTINE TESTS* FOR IDENTICATION OF MICROORGANISMS ISOLATED FROM THE INDIAN LAC INSECT

Serial No.	Physiological characteristics	Cultures			
		L_1	L_2	L_3	L_4
8	Hydrolysis of starch	(+)	(+)	(+)	(−)
9	Digestion of cellulose	(−)	(−)	(−)	(−)
10	Action on Milk:				
	i) Peptonization	(+)	(+)	(++)	(++)
	ii) Gas production	(−)	(−)	(−)	(−)
	iii) Curdling	(+)	(+)	(++)	(++)
	iv) Ropiness	(−)	(−)	(−)	(−)
	v) Serumzone clear	(+)	(+)	(+)	(+)
11	Reduction of litmus milk	(+)	(−)	(+)	(++)
12	Methyl Red test	(+)	(+)	(−)	(+)
13	Voges-Proskauer test	(−)	(−)	(−)	(−)

On the basis of these results, the four microorganisms have been provisionally identified as *Micrococcus* sp. (L_1), *M. conglomeratus* (L_2), *Clostridium* sp. (L_3) and *Bacillus subtilis* (L_4).

(+) — Positive.
(++) — Double positive.
(−) — Negative.

*These tests were carried out at the Division of Microbiology in the Indian Agricultural Research Institute, New Delhi and our gratitude to the authorities of the Institute is acknowledged.

**Gl for Glucose, Su for Sucrose, La for Lactose, Ma for Mannitol, Gy for Glycerol, L for less, M for moderate, H for heavy, N for nil or negative, F for found.

TABLE 5 — COLOUR INDEX, LIFE AND FLOW OF DIFFERENT SEEDLACS

Lac	Colour index	Life at 150°C (minutes)	Flow (mm/ 15 min.)
1. *Kusum* lac on *kusum*	7	108	66
2. *Kusum* lac on *palas*	6	118	54
3. *Palas* lac on *palas*	16	66	33

16. Study of pleiotropic effects of the yellow gene

Yellow is the first discovered mutant in lac insects which is inherited as a recessive Mendelian character and produces its most obvious effect on the body colour of these insects, conditioning it yellow from the normal crimson colour. Economic evaluation of this mutation was made by crossing the yellow females and crimson males and raising a large F_2 to recover the two parental colour forms for comparison of their average performance for (i) life period, (ii) fertility and (iii) resin output and quality.

BIOLOGICAL AND ECOLOGICAL STUDIES ON THE PESTS OF LAC HOSTS, LAC ENEMIES AND THEIR PARASITES

17. Collection of pests of lac hosts and studies on their life history and control operations against important pests

(a) *Life history studies*

(i) *Pest of Grewia multiflora* — The pest which was under study has been identified as *Cosmophila erosa* Hubn. (Noctuidae).

Studies were taken up again with the appearance of the pest in the Institute plantation at Namkum in June 1968 when larvae were collected for rearing in the laboratory. The pest was active in the field from June to October, thereafter the larvae entered into hibernation.

Four generations of the pest could be reared in the laboratory during this period. The egg, larval, pre-pupal and pupal periods were of 2-3, 14-19, 1-2 and 6-11 days respectively. The egg to adult stage occupied 24-34 days.

(ii) *Pest of bhalia* — A pest of *bhalia* identified as *Amsacta lactinea* Cram. (Arctidae) was noticed in the Institute plantation at Namkum from June 1968 to November 1968 which also passed into hibernation soon after. Only 2-3 generations could be reared in the laboratory. The moth lays 400-1000 eggs in batches. The first instar caterpillars feed gregariously and skeletonize the leaf surface and, after a week, they were found scattered all over the plant. The fully mature caterpillars are voracious feeders who devour the leaves completely. The egg, larval, pre-pupal and pupal periods were 4, 22-33, 1-3 and 8-40 days respectively. The egg to adult stage was 38-73 days.

(b) *Control aspects*

(i) *Field trials against pests of bhalia* — With the availability of the under mentioned insecticides, viz., Aldrex (30 E.C.), Dieldrex (18 E.C.), Endrex (20 E.C.), D.D.T. (25 E.C.), B.H.C. (50 per cent W.P.), D.D.T. (50 per cent W.P.) and chlordane (65 per cent dust), the control aspect of those insects whose life history studies have been completed was taken up since September.

The experiment was laid out on a randomized block design having 25 bushes in each treatment and replicated five times. The start was made by adopting a spraying schedule with all the insecticides at the same concentration of 0·25 per cent. The first spraying was done on 20th September and the second after a fortnight. Mortality counts of the pest was studied at intervals of 24, 48 and 72 hours after each spraying.

Endrex 20 E.C. was found to be more effective than the others against *Platypeplus aprobola* Meyr., *Hypena iconicalis* Walk., *Hemithea tritonaria* Walk., *Nephopteryx leucophaella* Zell. and *Dasychira mendosa* Hubn. var *fusiformis* Walk.

(ii) *Laboratory trials on P. aprobola and H. iconicalis* — Endrex (20 E.C.), Aldrex (30 E.C.), Dieldrex (18 E.C.) and D.D.T. (25 E.C.) as emulsion spray and B.H.C. (50 per cent W.P.) and D.D.T. (50 per cent W.P.) as suspension spray at 0·25 per cent concentration were tried. Endrex and D.D.T. (25 E.C.) were found to be very effective against *P. aprobola*, and Dieldrex against *H. iconicalis*. Complete mortality occurred in 48 hours.

(iii) *Field tials against Belippa laleana* Moore *on palas* — Attack of the pest was quite heavy during October and November in the Institute plantation at Namkum. Field trials were carried out in the same manner as detailed in the case of *bhalia* pests, and dosages used were Dieldrex at 0·30, 0·35 and 0·40 per cent, Endrex at 0·03, 0·10 and 0·17 per cent and D.D.T. at 0·3 and 0·35 per cent as suspension spray. These were replicated twice.

Incidence and mortality counts of the pests were taken 24 hours before and 24, 48 and 72 hours after spraying. Preliminary observations showed that Endrex 0·17 per cent was the most effective.

SURVEY OF LAC ENEMIES

18. Seasonal incidence and extent of damage by predators *Eublemma amabilis* and *Holcocera pulverea* on *Kusmi* lac grown on *bhalia*

This study was resumed and has been in progress since 1965.

Jethwi and *Aghani* crops were again raised on *bhalia* during the year. Random samples were collected at fortnightly intervals commeneing from the time of male emergence till maturity of the crops. They were microscopically examined for (i) population of lac insects living, dead and damaged, (ii) population of the predators including the immature stages, (iii) number of cells damaged or eaten up by the predators and (iv) the area of encrustation damaged by the predators.

It was found that the population of these predators was higher in the *Aghani* than in the *Jethwi* crop and the damage caused to lac crop in the two seasons were 41·43 and 22·62 per cent respectively as indicated in Table 6.

This study is to be concluded after the final harvest in Jan/Feb 1969.

TABLE 6 — INCIDENCE OF AND DAMAGE CAUSED BY THE PREDATORS

	E. amabilis		*H. pulverea*	
	Aghani	*Jethwi*	*Aghani*	*Jethwi*
Peak period	Sep. to Dec.	Second fortnight of June	At the time of crop maturity	Second fortnight of June
Damage caused to lac crop, per cent	16·54	7·86	24·89	14·73

BIOLOGICAL CONTROL OF LAC ENEMIES

19. Control of lac predators by the use of *Bacillus thuringiensis* Berl.

Preliminary trials with *Bacillus thuringiensis* in the laboratory as well as in the field had indicated that the larvae of *E. amabilis* and *H. pulverea* are highly susceptible to this bacterial insecticide. Trials were therefore continued in the field to determine the optimum concentration of the thuricide, spray interval and the number of sprays under each for an effective control of these predators.

The spray schedules tried included 0·02, 0·04, 0·06 and 0·12 per cent concentrations of the thuricide sprayed at 10, 20 and 30 days interval and with varying number of total sprays under each. The incidence of inimical insects was assessed by collecting lac sample (300-500 g) at random from the treated and untreated crops at three different stages in their development and caging these samples separately in parasite cages for noting emergence of various insects.

Aghani 1967-68 — The crop was on *bhalia*. Incidence of the predators was reduced by 65-82 per cent in the treated crops when sprayed with 0·06 and 0·12 per cent concentrations of the thuricide at 10 day intervals. Sticklac yield was increased by 70-80 per cent.

Baisakhi 1967-68 — The crop was raised on *palas*. Incidence of the predators was reduced by 73-86 per cent in the treated crops, resulting in substantial increase (68-81 per cent) in the yields of sticklac.

Jethwi 1968 — The crop was raised on *bhalia* as well as on *kusum*. The crop on the former, however, suffered heavy mortality and the results on *kusum* were more or less similar to those in the *Baisakhi* crop.

20. Survey of pathogenic organisms in the lac insect predators *E. amabilis* and *H. pulverea*

The survey of pathogenic organisms of lac predators was continued during the year by collecting larvae of the two predators from the Institute plantation and examining them for the presence of pathogenic microorganisms. Two microbial diseases were detected. The isolation and culture of the causative microorganisms have now been taken up recently and is in progress.

CHEMICAL CONTROL OF LAC INSECT PARASITES AND PREDATORS

21. Effect of different insecticidal sprays on the incidence of parasites and predators attacking *Kusmi* lac crop grown on *bhalia*

The *Jethwi* crop was sprayed with 0·40 per cent concentration of cryolite and sodium fluosilicate and 0·25 per cent concentration of Dieldrex at 10, 20 and 30 days interval. Lac samples were collected at random from treated and untreated crops at three different stages in their development and placed separately in parasite cages for noting emergence of the inimical insects. The first two insecticides were found effective against the predators reducing their incidence by 40-60 per cent but not against parasites. Dieldrex was only slightly effective against both the parasites and predators.

REGIONAL FIELD RESEARCH STATIONS

Three stations, two for *Rangeeni* lac at Damoh (M.P.) and Mirzapur (U.P.) and one for *Kusmi* lac at Dharamjaigarh (M.P.) continued to function during the year under report. *Ghont* (*Zizyphus xylopyra*) at Damoh, *ghont* and *palas* at Mirzapur and *kusum* at Dharamjaigarh continued to be the main hosts under study. The experiments on *ghont* were identical at Damoh and Mirzapur.

DAMOH AND MIRZAPUR

(i) *Studies on the response of ghont to pruning to grow lac crops and systematic cultivation of lac on this host*

The pruning periods were as follows:

Treatment	Pruning time	
	Baisakhi	*Katki*
A	2nd week of April	At the time of harvesting in November
B	3rd week of May	Second week of February
C	November	Second week of May. (There were two coupes in this for use in alternate years)

Damoh — The crop was poor, in both *Baisakhi* and *Katki* seasons yielding no broodlac in the former and only a negligible quantity in the latter season. Brood used to brood yield ratios in the *Katki* season were 1: 0·79; 1: 0·75 and 1: 0·60 for treatments A, B and C respectively.

With regard to total yield of sticklac also, the crop ratio (brood used to total yield of sticklac) was highest in treatment A.

Regarding the response to pruning, maximum surface area for colonization by lac insects was available in treatment C in both *Baisakhi* and *Katki* seasons.

Mirzapur — The study was discontinued in view of the repeated crop failures on this host at this station.

(ii) *Determination of optimum requirement of broodlac for crop inoculations on ghont (at Damoh) and ghont and palas (at Mirzapur)*

(a) *Ghont* — Three brood rates, namely 0·4 kg (treatment A), 0·8 kg (B), and 1·2 kg (C) per tree were tried, as hitherto, both in *Baisakhi* and *Katki* seasons at Damoh. At Mirzapur, the three rates were 0·5 kg (A), 1·0 kg (B) and 1·5 kg (C) because of the larger crown of trees in this region. The results obtained were as follows:

(i) *Damoh* — Although the yields of broodlac as well as sticklac were poor in both *Baisakhi* and *Katki* seasons, the ratio of brood used to brood yield and of brood used to total yield were highest in treatment ' A ' in both *Baisakhi* and *Katki* seasons.

(ii) *Mirzapur* — The study was discontinued in view of the repeated crop failures.

(*b*) *Palas* — The brood rates tried were 0·4 kg (A), 0·8 kg (B), 1·6 kg (C) and 2·4 kg (D).

In the *Baisakhi* crop, the ratio of brood used to brood yield were 1: 1·20, 1: 0·48, 1: 0·99 for A, B and C respectively. No broodlac was obtained in D. The ratio of brood used to total yield of sticklac were 1: 1·56, 1: 1·16, 1: 0·85 and 1: 0·84 for A, B, C and D respectively.

Inoculations were not made for the *Katki* season due to the imminent closing down of the station.

(iii) *Evolution of a suitable cultivation practice to be followed for ghont at Damoh and ghont and palas at Mirzapur*

The following cultivation schedules were studied:

Treatment	Time of prunning	Inoculation		Time of crop harvesting		Period from inoculation to har- (months)
		Month	Brood rate/tree	Partial	Complete	
A	Apr	Oct/Nov	0·5N*	—	Oct/Nov	12
B	,,	,,	N	Jun/Jul	,,	8 and 4
C	,,	,,	2N	—	Apr	5
C_1			2N	—	May	6
D	Oct/Nov	,,	0·5N	—	Oct/Nov	12
E	,,	Jun/Jul	N	—	,,	4

*N stands for Normal brood rate which was arbitrarily fixed as 0·4 kg at Damoh and 0·5 kg at Mirzapur per tree for *ghont* and 0·8 kg per tree at Mirzapur for *palas*.

Each treatment was tried on 5 trees with 10 replications. There were 500 trees under each host at each station. The results obtained were as follows:

(a) *Damoh* — With regard to the yield of broodlac, the ratio of brood used to brood yield was highest in treatment ' D '. In regard to crop ratio, *ari* cutting in May (treatment C_1) was better than in April (treatment C).

(b) *Mirzapur* — The crop was a failure excepting in treatment E where also the crop ratio was only 1: 1·07.

On *palas*, the crop ratios were 1: 3·93, 1: 2·82, 1: 2·0, 1: 2·19, 1: 1·4 and 1: 0·93 for treatments, A, D, B, E, C and C_1 respectively. These results are not consistent with those obtained earlier.

(iv) *Investigation of likely Rangeeni hosts occuring in the region and their proper use to supplement production of ghont and palas lac at Damoh and Mirzapur*

At Damoh, *palas, khair, dhobein, airma* and *renja* continued to be under study. All these hosts gave promising results.

At Mirzapur, *gular* has shown promise as a lac host whereas *kuchai* failed to carry lac.

(v) *Qualitative and quantitative survey of the friends and enemies of lac insects*

The following insects were found to emerge from the four crops:

Enemies	Friends
Parasites:	
1. *Coccophagus tschirchii* Mahd.	11. *Apanteles fakhrulhajiae* Mahd.
2. *Erencyrtus dewitzi* Mahd.	12. *Apanteles tachardiae* Cam.
3. *Eupelmus tachardiae* How.	13. *Brachymeria tachardiae* Cam.
4. *Marictta javensis* How.	14. *Bracon greeni* Ashm.
5. *Parechthrodryinus clavicornis* Cam.	15. *Bracon hebetor* Say.
6. *Tachardiaephagus somervilli* Mahd.	15. *Chelonella cyclopyra* Franz.
7. *Techardiaephagus tachardiae* How.	17. *Elasmus claripennis* (Cam.)
8. *Tetrastichus purpureus* Cam.	18. *Eurytoma palidiscapus* Cam.
Predators:	19. *Perisierola pulveriae* Kurian.
9. *Eublemma amabilis* Moore.	20. *Pristomerus sulci* Mahd & Kolu.
10. *Holcocera pulverea* Meyr.	*Miscellaneous*:
	21. Coleoptera
	22. Tineidae

Their distribution is indicated in Table 7 where the numbers refer to those in the above list.

DHARAMJAIGARH

(i) *Evolution of a suitable cultivation practice to be followed for kusum* — The trees have been pruned. As per schedule, they will be brought under further operations from 1970 onwards.

(ii) (a) *Investigations of likely Kusmi lac hosts occuring in the region and their proper use to supplement production of Kusmi lac* — As many as 14 species of plants were tried in *Aghani* 1967-68, *Jethwi* 1968 and *Aghani* 1968-69. So far, *khair* and *dumar* only showed promise.

(b) *Selection and introduction of suitable regional or exotic hosts to fortify cultivation of lac on kusum* — *Galwang* plants raised for this study failed to survive. Others such as rain tree, *khair* and *bhalia* also could not be raised.

(iii) *Qualitative and quantitative survey of the friends and enemies of the lac insect* — The data obtained are indicated in columns vii to x of Table 7.

TABLE 7 — EMERGENCE OF INIMICAL AND FRIENDLY INSECTS OF LAC INSECT

I	II	III	IV	V	VI	VII	VIII	IX	X
Month	Baisakhi 1967-68		Katki 1968			Jethwi 1968		Aghani 1968-69	
	At Damoh	At Mirzapur	Month	At Damoh	At Mirzapur	Month	At Dharam-jaigarh	Month	At Dharam-jaigarh
January 1968	No emer-gence	No emer-gence	August 1968	No emer-gence	1, 5, 7, 8, 10, 14 & 16	February 1968	10 & 12	October 1968	3, 5, 12, 16, 17, 18, 20 & 21
February	1, 2, 5 & 8	8	Sep-tember	1-3, 7-10, 12-14, 17, 18, 20-22	4, 5, 7-10, 12, 14, 16, 17, 19, 21 & 22	March	5, 7-10, 12 & 21	Novem-ber	3, 5-8, 11-13, 15, 18, 20 & 21
March	2, 5-8 & 10	8 & 10	October	1-3, 5, 6, 8-10, 12-14, 16 & 18-21	1-5, 7-10, 12-14, 16, 18, 19 & 20-22	April	9, 10, 12, 20 20 & 21	Decem-ber	3, 5-8, 10, 12, 15, 18 & 21
April	2, 4, 5, 7-10 & 20	No emer-gence	Novem-ber	1-3, 5-10, 12-14, 17 & 18	No emer-gence	May	9-12, 14 & 21 21		
May	9, 10 20	10 & 16				June	9-11, 14 & 21		
June	9 & 10	No emer-gence				July	9-11 & 21		
July	3, 9-12, 13, 16, & 20-22	5-10, 12, 21 & 22							

(c) RESEARCHES CONTEMPLATED

Four of the various studies in progress during the previous year were completed during the year under report. The remaining will be continued of which a few are expected to be completed. Besides, the items contemplated last year were initiated and are now in progress. It is also intended to take up the following new studies.

1. Vegetative propagation of major lac hosts to obtain plants of desired character
2. Mutation studies of lac hosts
3. Cytotaxonomic and mutation studies in lac host plants
4. Role of associated microorganisms in the physiology of lac insect
5. Lipid metabolism in lac insects
6. Mutation studies on lac insects
7. Quantitative inheritance — I: Genetic variation of dye content in lac insects.
8. Genetic analysis of chromosome behaviour in lac insects
9. Effect of delayed mating in lac insects
10. Influence of photo period on lac insect.

(B) CHEMISTRY DIVISION

Research activities of the Chemistry Division, like those of the Entomology Division, were as per Project Proposals for the year submitted to the Indian Council of Agricultural Research. These were largely based on the programme recommended by the Achievement Audit Committee (1966).

A detailed report on the results of the various items now follows:

(a) RESEARCHES COMPLETED

(i) *Shellac etch primer*

A single pack etch primer based on shellac had been developed in this Institute and the product had been manufactured and marketted by a leading firm of paint manufacturers. This composition contained the conventional pigment, zinc chrome, as one of the essential constituents. As zinc is an imported item, the possibility of replacing zinc chrome with other chromate pigments, produced from indigenously available raw materials such as barium chromate and barium potassium chromate, was investigated.

Compositions of satisfactory performance had been formulated and reported earlier (*A. Rep.* 1967, p. 38). Their shelf lives have now been tested. It has been found that shelf life of the primer using barium chromate was not satisfactory. Barium potassium chromate was, however, quite satisfactory, the optimum proportion being 50 parts in place of 95 parts of zinc chrome per 100 parts of lac. The following is the optimum composition of the primer:

Dewaxed shellac	100 parts
Methylated spirit	100 ”
n-Butyl alcohol	82 ”
Barium potassium chromate	50 ”
Phosphoric acid	30 ”

This primer is comparable in all respects with the one containing zinc chrome.

(ii) *Shellac-oil combinations modified with phenolics*

"Durophen" is a thermohardening butylated bisphenol A/formaldehyde condensate. The castor oil plasticised product possesses enamel like hardness, good elasticity and adhesion, and good resistance to chemicals, shock, impact and scratch. Shellac is a resin that combines easily with castor oil. Hence, attempts were made to develop a "Durophen" type product by incorporating shellac-castor oil combination in place of castor oil with the above phenolic resin.

Dewaxed shellac-castor oil compositions containing different proportions of the two were prepared, as usual, in the presence of calcium hydroxide (5 per cent on the weight of shellac) as incorporating agent. The phenolic condensate was prepared by the standard method from bis-phenol A (1 mol) in aqueous solution of sodium hydroxide (2 mols) and formaldehyde (1-4 mols). The condensate was then butylated. The two compositions were then mixed in different proportions and dissolved in toluene and films prepared on tin plate. They were baked at 150°C for 30 minutes and tested for hardness, flexibility and impact and solvent resistance.

Hardness was found to increase with increase in the proportion of the phenolic resin but flexibility suffered simultaneously. The films were found to have good adhesion but poor impact resistance. Most of the compositions were found to be resistant to 6*N* sulphuric acid and the usual types of solvents upto 7 days.

The best surface coating properties including resistance to chemicals and solvents were obtained when the ratio of lac to castor oil was 50: 50, the phenol to formaldehyde was 1: 2 mol and the lac oil combination to the phenolic resin was 1: 3 by weight.

(iii) *Water soluble lac dye*

A laboratory method has been developed earlier (*A. Rep.* 1967, p. 33) for recovering the total water soluble lac dye from sticklac wash water through the calcium salt. A few runs were conducted during the year under report on a semi-pilot scale. *Rangeeni* sticklac (100 kg) was washed with water (about 1,000 l) and the wash water treated with concentrated sulphuric acid (1 kg). The precipitated sludge carried down with it the major portion of the dye. After settling, the supernatant clear liquor was decanted and the dye still retained in it was recovered as the calcium salt by treating the liquor with lime.

The dye from the wet sludge was extracted with boiling water (30 l) and was recovered from the extract as its calcium salt. The two calcium salts (5·4 kg) were taken together and decomposed with hydrochloric acid (5·5 l concentrated acid diluted to 10 per cent concentration) when crude dye (807 g) was obtained. Recrystallization from water gave the pure dye (760 g or 0·76 per cent on the weight of sticklac). Ash content of this dye was only 0·8 per cent. It was completely soluble in water and has retained its solubility for 10 months so far.

(iv) *Effect of solvents on the film properties of lac*

Lac dissolves freely in the lower alcohols and partly in esters and ketones and produces highly glossy, hard, adherent and durable films on wood and other substrates. The rate of evaporation of the solvent from the film and retention

of solvent in the film play an important role in the properties of the film. This is particularly of importance in the printing ink industry.

A study was therefore taken up on the effect of various solvents on the film properties of lac. Varnishes containing 25 per cent solids were prepared in methyl, ethyl, propyl, isopropyl, butyl and amyl alcohols and mixtures of acetone-water (93:7) and ethyl acetate-ethyl alcohol (85:15). Films were prepared on tinplate and glass panels by flowing and on wood by French polishing. For comparison, a film without the use of solvent was also prepared by the familiar technique of wood turnary. Mechanical properties and resistance of these films to water, heat, solvents and chemicals were examined, both after air drying for seven days as well as after baking at 150°C for 30 minutes. It was found that there was hardly any difference in the film properties except in the case of the air dried films of varnishes prepared from butyl and amyl alcohols. These films were a little more flexible and somewhat less heat resistant, presumably, because the films still retained appreciable amounts of these alcohols at the time of testing (after seven days air drying). However, the heat and water resistance of the films formed by dry lacquering i.e. without the use of any solvent were better than those using solvents.

Solvent release from the various films was determined by spreading known weights of the varnishes on weighed 15 cm × 15 cm tinplate panels and weighing these from time to time till the weights became constant. It was found (see Fig. 3) that constant weight was reached within 7 days only in the case of varnishes in methyl and ethyl alcohols (Film thickness was approximately 0·8 mil). In all other cases, it took much longer.

(v) *Water thinned red oxide shellac primers*

Effect of both organic and inorganic corrosion inhibiting chemicals on water based red oxide primers developed earlier had been studied (*A. Rep.* 1967, p. 36).

During the year under report, the effect of various anticorrosive pigment mixtures was studied. Primers were prepared incorporating the following pigment mixtures in 200 g aqueous lac-maleinized linseed oil vehicle by grinding in a ball mill for 18-20 hours. The vehicle had 33 per cent solids containing lac and maleinized oil in the ratio of 3:2.

Pigment mixtures

1. Red oxide 30 g and zinc chrome 6 g
2. Red oxide 28 g and barium potassium chromate 8 g
3. Titanium dioxide 12 g and aluminium powder 24 g
4. Aluminium powder 24 g and zinc oxide 12 g
5. Red oxide 32 g and mica powder 4 g
6. Aluminium powder 24 g, zinc oxide 8 g and mica powder 4 g

Properties of the films were studied after baking at 150°C for 30 minutes. Compositions 3 to 6 did not show any corrosion on continuous immersion in water for 20 days and on exposure in a humidity cabinet for 40 days. The pigment mixtures were thus distinctly superior to red oxide alone as far as their anticorrosive properties are concerned.

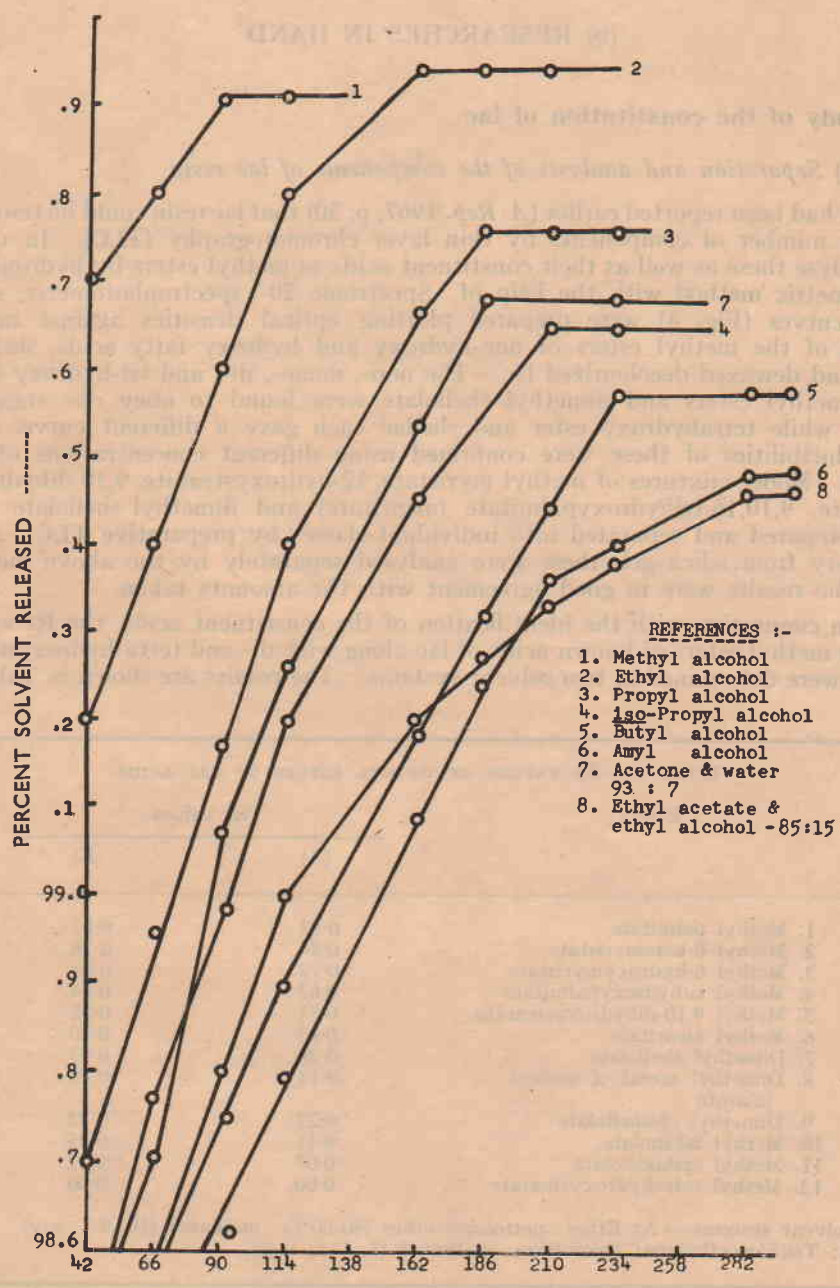

PERCENT SOLVENT RELEASED -------
.9
.8
.7
.6
.5
.4
.3
.2
.1
99.0
.9
.8
.7
98.6
42
66
90
114
138
162
186
210
234
258
282
1
2
3
7
4
5
6
8
REFERENCES :-
1. Methyl alcohol
2. Ethyl alcohol
3. Propyl alcohol
4. iso-Propyl alcohol
5. Butyl alcohol
6. Amyl alcohol
7. Acetone & water 93 : 7
8. Ethyl acetate & ethyl alcohol - 85:15
DRYING TIME------- HOURS

FIG. 3

(b) RESEARCHES IN HAND

1. Study of the constitution of lac

(a) *Separation and analysis of the components of lac resin*

It had been reported earlier (*A. Rep.* 1967, p. 30) that lac resin could be resolved into a number of components by thin layer chromatography (TLC). In order to analyse these as well as their constituent acids as methyl esters by hydroxamic colorimetric method with the help of 'Spectronic 20' spectrophotometer, standard curves (Fig. 4) were prepared plotting optical densities against micrograms of the methyl esters of non-hydroxy and hydroxy fatty acids, shellolic acid and dewaxed decolourized lac. The non-, mono-, di-, and tri-hydroxy fatty acid methyl esters and dimethyl shellolate were found to obey one standard curve while tetrahydroxy ester and shellac each gave a different curve. The reproducibilities of these were confirmed using different concentrations of the esters. Model mixtures of methyl myristate, 12-hydroxystearate, 9,10-dihydroxystearate, 9,10,16-trihydroxypalmitate (aleuritate) and dimethyl shellolate were also prepared and separated into individual classes by preparative TLC. After recovery from silica gel, these were analysed separately by the above method and the results were in good agreement with the amounts taken.

In connection with the identification of the constituent acids, the Rf values of the methyl esters of known acids of lac along with di- and tetra-hydroxystearic acids were determined in two solvent systems. The results are shown in Table 8.

TABLE 8 — Rf VALUES OF METHYL ESTERS OF LAC ACIDS

Esters	Rf values	
	(A)	(B)
1. Methyl palmitate	0·93	0·82
2. Methyl 6-ketomyristate	0·84	0·78
3. Methyl 6-hydroxymyristate	0·79	0·71
4. Methyl ω-hydroxypalmitate	0·62	0·54
5. Methyl 9,10-dihydroxystearate	0·51	0·51
6. Methyl aleuritate	0·13	0·29
7. Dimethyl shellolate	0·26	0·47
8. Dimethyl acetal of methyl jalarate	0·14	0·28
9. Dimethyl epishellolate	0·22	0·32
10. Methyl laksholate	0·11	0·25
11. Methyl epilaksholate	0·07	0·22
12. Methyl tetrahydroxystearate	0·00	0·00

Solvent systems — A: Ether: petroleum ether (40-60°C): methanol (10: 9:1, v/v).
B: Trichloroethylene: chloroform: methanol (5: 2: 1, v./v).

Kusum, ber and *palas* seedlacs and dewaxed decolourized lac were esterified directly with methanolic hydrogen chloride. After the usual working up, the ester mixtures were examined by TLC and found to separate into eight distinct classes of esters. The presence of a few more in traces was also noticed.

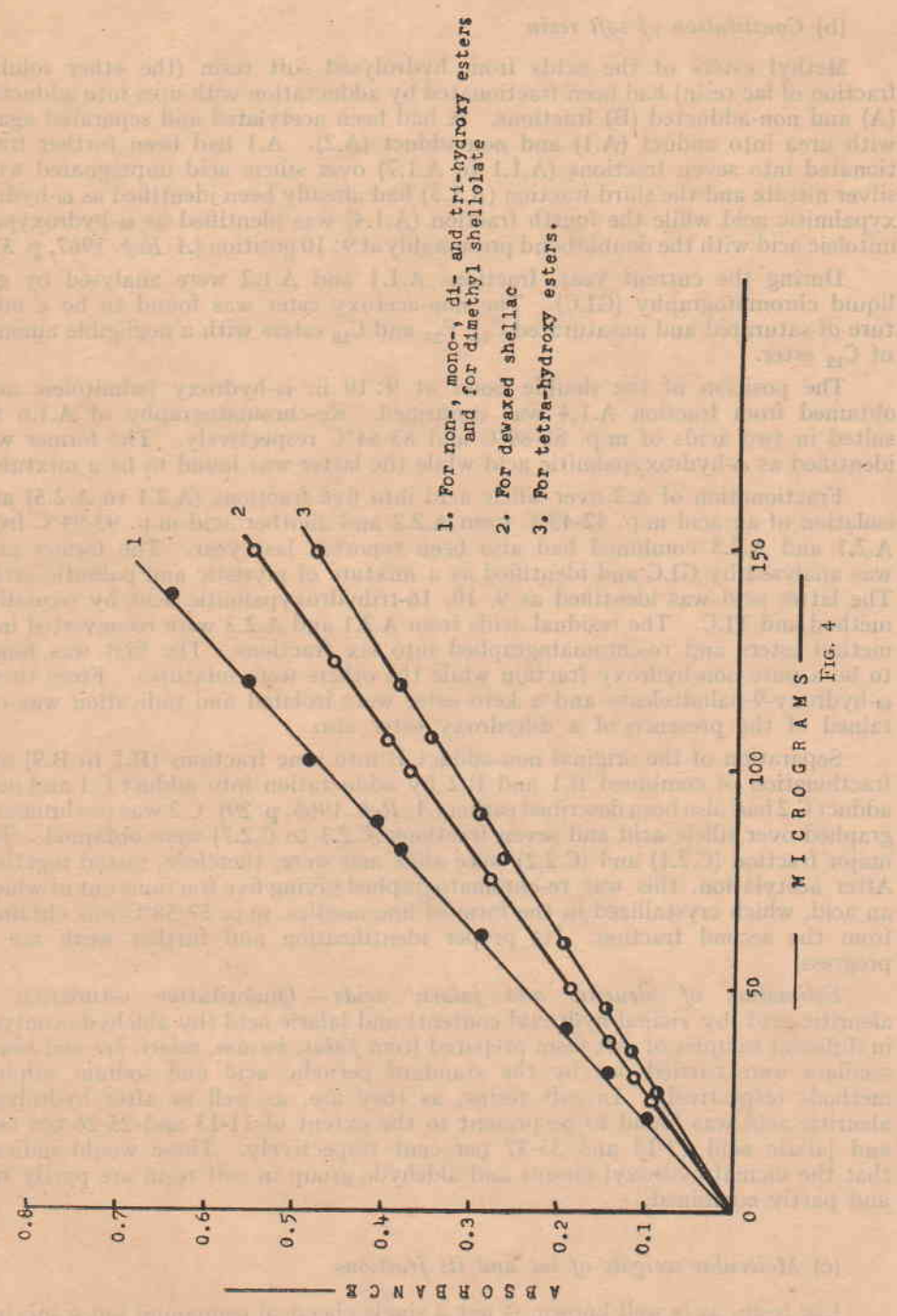

1. For non-, mono-, di- and tri-hydroxy esters and for dimethyl shellolate
2. For dewaxed shellac
3. For tetra-hydroxy esters.
1
2
3
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
50
100
150
ABSORBANCE
MICROGRAMS

FIG. 4

(b) *Constitution of soft resin*

Methyl esters of the acids from hydrolysed soft resin (the ether soluble fraction of lac resin) had been fractionated by adductation with urea into adducted (A) and non-adducted (B) fractions. A had been acetylated and separated again with urea into adduct (A.1) and non-adduct (A.2). A.1 had been further fractionated into seven fractions (A.1.1 to A.1.7) over silicic acid impregnated with silver nitrate and the third fraction (A.1.3) had already been identified as ω-hydroxypalmitic acid while the fourth fraction (A.1.4) was identified as ω-hydroxypalmitoleic acid with the double bond presumably at 9: 10 position (*A. Rep.* 1967, p. 31).

During the current year, fractions A.1.1 and A.1.2 were analysed by gas liquid chromatography (GLC). The non-acetoxy ester was found to be a mixture of saturated and unsaturated C_{14}, C_{16} and C_{18} esters with a negligible amount of C_{12} ester.

The position of the double bond at 9: 10 in ω-hydroxy palmitoleic acid obtained from fraction A.1.4 was confirmed. Re-chromatography of A.1.6 resulted in two acids of m.p. 88-89°C and 83-84°C respectively. The former was identified as ω-hydroxypalmitic acid while the latter was found to be a mixture.

Fractionation of A.2 over silicic acid into five fractions (A.2.1 to A.2.5) and isolation of an acid m.p. 42-43°C from A.2.2 and another acid m.p. 93-94°C from A.2.1 and A.2.3 combined had also been reported last year. The former acid was analysed by GLC and identified as a mixture of myristic and palmitic acids. The latter acid was identified as 9, 10, 16-trihydroxypalmitic acid by oxidative method and TLC. The residual acids from A.2.1 and A.2.3 were reconverted into methyl esters and re-chromatographed into six fractions. The first was found to be a pure non-hydroxy fraction while the others were mixtures. From these, ω-hydroxy-9-palmitoleate and a keto ester were isolated and indication was obtained of the presence of a dihydroxy ester also.

Separation of the original non-adduct B into nine fractions (B.1 to B.9) and fractionation of combined B.1 and B.2 by adductation into adduct C.1 and non-adduct C.2 had also been described earlier (*A. Rep.* 1966, p. 29). C.2 was re-chromatographed over silicic acid and seven fractions (C.2.1 to C.2.7) were obtained. The major fraction (C.2.1) and (C.2.2) were alike and were, therefore, mixed together. After acetylation, this was re-chromatographed giving five fractions out of which, an acid, which crystallized in the form of fine needles, m.p. 57-58°C was obtained from the second fraction. Its proper identification and further work are in progress.

Estimation of aleuritic and jalaric acids — Quantitative estimation of aleuritic acid (by vicinal hydroxyl content) and jalaric acid (by aldehyde content) in different samples of soft resin prepared from *palas, kusum, jalari, ber* and *bhalia* seedlacs were carried out by the standard periodic acid and sodium sulphite methods respectively. In soft resins, as they are, as well as after hydrolysis, aleuritic acid was found to be present to the extent of 11-13 and 25-26 per cent and jalaric acid 12-13 and 35-37 per cent respectively. These would indicate that the vicinal hydroxyl groups and aldehyde group in soft resin are partly free and partly combined.

(c) *Molecular weights of lac and its fractions*

Lac resin, as is well known, is not a single chemical compound but a mixture of several components, presumably of different molecular weights. The resin has

been fractionated by various methods into less complex mixtures, the earliest and most popular method being separation with the aid of ether into (i) a soluble fraction known as soft resin and (ii) an insoluble fraction known as hard or pure resin. The present study was undertaken to determine the proportions and molecular ranges of the various fractions by fractional precipitation of lac.

For this study, *Kusmi* seedlac was first separated into soft resin, hard resin and wax. The yields were 23·8, 67·5 and 4·87 per cent respectively.

The soft resin (25 g) was then fractionated by precipitation from acetone solution by the addition of water at 30°C. Eleven fractions were obtained accounting for 99·76 per cent of the starting material. Equivalent weights by titration and molecular weights by Rast method of these fractions were then determined. Their intrinsic viscosities were also determined in absolute alcohol at 30°C. The results obtained are reproduced in Table 9.

TABLE 9 — EQUIVALENT AND MOLECULAR WEIGHTS OF LAC FRACTIONS

Fraction No.	Yield per cent on soft resin	Acid value	Equivalent wt. calculated from III	Molecular wt.		Intrinsic viscosity [η]
				Rast method	intrinsic viscosity	
I	II	III	IV	V	VI	VII
1	0·77	241·0	232·3	228·0	255·3	0·030
2	3·30	184·6	303·3	336·0	328·1	0·035
3	5·83	140·0	373·3	365·0	357·9	0·037
4	20·36	134·2	417·3	406·0	432·1	0·042
5	6·58	127·0	441·0	414·0	455·2	0·044
6	13·83	108·6	515·0	503·8	487·5	0·046
7	17·94	92·4	606·0	616·4	526·0	0·048
8	3·91	83·0	674·0	669·6	645·7	0·055
9	12·56	73·0	767·1	821·3	820·0	0·065
10	10·40	70·0	800·0	859·0	948·4	0·066
11	4·34	64·0	875·0	875·0	946·2	0·071

It would be seen that the molecular weights determined by the two methods (columns V and VI) agree closely between themselves and with the equivalent weight (column IV) calculated from acid values. It would appear, therefore, that all the fractions of soft resin, and consequently soft resin itself, is mono-carboxylic.

The log of intrinsic viscosities were plotted against the log of number average molecular weights of the various fractions. A straight line (Fig. 5) was obtained, the value of K and α were calculated from the intercept and slope of the curve respectively. K was found to be equal to $7{\cdot}2\times10^{-4}$ and α as 0·67. Molecular weights indicated in column VI of Table 9 were calculated from the intrinsic viscosities on the basis of these values for K and α in the Staudinger equation

$$[\eta] = K\,M^{\alpha}$$

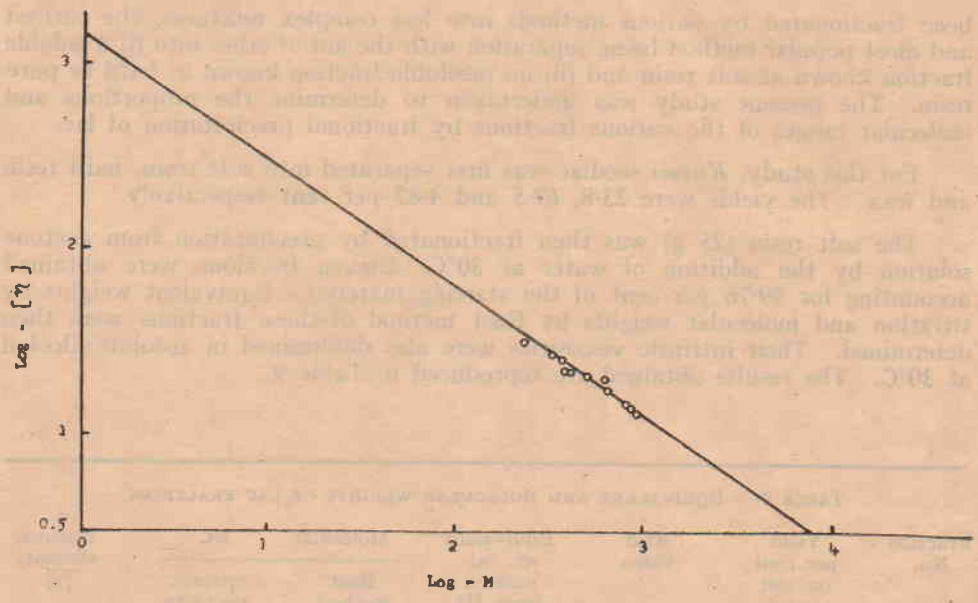


FIG. 5

2. Modification of shellac

(a) *Graft copolymerization of lac with vinyl monomers*

In an endeavour to find out suitable compositions of shellac and vinyl monomers which would give cold curing films, use of acrylic acid neutralized with ammonia in place of acrylamide was not found satisfactory for the graft copolymerization of lac with three vinyl monomers. Graft copolymerization of lac with higher acrylates, for example butyl acrylate, was then studied. A few compositions of lac, graft copolymerized with varying proportions of butyl acrylate, were prepared and examined. It was found that only the one containing 40 per cent of butyl acrylate on the weight of lac gave compositions with film properties superior to those of parent lac. When other monomers were tried in conjunction with butyl acrylate, it was found that a composition containing 20 per cent butyl acrylate, 10 per cent styrene and 10 per cent acrylamide on the weight of lac had improved film properties, specially in regard to flexibility, impact resistance and water resistance.

(b) *Mechanism of the reaction of lac with amino resins*

Lac-urea resin varnishes produce hard, smooth and glossy films which, on baking at 150°C for 30 minutes, show excellent resistance to the action of water, heat and spirituous liquors (*A. Rep.* 1967, p. 39). The nature of the chemical reactions taking place between the two resins in the films has now been studied.

Films on glass plates were prepared by flowing and, after a flash off period of 10 minutes, were baked at 150°C for different periods ranging from 2 to

60 minutes. The dried films were then scraped off from the plate and examined for acid and hydroxyl values and for percentage of curing. It was found that with increase in the baking time the acid value dropped from 57 to 7·6 and the hydroxyl value from 259 to 126 indicating two reactions taking place, namely (i) an esterification between the carboxyl of lac and methylol of urea resin, and (ii) an ether interchange between the hydroxyl of lac and butoxyl of the urea resin. The reactions were very fast in the beginning but slowed down thereafter. The curing as determined by acetone solubility was 90 per cent in 60 minutes (Fig. 6).

When the varnish was catalysed by the addition of 1·25 per cent of *p*-toluene sulphonic acid, the reactions were found to be accelerated and the curing went upto 99 per cent. This study also indicated that baking of the film at 150°C without catalyst for 10 minutes and with catalyst for 2 minutes was sufficient to give the optimum performance. The extent of curing under these conditions was 82 and 81 per cent respectively.

(c) *Fractionation of lac*

Conditions had been worked out to fractionate or completely precipitate lac from its alcoholic solution by the addition of aqueous 1 per cent solution of sodium chloride. The physical properties and chemical constants of these fractions had been studied and reported (*A. Rep.* 1967, p. 32).

During the period under report, efforts were made to confirm the results and to study the film properties of the fractionated samples. It was found that the fractions and even the completely precipitated lac showed remarkable water resistance. There was no blushing of the films even after one week of continued immersion in water whereas the control (film of ordinary dewaxed lac) blushed within 24 hours. This process thus hints at the evolution of a method for the manufacture of water resistant lacs.

This process was further extended to investigate the possibility of reclaiming lac resin of improved properties from seedlac and particularly from sticklacs. The procedure was to dissolve the lac in spirit (5 parts of spirit per part of lac resin in the sample), filter and wash, and precipitate the dissolved lac by the gradual addition of twice the volume of this solution of 1 per cent sodium chloride solution.

The precipitated lac settled quickly and the mother liquor could be decanted off easily. The settled mass invariably contained some alcohol and the electrolyte. Both of these as well as any water soluble dye retained by the resin could be effectively removed by two boilings with water. The recovered lac could be powdered and air dried after cooling, or fused to remove moisture and then flaked. Over 95 per cent of the lac content of the crude lacs were recovered by this process and the recovered lacs had good colour, life and flow.

Filtration of the alcoholic extract was easy and quick even through very thick (drill) cloth. The washed and dried residue was rich (20-25 per cent) in wax content which could be easily reclaimed by the usual solvent extraction. The extracted wax was of good colour and resembled commercial shellac wax in all respects.

The technique has been passed on to the team investigating improved manufacturing techniques of lac for more systematic investigation. Their report now follows.

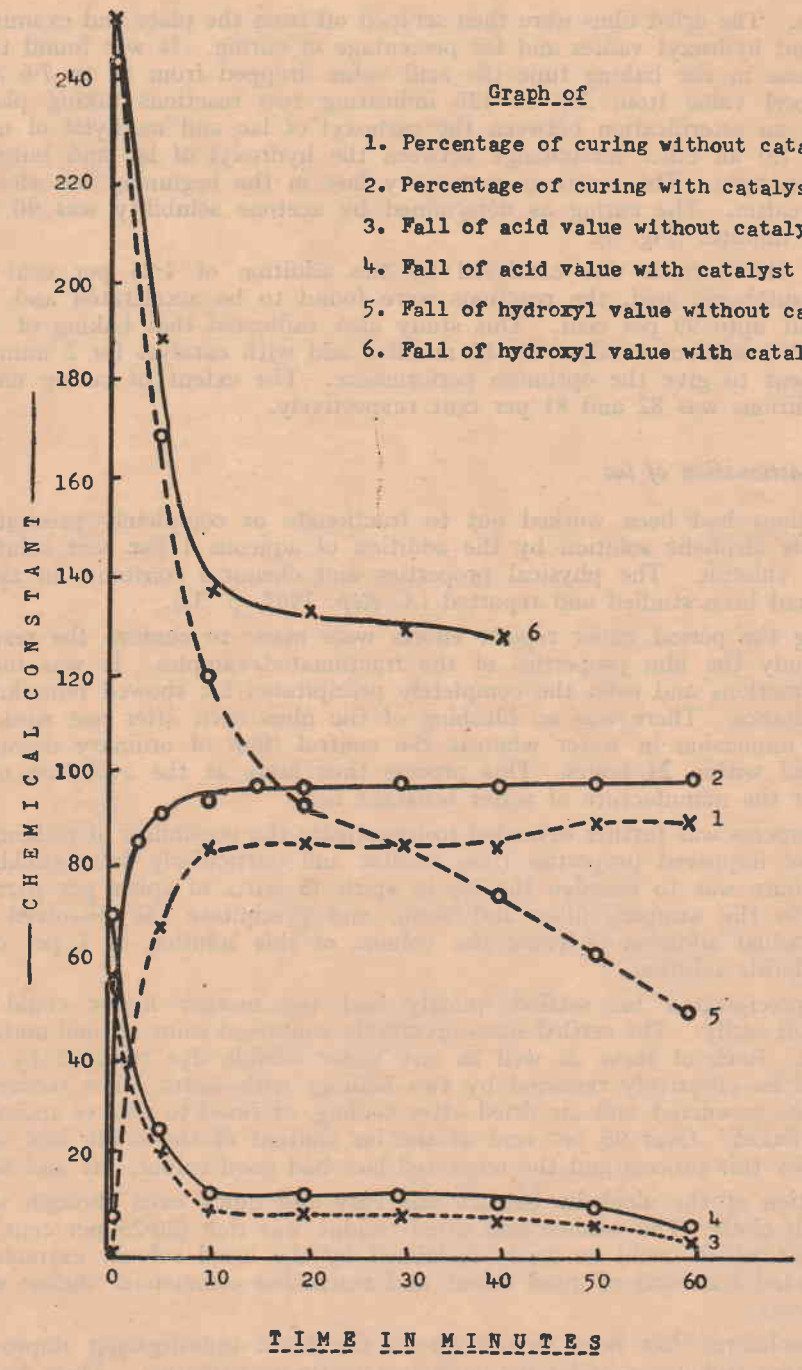

Graph of
1. Percentage of curing without catalyst
2. Percentage of curing with catalyst
3. Fall of acid value without catalyst
4. Fall of acid value with catalyst
5. Fall of hydroxyl value without catalyst
6. Fall of hydroxyl value with catalyst
CHEMICAL CONSTANT
240
220
200
180
160
140
120
100
80
60
40
20
0
10
20
30
40
50
60
TIME IN MINUTES

FIG. 6

3. Improvement in the manufacture of seedlac and shellac

(a) *Production of shellac direct from sticklac*

During the processing of sticklac into shellac by the conventional process, 20-30 per cent of lac resin is lost as by-products at various stages. In order to make the process more economical by minimizing this loss, attempts were made to evolve a process of shellac production directly from sticklac eliminating the intermediate seedlac stage. This was attempted by dissolving lac in solvents (distilled methylated spirit or acetone) in which lac dye and other impurities will not go into solution.

In the preliminary experiments, *ber* sticklac was dissolved in the solvent at room temperature by agitation. The solution was filtered and the residue was washed with the solvent. The dissolved lac was recovered from the filtrate either by distillation or by precipitation with 1 per cent common salt solution. Yield of shellac obtained was 82·5 per cent on the weight of sticklac which is much higher than 62 per cent obtained by the conventional *bhatta* method. Properties of this shellac were also comparable with those of *bhatta* shellac obtained from the same sticklac via seedlac. Life under heat (64-68 min) and flow (152-159 mm) were also better. Only colour index (14) was a little higher (by 3).

The possibility of dewaxing of the shellac during this process was also investigated. It was found that wax content could be reduced to within 0·18 per cent if the extraction of the sticklac is carried out with 95 per cent (distilled) methylated spirit at 20°C and to 0·04 per cent if at 0°C.

(b) *Hydrolysed lac and its modifications*

Total hydrolysed lac, i.e. hydrolysed lac containing *all* the products of hydrolysis of lac, had been prepared by hydrolysing lac in alcohol by *alcoholic* alkali and neutralizing with the exact equivalent of *alcoholic* mineral acid or by passing the *alcoholic* hydrolysate through an ion exchange resin column. Properties of this product as well as its life under heat, with and without catalysts, had been reported earlier (*A. Rep.* 1967, p. 33).

During the year under report, attempts were made to bleach this hydrolysed lac. For this purpose, lac was, as usual, hydrolysed with *alcoholic* alkali and the hydrolysate neutralized with *alcoholic* sulphuric acid. The *p*H of the solution was then brought down to 3-5 by the addition of more *alcoholic* sulphuric acid. This solution was then bleached by the addition of sodium chlorite, calcium hypochlorite or by passing chlorine gas. After bleaching, the excess chlorine remaining in the solution was destroyed by hydrogen peroxide and the excess sulphuric acid by treatment with sodium, lead or barium carbonate. The wax along with other insolubles, such as carbonates and sulphates of sodium and/or barium or lead were filtered off under suction. Solvent was distilled off and last traces removed by cooking at 120°C. Colour index of the resulting product was 0·49-0·6. Acid value was 179-185 and saponification value 204-210. Life under heat varied between 348 and 412 minutes. Ash content was 2·7-3·6 per cent. Calcium carbonate could not be used for neutralization of the excess sulphuric acid as it was found to form some complex.

4. Polymerization and Depolymerization of lac

The study could not be taken up due to shortage of staff.

5. Study of the reaction of lac with concentrated sulphuric acid

Precipitation occurs when concentrated sulphuric acid is gradually added to a solution of lac in alcohol under certain conditions. The precipitate is a modified lac differing in properties from the parent lac. The preparation of four such modified lacs (CSAL 1 to 4) prepared under different conditions as well as their physical properties and chemical constants were reported last year (*A. Rep.* 1967, p. 41).

The products have been further examined. They were fractionated with ether into the insoluble (hard) and soluble (soft) resins and their chemical constants determined (Table 10).

TABLE 10— YIELD PERCENT AND CHEMICAL CONSTANTS OF HARD AND SOFT RESIN FROM CSAL

	Treated lac		Parent lac	
	Hard resin	Soft resin	Hard resin	Soft resin
Yield, per cent	79·92—86·5	13·50—20·08	72—80	20—28
Acid value	39·27—44·32	8·13—8·37	55·60	103—110
Saponification value	103·20—167·80	230·10—241·30	218·23	207—229
Iodine value	27·20—28·40	52·00—53·90	10—13	50—55

Two more modified lacs (5 and 6) were also prepared. For these, after addition of concentrated sulphuric acid (89 g) to the lac (100 g) dissolved in methylated spirit (100 ml) the whole mass was heated at 70-80°C for 2 hours and allowed to stand overnight. In one case (sample 5), the product was then straightway salted out with 100 ml of 30 per cent sodium chloride solution. In the second (sample 6), the product was dissolved in 200 ml of hot water (70-80°C) and then salted out with 100 ml of the same brine. Both the products were freed from acid and salt by washing with distilled water. These were neutralized with 20 per cent sodium hydroxide solution and freed from moisture by heating in an open pan to about 120°C. The products were obtained in an yield of 68-75 and 65-70 per cent respectively and were found completely soluble in cold water in all proportions.

Acid, hydroxyl, saponification and iodine values of sample 5 were found to be 2·42, 60·50, 101·30 and 24·30 and of sample 6 were 2·13, 71·65, 143·60 and 25·30 respectively.

6. (a) Determination of shellac in presence of other resins

As is well known, shellac, in acetone solution, forms an insoluble complex when boiled under reflux with urea whereas other acetone soluble natural resins

do not form such a complex. Work was initiated to see if this property could be made use of to evolve a method for the quantitative determination of shellac in admixture with other natural resins.

A urea solution was first prepared by dissolving 7-8 g of urea in 10 ml of water and diluting the solution with dry acetone to 100 ml. Shellac (2·5 g) was dissolved in 10 ml aqueous acetone (95 ml acetone and 5 ml water) by warming and 4 ml of the urea solution added followed by 50 ml of dry acetone. The mixture was boiled under reflux for 5 hours and allowed to stand overnight. Next day, it was filtered and the precipitate washed with acetone. The washed material was extracted with dry acetone till the extract was clear. The residue was then dried and weighed.

Further work is being continued to standardize the procedure.

(b) *Age of seedlac*

It has been known that specific heat of lac falls with progressive periods of storage or degree of polymerization. This property was sought to be taken advantage of for determining the age (period of storage or extent of polymerization) of lac as specific heat is a constant which can be determined with a high degree of accuracy. Samples of seedlac of known histories had been stored in the Institute Laboratories under normal conditions and their specific heats determined from time to time. There was a drop of 13-20 per cent in the values after 36 months storage which remained practically unchanged during the next 16 months.

The data so far collected are being statistically analysed.

7. Water thinned wood finish

It had been mentioned earlier that water soluble lac varnish modified with water soluble melamine resin produced, on wooden surface, a highly glossy and durable finish resistant to heat and water (*A. Rep.* 1967, p. 36).

Since melamine is an imported item, attempts were made to develop a composition based on indigenously available materials.

Urea resin, which closely resembles melamine resin in most of its properties, was tried. It was found that though incorporation of this resin considerably improved the heat and water resistance of the film, gloss was impaired to an appreciable extent. It was further found that when maleic resin was used instead, there was no improvement in heat and water resistance but gloss was improved. Addition of polyvinyl alcohol did not help in any way.

Ultimately, as a result of a series of experiments, it was found that a composition containing 20 per cent urea resin and 10 per cent of maleic resin on the weight of lac gave the best overall performance. Incorporation of 5 per cent glycerine or maleinized linseed oil was found to improve cold checking and adhesion.

Alternate bases for dissolution of lac were also tried. The performance of aqueous varnishes in ammonia, borax, triethanolamine and caustic potash were compared. The best performance was, however, from the ammoniacal solution.

8. Rubber-shellac combination

(a) *Incorporation of shellac in natural rubber*

A study of the effects of incorporation of shellac and modified lacs into synthetic rubber (styrene-butadiene) was made during 1965 to 1967, when it was found that their addition improves many of the desirable properties of the rubber such as plasticity and hardness and in some cases (depending on the filler used) modulus, tensile strength and tear resistance as well.

During the year under report, the effect of incorporation of shellac into natural rubber was studied with gum stock (i.e. without fillers) using MBT (mercapto benzthiazole) as the accelerator. The following conclusions have been drawn:

1. Shellac acts as a processing aid and helps in the mixing of various rubber compounding ingredients.
2. It exerts a useful anti-scorching effect.
3. Tear strength is increased.
4. Hardness of the vulcanized stocks is enhanced.
5. Shellac has a beneficial effect on accelerated ageing of the rubber.

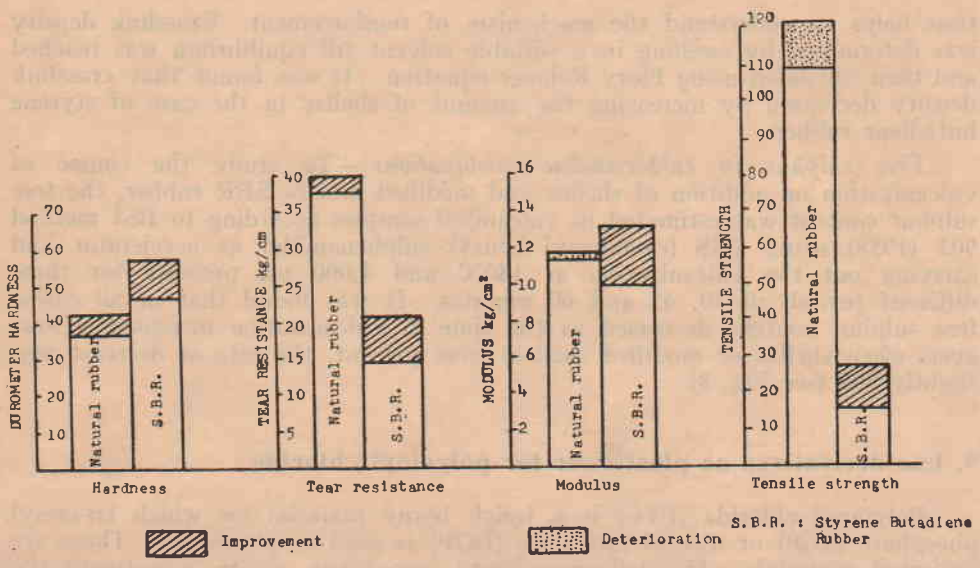
Further work was carried out to compare the performance of various types of lac into natural rubber. The three lacs studied were (i) dewaxed decolourized lac (platina), (ii) *Kusmi* and (iii) *Rangeeni*. All the three were found to behave more or less alike in influencing the mechanical properties, although there were minor variations in individual cases (see Table 11).

TABLE 11 — PERFORMANCE OF DIFFERENT TYPES OF LAC ON INCORPORATION INTO NATURAL RUBBER

(Base mix composition: Natural rubber, 100; Zinc oxide, 4; Sulphur, 2·5; Stearic acid, 1; MBT, 0·5; PBN, 1 + the following)

Type of shellac		*Platina*	*Kusmi*	*Rangeeni*
Parts/100 parts rubber added	0	10	10	10
Optimum cure time (at 140°C), minutes	30	45	45	45
Mooney viscosity	33·5	16·5	16·25	16·5
Scorch time, minutes	less than 4′	25′-12″	20′-45″	22′-15″
Modulus (at 200% elongation), kg/cm²	8·5	7·4	10·0	7·8
Ultimate elongation, per cent	800·0	610·0	580·0	650·0
Tensile strength, kg/cm²	110·0	73·5	85·7	85·7
Tear resistance, kg/cm	33·06	35·0	37·02	34·8
Durometer hardness	36·0	37·0	39·0	38·0
Impact resilience, per cent	74·3	65·3	67·0	65·3
Fall in tensile strength after accelerated ageing at 100±1°C for 5 days, per cent	93·7	77·5	71·5	73·0

An interesting point emerging by comparing the performance of shellac incorporated into synthetic and natural rubber gum stock is that the resulting improvements (in hardness and tear resistance) are much more marked with



EFFECT OF INCORPORATION OF SHELLAC ON THE PROPERTIES OF NATURAL AND SYNTHETIC RUBBERS

FIG. 7

synthetic rubber (see Fig. 7). Also whereas by incorporation of shellac, the modulus and tensile strength of the synthetic rubber are enhanced, these are lowered with natural rubber.

In styrene-butadiene rubber and with pigments — The effect of incorporation of ethylene glycol modified lac as additive to synthetic rubber (SBR 1502) using a white filler (clay) was reported last year (*A. Rep.* 1967, p. 36).

The study was repeated during the year under report using black fillers; namely, HAF (high abrasion furnace) and EPC (easy processing channel) blacks. It was found that with these the properties improved were Mooney viscosity, modulus and hardness. Abrasion resistance was impaired a little.

(b) *Mechanism of interaction of shellac on incorporation into rubber*

Samples were prepared by incorporating shellac into natural rubber without any other ingredient in order to determine the extent of their combination, if any, under the usual conditions of processing. It was found that 97 per cent of the shellac added could be extracted from the composition with acetone in the course of about 30 hours indicating that no combination had taken place between the two. However, when shellac and natural rubber were compounded in presence of other ingredients, nearly 80 per cent of the shellac added remained unextracted under the above conditions. The unextractable material rose to 87·7 per cent after the combination was vulcanized. It is, therefore, clear that shellac undergoes some sort of modification during compounding with the usual ingredients and especially after vulcanization. The nature of this change is under study.

Determination of crosslink density — The measure of crosslink density of a polymer throws useful light on the number of effective crosslinks created and

thus helps to understand the mechanism of reinforcement. Crosslink density was determined by swelling in a suitable solvent till equilibrium was reached and then calcuated using Flory Rehmer equation. It was found that crosslink density decreased by increasing the amount of shellac in the case of styrene butadiene rubber.

Free sulphur in rubber-shellac combinations — To study the course of vulcanization on addition of shellac and modified lacs to SBR rubber, the free sulphur content was estimated in vulcanized samples according to BSI method 903 (1958) using CBS (cyclohexyl benzyl sulphenamide) as accelerator and carrying out the vulcanization at 140°C and 4,000 psi pressure for three different periods of 30, 45 and 60 minutes. It was found that in all cases, free sulphur content decreased as the time of vulcanization increased. However, when shellac or modified shellacs were present, the rate of decrease was slightly less (see Fig. 8).

9. Lac derivatives as plasticizer for polyvinyl chloride

Polyvinyl chloride (PVC) is a tough horny material for which tri-cresyl phosphate (TCP) or dioctyl phthalate (DOP) is used as plasticizer. These are imported materials. The following study was taken up to investigate the possibility of substituting these imported plasticizers with lac derivatives.

As a result of a series of experiments, it was found that 10 per cent of TCP could be replaced by ethyl or butyl ester of shellac without affecting the flexibility of the finished unsupported film.

PVC and shellac were mixed in different proportions for moulding. It was observed that there was no proper incorporation beyond 10 per cent of PVC on the weight of shellac. Properties of shellac PVC moulded products in any proportion of the two were not satisfactory.

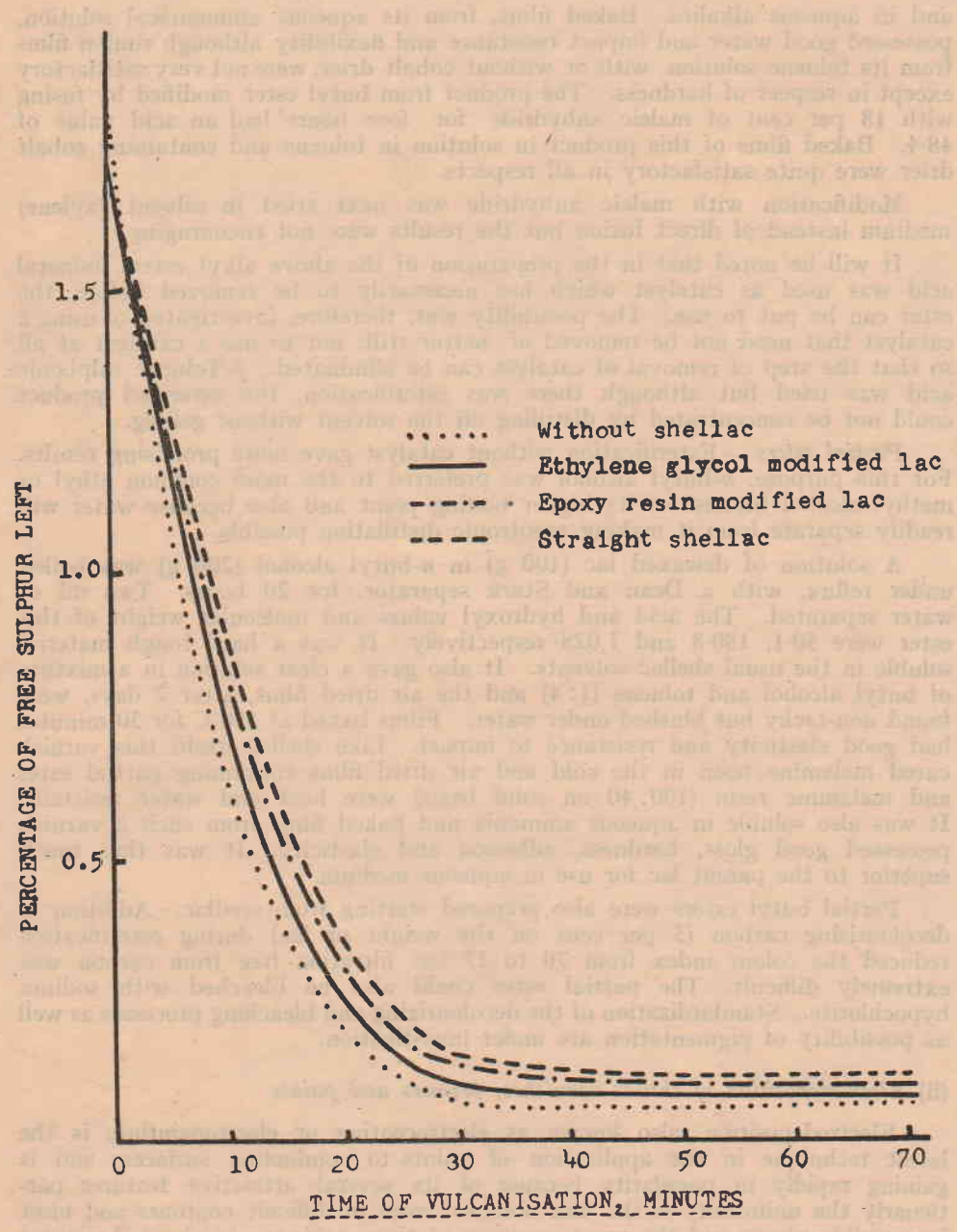
10. Use of lac and modified lacs in surface coatings

(i) *Shellac esters and their modifications*

Shellac esters possess a fairly long life under heat and are soluble in aromatic hydrocarbons. Consequently, they are very suitable for further modification into useful industrial products. The preparation of ethyl ester was reported last year which had an acid value of 29·4, hydroxyl value of 158·3 and a life of more than 72 hours at 150°C (*A. Rep.* 1967, p. 38).

During the year under report, the butyl ester was prepared in the same manner, i.e. by boiling under reflux dewaxed lac (100 g) with *n*-butyl alcohol (200 g) in the presence of concentrated hydrochloric acid (10 g) for 12 hours and removing the catalyst by boiling under reflux for a further one hour with barium carbonate. The resulting ester had an acid value of 16·2 and hydroxyl value of 106·6.

These esters, by themselves, did not possess satisfactory film properties. They were, therefore, condensed with maleic anhydride equivalent to their hydroxyl contents at 150°C. The product from the ethyl ester condensed with 12 per cent of its weight of maleic anhydride for 3·5 hours, had an acid value of 59·2. It was soluble in the usual shellac solvents as well as in toluene



PIG. 8 — Amount of free Sulphur left after vulcanization with various types of lac (10 part/100 parts of rubber)

and in aqueous alkalies. Baked films, from its aqueous ammoniacal solution, possessed good water and impact resistance and flexibility although similar films from its toluene solution, with or without cobalt drier, were not very satisfactory except in respect of hardness. The product from butyl ester modified by fusing with 18 per cent of maleic anhydride for four hours had an acid value of 48·4. Baked films of this product in solution in toluene and containing cobalt drier were quite satisfactory in all respects.

Modification with maleic anhydride was next tried in solvent (xylene) medium instead of direct fusion but the results were not encouraging.

It will be noted that in the preparation of the above alkyl esters, mineral acid was used as catalyst which has necessarily to be removed before the ester can be put to use. The possibility was, therefore, investigated of using a catalyst that need not be removed or, better still, not to use a catalyst at all so that the step of removal of catalyst can be eliminated. *p*-Toluene sulphonic acid was tried but although there was esterification, the esterified product could not be concentrated by distilling off the solvent without gelling.

Partial esters — Esterification without catalyst gave more promising results. For this purpose, *n*-butyl alcohol was preferred to the more common ethyl or methyl alcohol because of its higher boiling point and also because water will readily separate from it making azeotropic distillation possible.

A solution of dewaxed lac (100 g) in *n*-butyl alcohol (200 g) was boiled under reflux, with a Dean and Stark separator, for 20 hours. Two ml of water separated. The acid and hydroxyl values and molecular weight of this ester were 50·1, 180·8 and 1,028 respectively. It was a hard tough material soluble in the usual shellac solvents. It also gave a clear solution in a mixture of butyl alcohol and toluene (1: 4) and the air dried films, after 7 days, were found non-tacky but blushed under water. Films baked at 150°C for 30 minutes had good elasticity and resistance to impact. Like shellac itself, this varnish cured melamine resin in the cold and air dried films containing partial ester and melamine resin (100: 40 on solid basis) were heat and water resistant. It was also soluble in aqueous ammonia and baked films from such a varnish possessed good gloss, hardness, adhesion and elasticity. It was thus much superior to the parent lac for use in aqueous medium.

Partial butyl esters were also prepared starting from seedlac. Addition of decolourising carbon (5 per cent on the weight of lac) during esterification reduced the colour index from 70 to 17 but filtration free from carbon was extremely difficult. The partial ester could also be bleached with sodium hypochlorite. Standardization of the decolourizing and bleaching processes as well as possibility of pigmentation are under investigation.

(ii) *Electrodeposition of shellac varnishes, primers and paints*

Electrodeposition, also known as electrocoating or electropainting, is the latest technique in the application of paints to conducting surfaces, and is gaining rapidly in popularity because of its several attractive features particularly the uniformity of the film obtained even in difficult contours and most inaccessible places and the great economy of time, taking only about 2 minutes irrespective of the size of the object to be coated. The technique makes use exclusively of water thinned coatings. Shellac being a water "soluble" resin on its own right, the possibility of developing satisfactory compositions based on this resin for application by this technique was taken up for investigation.

Ammonia was first tried as the base for the dissolution of shellac in water for the production of water thinned varnishes and primers. The films were not uniform and throwing power was poor (*A. Rep.* 1967, p. 39)

Morpholine and triethanolamine were tried in place of ammonia during the year under report. These gave good performance in the case of dewaxed shellac varnish, but failed to give a satisfactory coating when pigmented with red oxide to 35 per cent pigment volume concentration. The coating characteristics were studied by changing the concentration of the base as well as the pigment volume concentration. As a result of a series of experiments (see Fig. 9), it was found that for a satisfactory coating, the optimum amounts of triethanolamine and red oxide to be used were 25 ml and 100 g per 100 g of lac. Addition of *n*-butyl alcohol (6 ml per 100 ml of the primer) was found to eliminate pin-holes and produced a more uniform film. The optimum electrical requirements for application of these compositions were 50 volts and a current of 40 amperes per sq. metre. Uniform coatings were obtained in 2 minutes at a bath temperature of 35°C. Thickness of the unpigmented shellac film was 0·8-1·0 mil and of the primer 1 mil.

Moisture content of the film before baking was 40-60 per cent (on dry film weight) in the case of shellac varnish and 5-20 per cent in the case of the primer. The films baked completely at 150°C within 10 minutes. Coulomb efficiencies of shellac varnish at 35°C (bath temperature) applied at 50 volts for two minutes, were 7·98, 7·43, 6·86 and 6·34 mg per coulomb at current densities of 0·4, 0.3, 0·2 and 0·1 amp per 100 sq. cm. Less than 0·2 amp failed to deposit a uniform film. Incorporation of pigments (mica and talc) along with red oxide had no effect on the uniformity and smoothness of the film. With below 10 per cent solids (binder and pigments) in the primer, rough films were obtained. Above 75 volts also, smoothness of the film decreased.

This technique of electrodeposition as well as the conditions for depositing shellac to mild steel plates by the technique were demonstrated and samples of a suitable varnish supplied to the engineers of the Heavy Engineering Corporation, Ranchi, for their use for insulating a large number of mild steel plates to be used in transformer for induction heating. The technique and composition were reported as particularly satisfactory and it is understood they used them for this purpose in their works. A copy of their report is reproduced in Appendix.

(iii) *Modification of lac with polyvinyl alcohol*

Aqueous solutions of shellac find very little use in flexible coatings due to its brittleness and poor adhesion. On the other hand, polyvinyl alcohol (PVA) is one of the best known resins for the purpose. Modification of lac with PVA was, therefore, taken up for investigation to develop a water based lacquer for use on flexible supports such as paper, fabric and leather.

Modification of lac with PVA was carried out by direct fusion as well as by blending the two solutions. The products obtained by fusion of the two at different temperatures and in different proportions did not completely dissolve in water or in dilute ammonia. Therefore, modification by blending the solutions were studied. Solution of lac in aqueous ammonia and PVA in water were first separately prepared. These varnishes were then mixed in different proportions under vigorous stirring and, after filtration, properties of the film on air drying

1. 15 ml triethanolamine/100 g lac
2. 25 ml triethanolamine/100 g lac
3. 35 ml triethanolamine/100 g lac
4. Pigment : binder 1 : 1
5. Pigment : binder 1 : 1.5
6. Pigment : binder 1 : 2
7. Pigment : binder 1 : 3

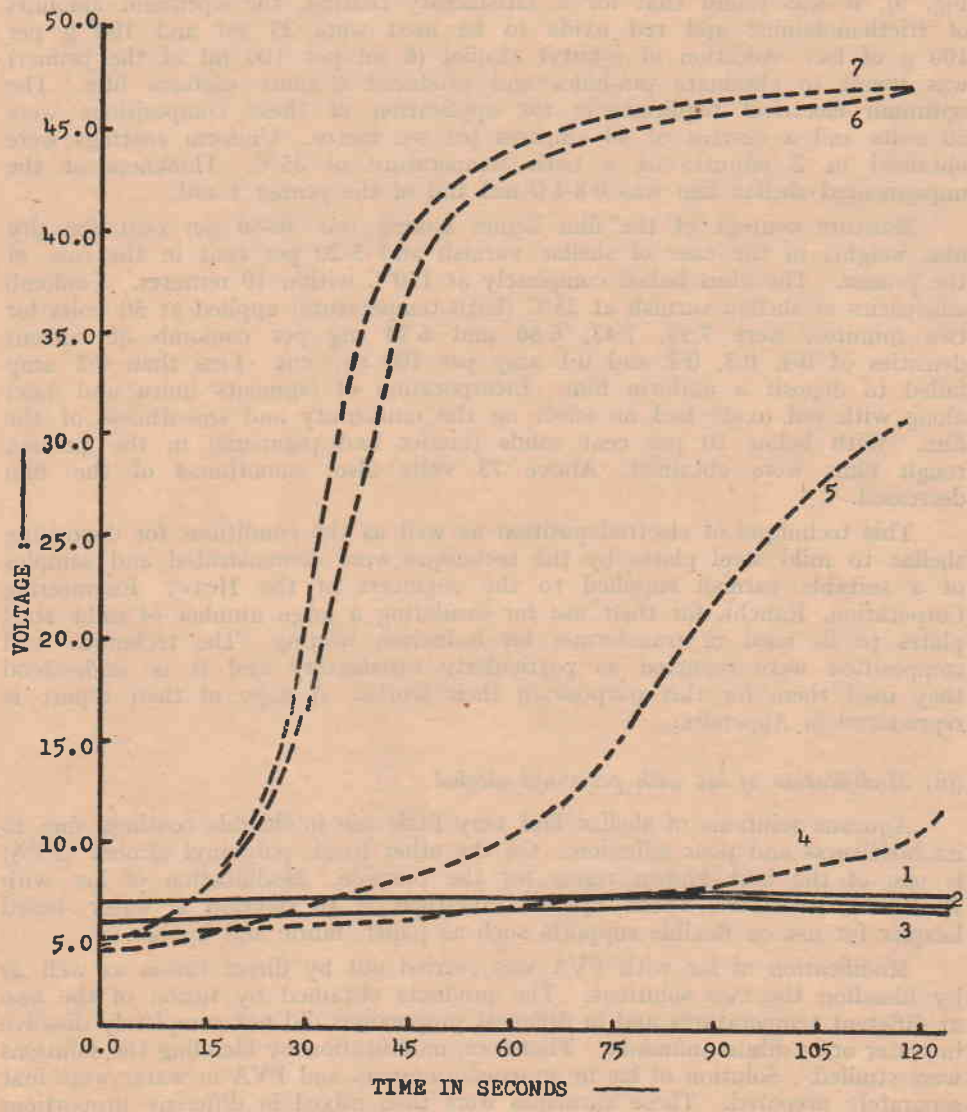


FIG. 9

as well as on baking at 150°C for 30 minutes were studied. It was found that clear and smooth films of good adhesion and flexibility were obtained. In regard to water resistance, the baked films did not show any blushing up to 24 hours immersion while the air dried films showed blushing after one hour. The optimum percentage of PVA was found to be 5 per cent on the weight of lac.

(iv) *Modification of lac-oil combination with polyisocyanates*

Shellac-castor oil or linseed oil combinations, produced through the glycerides, had been shown to be suitable for further modification with polyisocyanates to produce urethane coatings. These modifications possessed excellent film properties but had a relatively poor pot life (*A. Rep.* 1967, p. 37).

The poor pot life of these compositions was probably due to their higher reactivity. It was, therefore, proposed to find out if the alcoholysis products from linseed oil and propylene glycol could be used in place of the glyceride to produce the lac-oil combination which could subsequently be reacted with polyisocyanates to give products of better pot life.

Alcoholysis of linseed oil (alkali refined) was carried out with 10, 15 and 20 per cent of its weight of propylene glycol in presence of 0·5 per cent litharge (on the weight of lac) at 220-230°C in a fairly closed system with only a tubular outlet for the escape of fumes.

After completion of the reaction in 45 minutes the reaction products were cooked with 40-60 per cent of shellac at 250°C for 45-60 minutes. It was found that a minimum of 15 per cent propylene glycol (on the weight of linseed oil) gave a product compatible with shellac and that the combination was soluble in white spirit. A maximum of 60 per cent of shellac could be combined with the alcoholysis product.

The shellac/linseed oil/propylene glycol combination was reacted with different proportions of toluene diisocyanate by allowing the mixture in white spirit/xylene solution to stand for 30 minutes at room temperature (25-30°C) before films were made. The following composition was found to give the best film properties:

Alcoholysis product of linseed oil with 15 per cent propylene glycol	100 parts
Shellac	50 ,,
White spirit	100 ,,
Xylene	50 ,,
Toluene diisocyanate	40 ,,
Cobalt naphthenate	0·5-1·0 parts

Films produced from this were found highly glossy and smooth. After one week at room temperature, scratch hardness was 1800 g. The films also possessed excellent resistance to water, 5 per cent sodium hydroxide and 20 per cent sulphuric acid and denatured spirit, toluene and acetone. The pot life was 10-12 hours.

Shellac-castor oil combination also was similarly prepared and cured with polyisocyanate. Films obtained from the resulting composition were very hard, tough and very resistant to many chemicals but the pot life (2-3 hours) was relatively poor.

(v) *Accelerated curing of Melfolac*

Melfolac (dewaxed lac varnishes blended with butylated melamine resin) produces hard, smooth and highly lustrous finishes which are resistant to heat, water and spirituous liquors (*A. Rep.* 1967, p. 39).

These properties are normally acquired in 7 days of air drying. With a view to bring down the curing period to less than 24 hours, catalysis with various mineral and organic acids was studied. It was found that incorporation of 1·25 per cent of either hydrochloric or *p*-toluene sulphonic acid gave the desired performance in 24 hours of air drying. Refluxing of the varnish did not improve the performance nor accelerate the curing process further. It was found that only dewaxed varieties of lac such as platina, super blonde, dewaxed lemon and refined bleached lac gave satisfactory performance. A very slow increase in viscosity was noticed after a week but none of the samples was found to gell up to 4 months storage.

Films from catalysed Melfolac showed the desired heat and water resistance after seven days even at 5°C while uncatalysed Melfolac failed to show the improved performance under these conditions.

(vi) *Solvent-release of shellac films*

In a previous study (vide page 29) the rate of solvent release from films was determined gravimetrically. In the present case, a thorough study was undertaken to determine the rate of solvent release by estimating the ethoxyl content in the film by Ziesel's semimicro method. The apparatus was first standardized with anisic acid (for methoxyl value) and ethylene glycol mono-ethyl ether (for ethoxyl value).

Film from dewaxed decolourized lac varnish (25 per cent solid content) in ethyl alcohol were prepared on amalgamated plates. After 15 minutes of air drying the films were transferred from the amalgamated plates to ordinary washed plates and then exposed in an oven at 40°C under constant air circulation. Ethoxyl values were determined after 24 hours and subsequently after intervals of two days. Results indicated that solvent release from the films was not uniform under the above conditions.

The method was modified and films were prepared on a small glass capsule (5 cm in length and 0·9 cm in diameter). Ethoxyl values after 1, 3, 5, 7, 9 and 13 days were found to be 4·27, 2·62, 2·24, 1·13, 1·01 and 0·85 per cent respectively. The average film thickness was nearly 1·3 mils. The work is being continued.

11. (a) Use of lac in combination with jute

A shellac/cashewnut shell liquid combination modified with urea and formalin had been used to produce a water and seepage proof coating on hessian so that such bags could be used for packing moisture sensitive materials (*A. Rep.* 1967, p. 40).

The minimum thickness of film required to give water and seepage resistance has now been determined to be 1·50 mil. Samples of D.W. hessian coated with the composition were examined by Sindri Fertilizer Factory who found the product satisfactory. This composition was also found to be a good

adhesive for laminating craft and crepe papers on hessian. Samples have been tested by the Indian Jute Industries Research Association Laboratory, Calcutta and found satisfactory.

(b) Use of lac for coating fertilizers

Study has been initiated to make fertilizers moisture resistant and non-caking in order to prevent rapid leaching in contact with water, so that release of nitrogen to the soil would be slow and in accordance with the need of the plants. Shellac and modified shellac compositions were tried for coating on urea fertilizer. The composition in the form of a varnish was sprayed over the granules in a rotating drum, the tumbling being continued till the coating was uniform and dry, a jet of hot air being blown to accelerate the drying. Ordinary shellac in methylated spirit was found unsatisfactory but a coat of shellac-linseed oil combination followed by another of paraffin wax was found quite effective. The composition and coating process were as follows:

Shellac (50 g) was combined with linseed oil (100 g) using lime as incorporating agent. This lac linseed oil combination (5 g) dissolved in white spirit (5 g) was added to urea (100 g) and tumbled. Solvent evaporation was assisted by blowing hot air while continuing the tumbling. A solution of paraffin wax in hexane (1:1) was then sprayed on the coated urea composition under hot condition. On cooling, the final product was found to be uniform. Samples of coated and uncoated urea granules were kept in petri dishes over water in a closed container (R.H. 100 per cent) at room temperature. Increase in weight of the samples at different intervals of time were then determined. It was found that coated urea granules were only one quarter as hygroscopic as uncoated urea.

AD HOC RESEARCHES

(i) *Bleaching of shellac wax*

Bleaching or decolourization of ordinary shellac wax was carried out with different agents, namely, hydrogen peroxide, activated carbon and sodium hypochlorite. Of these, only hypochlorite proved to be effective and the successful method was as follows:

Crushed wax (10 g) was dispersed in 2 per cent sodium carbonate solution (50 ml) by heating at 70-80°C. Sodium hypochlorite solution (40-50 ml) containing 3 per cent available chlorine was added and kept overnight at a temperature of 40-45°C. The solution was acidified with sulphuric acid and the precipitated wax was washed free of sulphate. The colour of the resulting wax was nearly halved.

(ii) *Coating of hose pipe (dia. 80 mm)*

The possibility of developing a shellac composition for impregnating rubber hose pipes used by Railways in the vacuum systems of trains in order to make them non-porous to mild vacuum was investigated.

A 20 per cent solution of hydrolysed lac and water soluble lac (80: 20) in liquor ammonia or triethanolamine was found suitable. Impregnated samples have been sent to the Railways for assessment of the product.

(c) RESEARCHES CONTEMPLATED

Studies on shellac etch primer, shellac oil combinations modified with phenolics, water soluble lac dye, effect of solvents on the film properties of lac and water thinned red oxide shellac primers have been completed. The rest of the studies already in hand will be continued. Besides, the following are also proposed to be taken up for investigation.

1. Modification of shellac wax
2. Solvent release of shellac films
3. Lac modified with melamine resin
4. Lac and modified lacs in adhesives

(d) SPONSORED RESEARCH SCHEMES

1. Constitution of lac

(a) *At Delhi University*

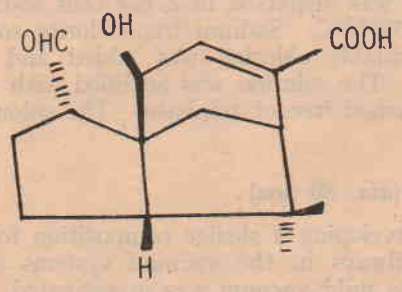
A number of derivatives of *threo* and *erythro* aleuritic acids were prepared and their separation was studied by thin layer chromatography (TLC) using a number of solvent systems.

Further, a preliminary series of oxidation experiments were carried out on aleuritic acid with a number of oxidizing agents and various breakdown products were isolated and identified where possible and also studied by TLC.

The basic information obtained from these experiments is being utilized in a study of the oxidative degradation of lac resin, using different oxidizing agents.

(*b*) *At National Chemical Laboratory, Poona*

(i) Continuing the study on the constitution of hard resin, prepared from *palas* seedlac, a new aldehydic acid in the terpenic series, m.p. 164-65°C, was isolated from the aqueous portion of the acidified resin hydrolysate. From the spectral data (IR, NMR and UV), the acid has been assigned the following structure (I).

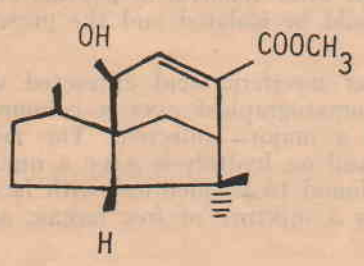


(I)

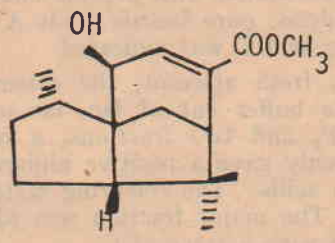
Taking into consideration the basic structural similarity with jalaric acid, this new aldehydic acid has been named as 'Laccijalaric' acid. It was oxidized with alkaline silver oxide to the corresponding dicarboxylic lacciepi-

shellolic acid, m.p. 240-242°C and was reduced with borohydride to the dihydroxy lacciepilaksholic acid, m.p. 206-208°C.

Wolf Kishner reduction of laccijalaric acid and, methylation of the reduced acid yielded two esters, one of which was found to be identical in all respects with the synthetic methyl ester of 5-β-hydroxy-3-cedrene-12-oic acid (II). The major product was, however, the desired epimer of II (III). Thus the correlation of laccijalaric acid with cedrene was established for the first time.



(II)



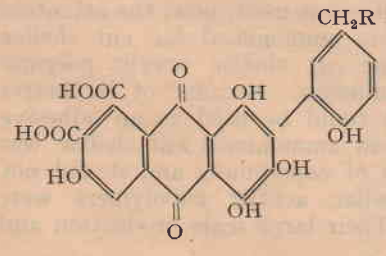
(III)

(ii) In order to find out a direct bearing on the constitution of lac resin, some stepwise selective condensation of aleuritic acid with epishellolic acid was reported last year. The condensation of triacetyl aleuritic acid chloride with dimethyl epishellolate afforded a monoester and a diester. In the monoester, the primary hydroxyl group was esterified. The esterification through the secondary hydroxyl group of epishellolic acid was achieved by condensing the δ-lactone of epishellolic acid, prepared by warming the acid with acetic anhydride under controlled condition, with the triacetyl aleuritic acid chloride and by treatment of the condensed product with mild alkali. Further work is in progress.

2. Lac Dye Scheme at National Chemical Laboratory, Poona

The isolation of laccaic acids A, B and D (structures IV, V and VIII) and their characterization have already been reported earlier (*A. Rep.* 1967, p.62). Two more new laccaic acids C and E, have been isolated which constituted nearly 5 per cent of the total dye.

Laccaic acid C crystallized from methanol in dark red needles (dec. above 360°C; N content 2·8 per cent). NMR and Mass spectrophotometric studies showed that the acid has the structure (VI). It is the first naturally occuring anthraquinone carrying an amino acid side chain.

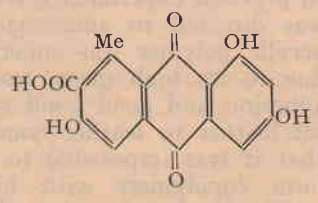


IV: R=CH_2NHAc

V: R=CH_2OH

VI: R=$CHCOOH$ (with NH_2)

VII: R=CH_2NH_2



(VIII)

Laccaic acid E (VII) is probably deacetyl laccaic acid A. It has not yet been possible to isolate it entirely free from laccaic acid C, but acetylation of laccaic acid E and hydrolysis of the *O*-acetyl groups gave a product chromatographically identical with laccaic acid A (I).

The colouring matter of lac larvae

It was reported last year that the colouring matter from lac larvae remains associated with peptide chain and that after removal of peptide chain by hydrolysis, pure laccaic acids A and B could be isolated and the presence of laccaic acid C was indicated.

In a fresh attempt, the colouring matter lacciferic acid extracted with phosphate buffer out of lac larvae was chromatographed over a column of Bio-gel P_2 and two fractions, a minor and a major, collected. The minor fraction only gave a positive ninhydrin test and on hydrolysis gave a number of amino acids. The colouring material was found to be identical with laccaic acid C. The major fraction was identified as a mixture of free laccaic acids A and B with a trace of C.

The residual larvae after phosphate buffer extraction were treated with concentrated hydrochloric acid and extracted with methanol. Removal of methanol afforded a red product containing nitrogen (1·5-2·0 per cent). This product was found to be composed of laccaic acids A and B and with a trace of C.

The above findings conclusively proved that lacciferic acid does not belong to the ommochrome group of pigments as claimed by Seshadri and coworkers [*Tetrahedron Letters*, 1101 (1966)] but is composed of a coloured fraction (laccaic acid C) associated with protein and free laccaic acids A, B and C which are all anthraquinone derivatives.

3. Shellac-based leather finishes at Central Leather Research Institute, Madras

Use of lac products for leather finishing

The products developed earlier such as the Top dress MS, MSS and wax emulsion were produced in small quantities in the pilot plant and sold to the industry. One more top dress composition, completely solvent based, was prepared and standardized. A glazable lac based binder was prepared by modifying shellac with hydroxylamine. The preparation and application were standardized.

Process for the production of shellac acrylic resin dispersions was finished. In previous experiments, triethanolamine cut shellac was used; now, the attention was directed to ammoniacal lac solutions. This ammoniacal lac cut shellac acrylic polymer was superior to triethanolamine cut shellac acrylic polymer due to its high gloss, less tack and better adhesion. Because of its better adhesion and good bond strength, this product could be used as an adhesive for leather to leather bonding. The drawback in ammoniacal cut shellac was that it was impossible to make various ranges of copolymers and it did not form copolymers with higher monomers. Shellac acrylic copolymers were standardized and evaluated in the laboratory. Their large scale production and

commercial exploitation will be taken up after procurement of sufficient quantity of the acrylic monomers.

Sulphonated lac was fractionated by solvent extraction and the fractions were isolated by chromatography. IR spectra study of the components were taken up.

Lac based showerproofing agent, re-tanning and neutralizing syntan and fat liquors were prepared and their properties were studied. Screening of these products with standard marketed products is being taken up.

Field trials were conducted in various tanneries at Ambur and Vinnamangalam on 'suedefil' which is a lac based product intended to upgrade the qualities of suede leathers and lac based 'binders' for finishing kattai and coloured lining leathers. The trials were conducted to see whether the above said products work satisfactorily in the conditions that exist in the private industry and very promising results were obtained.

3. LIST OF PAPERS PUBLISHED DURING 1968

A. ENTOMOLOGY DIVISION

Sl. No.	Authors	Title of paper	Name of Journal/ date of publication
1	Majumdar, N. and Bhattacharya, A.	Studies on the effect of male population on the size and fecundity of female lac insect *Kerria lacca* (Kerr) (Homoptera: Coccidae)	*Proceedings of the 55th session, Indian Science Congress Associatin* (Part III), 1968
2	Majumdar, N., Bhattacharya, A. and Kumar, Sant.	Studies on the variability in fecundity of the female lac insect, *Kerria lacca* (Kerr) (Homoptera-Coccoidae) in relation to size	*The Indian Journal of Agricultural Science*, Vol. **38**(3), June 1968
3	Majumdar, N. and Bhattacharya, A.	Effect of insecticidal sprays on the longevity and fecundity of *Eublemma amabilis* Moore and *Holcocera pulverea* Meyr.	*Indian Journal of Entomology*, Vol. **30**, September 1968
4	Malhotra, C. P. and Chowdhury, S. G.	Control of predators of lac insect by *Bacillus thuringiensis*	*Proceedings of the 55th session, Indian Science Congress Association* (Part III), 1968
5	Malhotra, C. P. and Chowdhury, S. G.	Control of *Eublemma amabilis* Moore (Lepidoptera: Noctuidae) and *Holcocera pulverea* Meyr. (Lepidptera: Blastobasidae) Predators of the lac insect, *Kerria lacca* (Kerr) by *Bacillus thuringiensis* Berliner	*J. Invertebrate Pathol.*, **11**(3), Sept. 1968
6	Mehra, B. P., Gokulpure, R. S. and Sah, B. N.	New records of *Hexamermis* spp. (Nematoda: Mermithidae) from Neoroptera and Lepidoptera in India	*Bull. Ent.*, **9**(1), 1968
7	Sah, B. N.	Bionomics of *Dasychira mendosa* Hubn. f. *fusiformis* Walker a pest of *Moghania macrophylla*	*Proceedings of the Indian Science Congress Association* (Part III), 1968, section Agricultural Sciences
8	Varshney, R.K., Sundaram, R. M. and Griyaghey, U.P.	Record of acidity in the gut of caterpillars of *Holoccera pulverea* Meyr. a predator of the lac insect	*Proceedings of the 55th session, Indian Science Congress Association* (Part III), 1968

B. CHEMISTRY DIVISION

Sl. No.	Authors	Title of paper	Name of Journal/ date of publication
1	Khanna, B. B.	Modified Lacs as Compounding Ingredients of Styrene Butadiene Rubber: Part I — Epoxidized Lac in Gum Stock	*Research and Industry*, Vol. **13**(3), Jul-Sep, 1968, p. 121-125
2	Khanna, B. B.	Modified Lacs as Compounding Ingredients of Styrene Butadiene Rubber: Part II—Epoxidized Lac in Filled Stock	*Research and Industry*, Vol. **13**(3), Jul-Sep. 1968, p. 125-28
3	Mukherjee, M. and Sankaranarayanan, Y.	Shellac Modified with Urea	*Paintindia*, Vol. **17**(12), March 1968, p. 17-20
4	Sahu, T. and Misra, G. S.	Studies on Hydroperoxidation of Lac	*Indian Journal of Technology*, Vol. **6**(2), Feb. 1968, p. 59-61
5	Sahu, T. and Misra, G. S.	Shellac Graft Copolymer: Part III — Shellac vinyl monomer mixture-Graft copolymer	*Research and Industry*. Vol. **13**(2), April-June 1968, p. 61-63
6	Sahu, T. and Misra, G. S.	Shellac-Graft Copolymer: Part II — Shellac Ethyl Acrylate-Styrene-Acrylamide-Graft Copolymer	*Indian Journal of Technology*, Vol. **6**(12), 1968, p. 371-73
7	Sankaranarayanan, Y., Bhowmik, T. and Srivastava, B. C.	Water thinned Shellac/Redoxide Primer	*Indian Paint News*, Vol. **12**(1), Jan-Jun 1968, p. 23-25
8	Srivastava, B. C. and Bhowmik, T.	Lac and Paper Industry	*Indian Pulp and Paper*, Vol, **XXII**(3), Feb. 1968, p. 467-469
9	Srivastava, B. C. and Bhowmik, T.	Standard ILRI Waxes for testing papers	*Indian Pulp and Paper*, Vol. **XXIII**(3), Sep. 1968, p. 223
10	Srivastava, B. C. and Bhowmik, T.	Destructive dry distillation of lac	*Indian Journal of Technology*, Vol. **6**(4), April 1968, p. 128
11	Tripathi, S. K. M. and Misra, G. S.	Oil Modified Urethane Coatings from Shellac	*Paintindia*, Vol. **XVII** (10), Jan. 1968, p. 7-9
12	Tripathi, S. K. M. and Misra, G. S.	Oil Modified Urethane Coatings from Shellac modification with Castor Oil	*Research and Industry*, Vol. **13**(3), Jul-Sep. 1968, p. 129-33

4. EXTENSION

(A) ENTOMOLOGY DIVISION

As already indicated in the previous reports (*A. Rep.* 1967) all activities relating to extension of lac cultivation are the responsibilities of the Regional Office for Lac Development under the Ministry of Food and Agriculture, Government of India, the functions of this Institute being limited to providing necessary technical assistance to those interested. The principal activity in this regard during the year under report was forecasting of the date of larval emergence during the different seasons and determination of the causes of excessive mortality, if any, of lac insects and crop failures on the basis of examination of samples received from different lac growing areas. The other major activities were assistance rendered to the Forest Department of the Government of Bihar in regard to:

i) large scale cultivation of lac on *palas* at Kundri (a hot area) and
ii) establishment and maintenance of *Kusmi* broodlac demonstration farm at Maheshpur Sirka.

Large scale cultivation on palas at Kundri

These experiments have been going on in Kundri lac orchard for the past several years. The orchard has a total of about 40,000 *palas* trees.

During the year, operations were carried out on a total of 22,878 trees belonging to coupes A and B. The total quantity of broodlac produced was 10,546 kg of which only 6796 kg were used in the area itself. There was no demand for broodlac and, therefore, the surplus could not be disposed off and was, therefore, scraped along with rejected lac which gave an yield of 4,706 kg of sticklac.

Establishment of Kusmi broodlac farm at Maheshpur Sirka

This *Kusmi* broodlac demonstration farm has been established by the Forest Department of Bihar with technical assistance being provided by this Institute. Side by side, different techniques are being investigated in this area to stimulate lac production and to study the behaviour of *kusum* trees in the production of lac during different seasons.

Lac production on *kusum* by the conventional techniques adopted by villagers is notorious for its uncertainties and hence the new techniques (established and modified) as reported last year (*A. Rep.* 1967) are under investigation. These techniques involve harvesting of the host in June/July which ensures optimum growth of bushes by inoculation in 12 months, i.e. by the next June/July when inoculation is carried out. However, unlike the established practice, the crop is not harvested when it matures in the following January/February but is allowed to remain on the host. This results in self-inoculation at this time and the crop is finally harvested when it matures again in June/July, i.e. one year after the initial inoculation. The modified technique is so planned that 18 months rest is provided and complete harvesting is resorted to every

6 months. Such procedures ensure main harvesting and pruning in both techniques in June/July which stimulate better shoot growth suitable for lac cultivation. It also involves less operational costs, requires less broodlac and provides use of the maximum proportion for extending trees available for cultivation at any one period. Under this technique, sustained production of broodlac could be maintained. During the year, despite the fact that broodlac was stolen, a higher yield of broodlac was obtained during *Aghani*-cum-*Jethwi* crop in comparison with conventional practice. Subsequent inoculation for the following *Aghani* and *Agahani*-cum-*Jethwi* crops were carried out which are progressing satisfactorily.

Namkum Plantation

General upkeep of the plantation was maintained as far as possible. Hoeing and weeding were carried out. Seedlings of various lac hosts were raised in nursery beds for re-stocking vacant places and for use in pots for laboratory experiments. Infestation of termites could be controlled to a large extent by periodical spraying of insecticides. 500 *galwang* plants were raised in low water logged areas by making contour bunds.

(B) CHEMISTRY DIVISION

Unlike extension of cultivation, extension activities regarding processing and utilization aspects of lac are the complete responsibility of this Institute. For this purpose, the Institute maintains a Utilization Section, the main activities of which are technical service, developmental activities, publicity and propaganda, etc.

Technical Services

Technical service was, as usual, provided to all those interested and who made a request. These included several Government organizations, private institutions and individuals interested in using shellac and shellac compositions. Literature on bleached lac, sealing wax, French polish, hydrolysed lac, etch primer and constitution of lac, and samples of various paints and varnishes, bleached lac, lac wax, etch primers, and moulding powder were also supplied. In addition, samples of Melfolac, gasket shellac compound, cable dressing compounds, coating for braided wire, adhesive for mica, and rubber shellac compositions were also supplied to various industries for testing suitability for use in their manufactures.

A few of the more important other activities are listed below:

1. Ministry of Commerce and Industry, State of Israel was supplied with information regarding qualities of refuse lac and methods of testing them.

2. Samples of water based primers have been supplied to Chotanagpur Industries and Indian Steel Manufacturing Co., Ranchi, M/S P. C. Chanda and Co., Calcutta and National Metallurgical Laboratory, Jamshedpur for industrial assessment of performance.

3. The Institute developed the following composition of shellac powder for use as adhesive for manufacture of micanite by the solventless process.

Autoclave shellac	— 95 parts
Rosin	— 5 parts

Samples submitted were approved by the Heavy Electricals Ltd., Bhopal who were then supplied regular quantities of the product, from the Pilot Production Unit of the Institute, at the rate of 400 kg per month pending arrangement for regular supplies from commercial sources.

4. Training on manufacture of bleached lac was imparted to a nominee of the Forest Department of Bihar and a few others. One technician of an industrialist was also provided training on the production of shellac moulding powder.

5. A leading manufacturer of wax products in the country was provided technical assistance for the designing of a suitable plant for extraction of wax from the acid precipitated sludge of lac factory effluents. Assistance was also extended to them for the procurement of the sludge from lac processing factories. It is understood they are going ahead with the project.

6. Formulations of water proof inks, nail polish and paper testing wax developed in the Institute were supplied to a few parties on request.

7. A request was received from the Special Officer of India in Bhutan for a shellac composition for lacquering wooden bowls used for taking food. A sample of Melfolac pigmented with Burnswick Green (2 parts) and TiO_2 (20 parts) which was considered suitable, has been supplied.

8. One party asked for a composition for making "beam" paper used in textile industries. A sample of blank sheet supplied by the party was coated with a solution of 100 g shellac in 400 ml water containing 10 g triethanolamine by brush. After air drying, the sheet was baked at 120°C for one hour and the coated sample returned to the party who has reported that the composition was satisfactory.

Development work

A few schemes for industries on processing of lac and utilization were received from different parties for scrutiny and advice. These were attended to. On the basis of details supplied by the Institute, the West Bengal Lac Board has adopted a scheme for production of bleached lac on a large scale. At the request of the Deputy Industrial Adviser to the Government of Bihar, technical information regarding different industries based on lac was supplied. Under the Rural Industrialization Scheme, the Community Project Officer (Industries), Ranchi requested for schemes based on lac which were supplied. A French polish factory and lac factory for a Growers' Co-operative Society have been set up by the said organization.

The Khadi and Village Industries Commission had started a lac processing factory in Dhudi (Uttar Pradesh) for which the necessary technical assistance was provided. The Heavy Electrical Ltd., Hardwar and Bharat Heavy Electricals Ltd., Ramchandrapuram, Hyderabad were supplied all available information regarding electrical properties of shellac to find out the scope of increasing consumption of shellac in the electrical industries. The Indian Institute of Science, Bangalore was supplied samples of shellac derivatives for high insulation.

A circular was sent out to all important rubber goods manufacturers indicating the advantages of incorporating shellac with rubber. As a result, several requests were received for samples which were supplied. A few comments have been received. A premier rubber goods manufacturer in the country has started using increasing quantities of shellac for their production. Contact has

been established with them to assist them for supplies and to tackle their technical problems, if any.

Propaganda and Publicity

Due to shortage of staff, the Institute could not participate in any exhibition. However, samples of lacs and lac products were freely supplied to all those who asked for them for display in different exhibitions.

Pilot Production Unit

The Pilot Production Unit continued to function throughout the year and five grades of special shellacs, namely, two grades of bleached lac — refined and regular, two grades of water soluble lac — (DL and AL), and one grade of autoclave shellac (ASK) were manufactured and sold to interested consumers. Besides, hydrolysed lac, French polish, and Melfolac, etc. were also manufactured and sold.

Sale figures of production unit:

Material	*Quantity in kg*	*Price in Rupees*
1. BRF grade bleached lac	167·30	1,330·60
2. BR grade bleached lac	365·20	2,453·08
3. DL grade water sol. lac	348·00	2,399·25
4. AL grade water sol. lac	61·00	386·00
5. ASK grade autoclave shellac	2930·00	18,188·00
6. Miscellaneous lac products (Melfolac, hydrolysed lac, lac wax, cable dressing compounds, etc.)		1,495·90
	Total:	26,252·83

Thus during the year under report, the unit has sold 3,871·50 kg of special shellacs for Rs. 24,756·93 and other miscellaneous lac based products like varnishes, hydrolysed lacs, etc. values at Rs. 1,495·90. The total sale from the Pilot Production Unit during the year 1968 thus amounted to Rs. 26,252·83.

5. SUMMARY

(A) ENTOMOLOGY DIVISION

Researches in the Entomology Division were aimed, as hitherto, at intensifying lac cultivation and improving the quality of lac produced. Among the notable results during the year are the isolation and identification of four micro-organisms associated with the lac insect and the determination of (i) the optimum brood rate for *palas* where self inoculation is desired to be allowed for one season, (ii) the optimum spacing between *bhalia* bushes for lac cultivation on plantation basis, (iii) the manurial requirement of these bushes and (iv) the optimum period for advance cutting of *palas* and *ber* broodlacs. Itemwise summary of the various results now follows.

(a) Researches completed

1. Brood rate trials on *palas* have shown that where it is desired to harvest the crop only once in two seasons allowing self inoculation in between, light inoculation (with about 0·25 kg of broodlac per tree) gives as good a crop as heavier inoculations besides resulting in higher yields of broodlac also.

2. It has been found that in a plantation of the recently discovered bushy host, namely *bhalia*, for growing the superior *Kusmi* lac, yields of sticklac are highest when the bushes are spaced at 1·22×1·22 metres.

3. Manuring with NPK or farmyard manure increases the yield of sticklac on *bhalia* bushes substantially, farmyard manure at the rate of 36 quintals per acre being the best.

4. A general survey of the inimical and beneficial insects of lac has shown that incidence of lac parasites and predators was slightly more in lac crops raised on *bhalia* than on *kusum*. Of the predators, *E. amabilis* outnumbered *H. pulverea* and in the case of parasites, *T. purpureus* was in the largest number followed by *P. clavicornis* and *C. tschirchii*. Among the beneficial insects, *P. sulci* was the most prevalent. Incidence of these insects was found to increase as the crop matured.

(b) Researches in hand

1. Unlike in the previous years, larval emergence took place and fairly good crops were obtained from broodlac harvested from *ber* even three weeks prior to the time of larval emergence. This is rather unusual and is being looked into.

2. Of the two broodlacs commonly used for crop inoculations on *Rangeeni* hosts, namely those harvested from *palas* and *ber*, the latter was found to be better for inoculating *palas* and *ber* in both *Baisakhi* and *Katki* seasons.

3. This year also, although larval emergence took place from *palas* broodlacs harvested upto 3 weeks prior to the time of larval emergence, lac crops developed only from those harvested at the time of larval emergence and one week earlier.

4. *Bhalia* bushes are being raised for experiments to evolve an optimum lac cultivation schedule for this host.

5. Trials with various improvements on the existing cultivation practice for *kusum* have provided further confirmation that this host is better exploited if inoculated one year after pruning in January/February and the crop is harvested once in two seasons, that is in the following January/February.

6. A new study was initiated during the year to determine the optimum time of harvesting-cum-coppicing *bhalia* for growing *Kusmi* lac. The four practices under trial involve crop inoculations in Januarj/February but different brood rates and periods of harvesting-cum-coppicing.

7. Another study initiated during the year concerns determination of the irrigational and manurial requirements of *bhalia* for growing *Kusmi* lac. Although the lac yields were not satisfactory, treatment differences were quite evident, the highest yield being recorded with the use of farmyard manure under irrigated condition.

8. The conventional tree host species such as *kusum, palas, ber* and *galwang* are being trained into suitable bushes to reduce the cost of lac cultivation operations and to facilitate agronomical treatments to increase yield of lac. The process of training *palas* and *kusum* were continued. *Ber* and *galwang* already trained into bushes were used for lac cultivation. Both produced satisfactory lac crops in the *Katki* and *Baisakhi* seasons.

9. Studies to find out alternate hosts for *Kusmi* lac were continued and those for *Rangeeni* lac initiated during the year. *Galwang* continued to show promise as an alternate host for raising *Jethwi* corp. Preliminary trials with two species each of *Albizzia* and *Ficus* as alternate hosts for *Rangeeni* lac have not been encouraging.

10. As it has already been established that *bhalia* is unable to carry a full lac crop during the summer months, induction of physiological drought resistance in it was attempted by exposing its seeds to high temperatures, namely 40°, 45° and 50°C for 24 hours and studying the behaviour of the resulting seedlings both under field and potted conditions. The percentage of germination was highest in the case of seeds treated at 50°C.

11. Development of polyploid varieties of *bhalia* for subsequent use as lac host was attempted using colchicine treatment.

12. The free amino acid content of body extracts from *Rangeeni* and *Kusmi* strains of lac insects at different developmental stages was determined using paper chromatography. Five to six amino acids were detected and identified at the crawling stage and after the first moult of *Rangeeni* insects whereas in the case of *Kusmi* insects six to seven and seven to eight amino acids were detected and identified at the crawling stage and in the fertilized female respectively.

13. The relation of host to the fecundity and resin secretion efficiency of the *Rangeeni* strain of lac insects is being studied. Cultures of the insects were raised on five host species for a comparison of their performance.

14. Four of the six microorganisms isolated from inside the body of lac insects were identified for the first time.

15. The possibility of adapting the superior *Kusmi* strain of lac insects to breed on *palas* to boost up production of the better quality lac continued to be examined by raising *Kusmi* lac insects successively on *palas*. The insect, after four

generations on *palas*, produced lac which compared favourably with pure *Kusmi* lac in regard to colour index, life and flow.

16. Economic evaluation of the first discovered mutation in lac insects, namely yellow, is being made by raising a large F_2 from crosses involving the crimson and yellow colour forms and recovering from this generation the two parental colour forms for a comparison of their average performance.

17. Life history studies of the important pests of the lac hosts *Grewia multiflora* and *bhalia* were continued. The relative efficiency of different insecticides against the important pests was also studied. Endrex (20 E.C.) was found to be the most effective.

18. Seasonal incidence and extent of damage by the lac predators, *E. amabilis* and *H. pulverea* were again studied in *Kusmi* lac grown on *bhalia*. Incidence of these predators was more in *Aghani* than in *Jethwi* crop. Damage by these predators was estimated at 41·43 and 22·62 per cent in the *Aghani* and *Jethwi* crops respectively.

19. Trials with *Bacillus thuringiensis* for the control of *E. amabilis* and *H. pulverea* in the field were continued with different concentrations and spray intervals and with varying numbers of total sprays under each. The best control was achieved with 0·06 and 0·12 per cent concentrations of the thuricide sprayed at 10 day intervals throughout the entire crop period.

20. The survey of pathogenic organism of lac predators was continued. Two microbial diseases were detected and isolation and culture of the causative organisms are under way.

21. The relative efficiency of (i) cryolite, (ii) sodium fluosilicate and (iii) Dieldrex in the control of lac parasites and predators was again studied in the field. The first two were effective against the predators only while the third was only slightly effective against both the predators and parasites.

Regional Field Research Stations

The routine problems under investigation were continued at Damoh and Mirzapur on the local hosts *ghont* and *palas*, and on *kusum* at Dharamjaigarh. The crops raised on these hosts were again rather poor to justify any inference.

A survey of the various insects associated with lac was also carried out in both the crops at all the stations.

(B) CHEMISTRY DIVISION

Researches in the Chemistry Division were aimed at, among others, improving the processing techniques and developing economic methods for utilization of the by-products, development of newer methods of grading and analysis as well as at developing newer and improved modifications and avenues for utilization of lac. Fundamental studies were also carried out in order to determine the constitution of lac as well as its physico-chemical properties.

Among the more important findings during the year are (i) an improved water thinned anticorrosive primer, (ii) a composition and technique for the application of shellac by electrodeposition which was successfully used by the Heavy Engineering Corporation, Ranchi, for insulating mild steel core plates of

transformers for induction heating and (iii) a method and compositions for coating urea fertilizer to reduce its moisture sensitivity and leaching rate in the soil.

Researches completed

(i) A single pack etch primer had been developed based on barium potassium chromate, a pigment produced entirely from indigenously available raw materials, in replacement of zinc chrome, as zinc is an imported item. The new primer is comparable in all respects with the one containing zinc chrome.

(ii) A " Durophen " type product has been produced based on shellac-castor oil combination and bisphenol A/formaldehyde condensate. The optimum ratio of lac and castor oil for the composition was 50: 50 and the lac-oil combination to the phenolic condensate, 1: 3 by weight, for the best surface coating properties including resistance to chemicals and solvents.

(iii) The laboratory method developed earlier for recovering the total water soluble dye from sticklac wash water was repeated on a semi-pilot plant scale using 100 kg of sticklac per charge. The pure dye (ash content 0·8 per cent) was obtained in an yield of 0·76 per cent on the weight of sticklac. It has retained its solubility in water for 10 months so far.

(iv) Effect of solvents used on the film properties of lac varnish was examined. Varnishes containing 25 per cent solids were prepared in methyl, ethyl, propyl, *iso*-propyl, butyl and amyl alcohols and in mixtures of acetone and water (93: 7) and ethyl acetate and ethyl alcohol (85: 15) and examined. It was found that there was hardly any worth the while difference in the properties of the air dried and baked films. Air dried films of varnishes in butyl and amyl alcohols were, however, somewhat more elastic and less heat resistant presumably because of retained solvent at the time of testing after seven days. Further, only films of varnishes in methyl and ethyl alcohols air dried to constant weight within 7 days. The others took much longer.

(v) A number of two component pigment mixtures were tried in place of red oxide alone for improving the corrosion resistance of water thinned shellac maleinized linseed oil primers. Mixtures containing (i) aluminium powder (24 g) and zinc oxide (12 g), (ii) red oxide (32 g) and mica powder (4 g) and (iii) aluminium powder (24 g and zinc oxide (8 g) and mica powder (4 g) per 200 g of vehicle (of 33 per cent solids) were found to produce primers of improved performance.

Research in hand

1. *Constitution of lac*—(a) It has been found that methyl esters of non-, mono-, di-, and tri-hydroxy fatty acids and shellolic acid gave identical standard curves, on plotting optical density, determined in " Spectronic 20 ", against microgram of the esters, while tetrahydroxy acid and shellac each gave a different curve. Rf values of the methyl esters of the known acid constituents of lac resin were determined in two solvent systems. Ester mixtures from *kusum*, *ber* and *palas* seedlacs and dewaxed decolourized shellac were examined by thin layer chromatography and found to separate into eight distinct classes of esters.

(b) The non-adduct, obtained by urea treatment of the acetylated urea adducted portion of soft resin, gave a mixture of myristic and palmitic acids and 9,10,16-trihydroxypalmitic acid (m.p. 93-94°C) on fractionation over silicic acid.

Quantitative estimation of aleuritic and jalaric acids in different samples of soft resin indicated that the vicinal hydroxyl groups and aldehyde group in soft resin are partly free and partly combined.

(c) Soft resin was separated into 11 fractions by fractional precipitation of its acetone solution with water at 30°C. Molecular weights of these fractions determined by Rast method and those calculated from their intrinsic viscosities using the formula $[\eta] = KM^{\alpha}$ agreed closely among themselves and with the equivalent weight calculated from acid values, indicating that all these fractions and consequently soft resin itself are monobasic. K and α were found to be $7{\cdot}2 \times 10^{-4}$ and 0·67 respectively.

2. (a) For cold curing films, dewaxed lac graft copolymerized with 40 per cent of its weight of butyl acrylate alone or with a mixture of 20 per cent butyl acrylate, 10 per cent styrene and 10 per cent acrylamide gave films superior to those of the parent lac, the latter particularly in regard to flexibility, impact resistance and water resistance.

(b) It has been found that during the baking of dewaxed lac/urea resin films, there is a progressive drop in the carboxyl and hydroxyl values of the blend indicating esterification and ether interchange between the two resins. The ultimate films are consequently much more complex than the initial mixture. Curing of the film proceeds to the extent of 90 per cent on baking for 60 minutes but when catalysed with 1·25 per cent of *p*-toluene sulphonic acid, the curing is almost complete (99 per cent) within this period.

(c) Air dried films of lac fractions and of even completely precipitated lac obtained from its alcoholic solution by the addition of 1 per cent aqueous solution of sodium chloride showed remarkable water resistance, no blushing being visible upto one week's continued immersion. The technique has now been extended to produce dewaxed lac fo good colour, life and flow from seedlac and even from sticklac. All the lac resin is thus recovered and there are no lac containing by-products. The residue is a valuable source of good clean lac wax.

3. (a) In the above process, the comparative performance of acetone and alcohol as the extracting solvent was investigated. Extraction of *ber* sticklac with acetone as well as with alcohol resulted in a much higher yield (82·5 per cent) of shellac than (62 per cent) obtained by the conventional *bhatta* method, and the product had all the desirable properties except colour index which was higher by 3. Wax content of the lac produced could be reduced to 0·04 per cent if the extraction is carried out with 95 per cent distilled methylated spirit at 0°C.

(b) Total hydrolysed lac could be bleached with sodium chlorite, calcium hypochlorite or chlorine gas at a *p*H of 3 to 5. The bleached product had a colour index of 0·47 to 0·6 and acid and hydroxyl values of 179-185 and 204-210 respectively. Ash content was 2·7 to 3·6 per cent and life under heat varied between 348 and 412 minutes.

4. The study on polymerization and depolymerization of lac could not be taken up due to shortage of staff.

5. (a) Sulphuric acid treated lacs were separated by means of ether into soluble (soft resin) and insoluble (hard resin) fractions and the constants of these fractions determined. Two more modified sulphonated lacs were prepared (i) by salting out the sulphonation product of lac with 30 per cent sodium chloride solution and (ii) by dissolving the product first in hot water (70-80°C) and then salting out with brine. Both the products had different chemical constants.

6. (a) Shellac forms an insoluble product with urea on boiling in acetone solution. This property is being utilized for the development of a quantitative method for the estimation of shellac in presence of other resins. The procedure is being standardized.

(b) Specific heat of lac, which falls with progressive period of storage, is being investigated as a possible means to determine the age of seedlac. The value dropped by 13-20 per cent within 36 months and remained unchanged thereafter for the next 16 months.

7. Incorporation of water soluble urea resin into aqueous ammoniacal solution of lac produces air dried films (on wood) of improved heat and water resistance but poor gloss. Use of maleic resin in place of urea resin resulted in good gloss but poor heat and water resistance. Incorporation of 20 per cent urea resin and 10 per cent of maleic resin on the weight of lac gave the best overall performance. Ammonia was the most satisfactory base for such varnishes.

8. (a) When milled with gum stock of natural rubber (that is without filler) and with MBT as accelerator, shellac has been found to act as a processing aid and to improve tear strength, hardness and ageing properties. It also exerts a useful antiscorching effect. A comparison of the effect of incorporation of various types of shellac was also made. As regards mechanical properties, plantina and *Rangeeni* lacs behaved alike while *Kusmi* appeared to be somewhat better. As regards effect on accelerated ageing, *Rangeeni* and *Kusmi* were alike while platina appeared to be inferior. Addition of ethylene glycol modified lac to synthetic (SBR 1502) rubber together with black fillers improved Mooney viscosity, modulus and hardness but abrasion resistance was somewhat reduced.

(b) It has been observed that no apparent change takes place when shellac is milled with natural rubber alone. However, 80 per cent of the shellac added appeared to undergo some change when milled in presence of other ingredients, which rose to 87·7 per cent after the combination was vulcanized.

Free sulphur contents were also estimated in vulcanized shellac and modified lac (SBR) rubber combinations. It was found to be the least with ethylene glycol modified lac and the maximum with plain shellac. Epoxy resin modified lac came in between. Crosslink density decreased with increasing amounts of shellac in the case of SBR rubber.

9. It has been found that for plastic moulding, upto 10 per cent of tri-cresyl phosphate, an imported item, could be replaced by ethyl or butyl ester of shellac for plasticization of polyvinyl chloride.

10. (i) Butyl and ethyl esters of lac do not possess satisfactory film properties but when modified by fusing with maleic anhydride equivalent to their hydroxyl contents, fairly satisfactory aqueous or solvent based varnishes of the baking type could be obtained.

Esterification of lac with *n*-butyl alcohol without catalyst was studied to avoid one step of removing the catalyst before use. The partial ester produced had acid and hydroxyl values of 50·1 and 180·0 and molecular weight of 1028. Like the parent lac, it cured melamine resin in the cold producing heat and water resistant film. It also dissolved in aqueous ammonia and baked films of the aqueous varnish possessed good gloss, hardness, adhesion and elasticity and was thus superior to plain shellac for use in aqueous finishes. Addition of decolourized carbon (5 per cent on the weight of lac) during the esterification reduced colour index from 70 to 17.

(ii) Triethanolamine and morpholine have been found to be superior to ammonia for the preparation of shellac varnishes for application by electrodeposition. The optimum electrical data for application of these varnishes as well as red oxide primers based on these have been determined. Uniform coatings were obtained in 2 minutes at a bath temperature of 35°C using 50 volts and a current of 40 amperes per sq. meter.

(iii) Modification of lac with polyvinyl alcohol (PVA) was carried out to develop a water based lacquer for use on flexible supports. Air dried and baked films (150°C for 30 minutes) of varnishes prepared by blending the solutions of lac in aqueous ammonia and PVA in water, showed good adhesion and flexibility. Five per cent of PVA on the weight of lac was the optimum. Fusion of the two resins before dissolution was not satisfactory.

(iv) Propylene glycol has been shown to be superior to glycerol for the alcoholysis of linseed oil for further treatment with shellac to produce urethane coatings. A shellac/linseed oil/propylene glycol combination (100 parts) treated with toluene di-isocyanate (40 parts) in white spirit (100 parts) at room temperature (25-30°C) for 30 minutes showed improved pot life (10-12 hours). Films were also glossy, smooth and of high scratch hardness (1800 g) and good resistance to water and common solvents.

(v) Melfolac (a dewaxed lac/melamine resin, 100: 40, varnish) produces films of good hardness, gloss and resistance to heat, water and spirituous liquors but these improved properties are obtained only after about seven days of air drying. Studies were taken up to accelerate this. It has been found that incorporation of 1·25 per cent of hydrochloric or *p*-toluene sulphonic acid produced the same performance in 24 hours.

(vi) Solvent retained in shellac films was determined by estimating the ethoxyl content of the film. Ethoxyl contents of a 1·3 mil film after 1, 3, 5, 7, 9 and 13 days were found to be 4·27, 2·24, 1·13, 1·01 and 0·85 per cent respectively.

11. (a) The minimum film thickness of shellac/cashewnut shell liquid/urea/formaldehyde film to render hessian water and seepage proof has been determined as 1·5 mils. Bags of hessian so coated have been reported as satisfactory by Sindri Fertilizer Factory (a Central Government Undertaking). The composition is also satisfactory as an adhesive for laminating craft and crepe papers on hessian. Samples produced have been found satisfactory by Indian Jute Industries Research Association Laboratory, Calcutta.

(b) Investigations were taken up to study the possibility of giving a shellac coating to fertilizers in order to make them moisture resistant and non-caking and to slow down their leaching rate in the soil so that their release for the plants will be gradual and according to need. A spray coat of shellac in spirit was unsatisfactory. A two coat system sprayed on to granules on a revolving barrel with blowing of hot air to accelerate the drying was effective. The first coat of shellac/linseed oil/lime combination (5 g) in white spirit (5 g) sprayed on urea (100 g) followed, after drying, by a second coat of paraffin wax in hexane (1: 1) reduced the hygroscopicity of urea by 75 per cent.

Ad-hoc researches

(i) *Bleaching of shellac wax* — Bleaching/decolourization of shellac wax was tried using hydrogen peroxide, activated carbon and sodium hypochlorite. Only hypochlorite bleaching at 40-45°C of a suspension of wax in aqueous sodium carbonate proved satisfactory.

(ii) Impregnation with a 20 per cent aqueous ammonia or triethanolamine solution of hydrolysed lac (80 parts) and dewaxed lac (20 parts) was found to reduce the porosity and improve vacuum retention of rubber hose pipes used by Railways in the vacuum system of trains. An impregnated sample has been sent to the Railways for further assessment.

Shri Y. Sankaranarayanan
Director

6. METEOROLOGICAL REPORT FOR THE YEAR 1968

The average monthly meteorological data were as follows

Month	Mean pressure mm of mercury	Mean maximum temperature °C	Mean minimum temperature °C	Mean dry bulb temperature °C	Mean wet bulb temperature °C	Mean humidity per cent	Mean sunshine hrs/day	Total rainfall mm	Highest maximum temperature °C	Lowest minimum temperature °C
1	2	3	4	5	6	7	8	9	10	11
January	708·6	22·3	9·5	18·1	14·6	69·0	6·74	54·36	27·0	5·0
February	707·7	25·3	10·8	21·1	15·8	57·0	8·42	11·94	30·0	5·5
March	705·0	31·4	15·6	27·6	19·6	45·5	8·03	10·92	37·0	12·2
April	703·3	39·5	20·3	31·7	23·4	48·0	7·31	1·27	39·0	12·5
May	699·6	39·2	23·7	35·3	25·5	45·0	8·80	49·53	42·0	20·3
June	697·8	31·9	22·7	28·5	25·2	76·0	4·27	333·20	39·2	20·2
July	697·6	29·9	23·1	27·5	25·5	85·0	3·42	401·33	32·5	22·0
August	698·4	29·1	22·6	26·7	25·0	87·0	3·76	519·18	31·5	20·0
September	701·3	31·6	22·2	29·4	26·5	79·0	6·53	91·06	35·5	21·0
October	705·5	29·3	17·6	26·6	23·6	77·0	7·00	102·36	32·6	12·7
November	708·5	27·3	11·9	24·6	21·3	73·5	7·88	nil	30·5	8·3
December	708·8	24·1	8·0	20·7	17·5	71·0	7·47	nil	26·5	4·5

The maximum temperature during the year was 42°C on 29th May and the lowest 4·5°C on 30th December. The total rainfall during the year was 1575·15 mm of which the monsoon (June-September) rainfall was 1344·77 mm. The total rainfall during the year was higher than 1967 by 87·50 mm. There were hail storms on 14th January and 16th May.

7. PERSONNEL

STATEMENT SHOWING APPOINTMENTS, PROMOTIONS, RESIGNATIONS, RETIREMENTS, ETC., DURING JANUARY-DECEMBER 1968

Division/Section	Name	Post to which appointed	Date
1	2	3	4
A. Appointments			
Entomology Division	1. Shri Pranay Kumar	Research Assistant	25-1-1968
	2. ,, R. C. Misra	Instructor Research Assistant	27-1-1968
	3. ,, Y. D. Misra	Research Assistant	29-5-1968
	4. ,, M. L. Bhagat	do	4-6-1968
	5. Miss Kanta Rani Lal	do	15-6-1968
Chemistry Division	1. Shri B. C. Srivastava	Research Assistant	6-1-1968
	2. ,, N. Prasad	do	1-6-1968
	3. ,, Radha Singh	do	3-6-1968
	4. ,, R. N. Majee	do	20-6-1968
	5. ,, V. K. Srivastava	do	12-7-1968
Administrative Section	1. Shri Hari Ram	Peon	19-1-1968
	2. ,, D. K. Jain	Technical Assistant	5-2-1968
	3. ,, Phekuwa Munda	Monthly rated Majdoor	1-6-1968
	4. ,, S. Prasad (on deputation)	Accounts Officer	17-6-1968
	5. ,, R. P. Tiwary	Librarian	20-9-1968
	6. M. Beck (on deputation)	Assistant	19-11-1968
	7. Smt. Sati Guha	Junior Clerk	12-12-1968
B. Promotion			
Administrative Section	1. Shri D. P. Sen Gupta	Assistant	28-11-1968
	2. ,, Musafir Singh	U.D.C.	28-11-1968
	3. Smt. Shibani Pattadar	do	28-11-1968
	4. Shri Md. Samiullah	do	28-11-1968
	5. ,, A. K. Chowdhury	do	10-12-1968
C. Resignation			
Chemistry Division	1. Shri K. B. Lal	Research Assistant	12-3-1968
	2. ,, R. N. Pandey	do	13-9-1968
	3. ,, V. K. Srivastava	do	22-10-1968
Administrative Section	1. Shri M. P. Potty	Junior Clerk	1-6-1968
	2. ,, R. P. Indwar	Librarian	9-7-1968
D. Retirement			
Entomology Division	1. Shri A. C. Chattarjee	Fieldman	5-2-1968

STAFF: DIVISIONWISE

Sl. No.	Name of the post	Sanctioned strength	Staff in position as on 31-12-1968
1	Director	1	Dr. G. S. Misra
	Entomology Division		
2	Entomologist	1	Dr. A. Bhattacharya
3	Scientific Officer (Cultivation and Training)	1	Shri B. P. Mehra
4	Scientific Officer (Field Station)	1	,, C. P. Malhotra
5	Scientific Officer (Insect Genetics)	1	,, N. S. Chauhan
6	Scientific Officer (Arboriculture)	1	Vacant
7	Scientific Officer (Physiology)	1	Vacant
8	Scientific Officer (Biology)	1	Vacant
9	Senior Research Assistant	8	1. Shri B. K. Purkayastha 2. ,, R. S. Gokulpure 3. ,, A. H. Naqvi 4. ,, N. Majumdar 5-8 Vacant
10	Instructor	1	Shri R. C. Misra
11	Research Assistant	16	1. Shri Parimal Sen 2. ,, A. K. Sen 3. ,, S. G. Choudhary 4. ,, U. P. Griyaghey 5. ,, B. N. Sah 6. ,, J. M. Das Gupta 7. ,, R. C. Maurya 8. ,, Pranaya Kumar 9. ,, Y. D. Misra 10. ,, M. L. Bhagat 11. Miss Kanta Rani Lal
		J.R.A. working against the vacancy of R.A.	12. Shri M. K. Chowdhury
			13-16 Vacant
12	Senior Artist-cum-Photographer	1	Shri R. L. Singh
13	Junior Artist-cum-Photographer	1	Shri P. Das
14	Junior Field Assistant	4	Vacant
15	Steno-typist	1	Shri K. Divakaran
16	Fieldman	17	1. Shri S. N. Sharma 2. ,, H. R. Munda 3. ,, Sant Kumar 4. R. K. Paul 5. ,, R. S. Maliya 6. ,, K. C. Jain 7. ,, Jawahir Lal 8. ,, B. D. Tiwari 9. ,, S. S. Prasad 10. ,, B. P. Sah 11-17 Vacant
17	Field, Plantation and Store Assistant	1	Shri Gabriel Lakra
18	Insect Collection Tender	1	Shri Md. Ali Ansari
19	Laboratory Assistant	10	1. Mrs. Namita Nandi 2. Shri Ajmer Hussain 3. ,, K. L. Chowdhury 4. ,, D. D. Prasad 5. ,, G. K. Jha 6. ,, R. D. Pathak 7. ,, R. C. Singh 8-10 Vacant

Sl. No.	Name of the post	Sanctioned strength	Staff in position as on 31-12-1968
20	Museum Assistant	1	Vacant
21	Laboratory Attendant	10	1. Shri Mani Mahato
			2. ,, Jagarnath Oraon
			3. ,, Dema Oraon
			4. ,, Yakub Tirkey
			5. ,, Md. Shariff
			6. ,, Kamal Prasad
			7. ,, S. K. Chatterjee
			8. ,, H. N. Shukla
			9. ,, Mohor Sahu
			10. ,, Gendu Bauri
22	Peon	2	1. Shri Shyamlal Ram
			2. ,, Gandur Singh
23	Mali	2	1. Shri Budhua Oraon
			2. ,, Mariya Oraon
24	Durwan	4	1. Shri Jiwan Lal
			2. ,, Kashi Nath
			3. ,, Chhotelal Dhimar
			4. Vacant
25	Field Chowkidar	9	1. Shri Dubraj Munda
			2. ,, Aghnu Munda
			3. ,, Keshar Bhuian
			4. ,, Madhuri Bhuian
			5. ,, Jharia Pahan
			6-9 Vacant
26	Monthly rated Majoors (Plantation)	11	1. Shri Khainya Christan
			2. ,, Mahadeo Oraon
			3. ,, Santo Christan
			4. ,, Tunuwa Oraon
			5. ,, Etwa Oraon
			6. ,, Bitan Oraon
			7. ,, Sukra Oraon
			8. ,, Remna Oraon
			9. ,, Jatru Oraon
			10. ,, Daniel Tirkey
			11. Vacant
	Chemistry Division		
1	Senior Scientific Officer (Organic)	1	Shri Y. Sankaranarayanan
2	Senior Scientific Officer (Utilization)	1	Dr. T. Bhowmik
3	Scientific Officer (Physical)	1	Dr. P. R. Bhattacharya
4	Scientific Officer (Applied)	1	Shri S. C. Sen Gupta
5	Scientific Officer (Decorative Coating)	1	,, Shravan Kumar
6	Scientific Officer (Factory)	1	Dr. B. B. Khanna
7	Scientific Officer (Utilization)	1	Vacant
8	Junior Scientific Officer	1	Shri P. K. Ghosh
9	Senior Research Assistant	6	1. Shri A. K. Ghosh
			2. ,, P. C. Ghosh
			3. ,, A. Kumar (on leave)
			4. ,, P. C. Gupta
			5-6 Vacant
10	Senior Analyst	2	Vacant
11	Research Assistant	17	1. Shri A. Rahman
			2. ,, T. Sahu
			3. ,, R. K. Banerjee
			4. ,, S. K. M. Tripathi

Sl. No.	Name of the post	Sanctioned stength	Staff in position as on 31-12-1968
			5. Shri August Pandey
			6. ,, M. Mukherjee
			7. ,, M. Islam
			8. ,, S. C. Agarwal
			9. ,, G. C. Sharma
			10. ,, D. K. Guha Sarkar
			11. ,, A. K. Das Gupta
			12. ,, B. C. Srivastava
			13. ,, Niranjan Prasad
			14. ,, Radha Singh
			15. ,, R. N. Majee
			16-17 Vacant
12	Analyst	3	1. Shri L. C. Misra
			2. ,, B. P. Banerjee
			3. ,, Ramesh Prasad
13	Junior Analyst	3	Vacant
14	Glass Blower	1	Shri S. K. Dey
15	Steno-typist	1	Shri P. N. Sivankutty
16	Laboratory Assistant	11	1. Shri Dominick Runda
			2. ,, Noas Minz
			3. ,, G. M. Borkar
			4. ,, B. B. Chakravorty
			5. ,, Nagendra Mahto
			6. ,, Umeshwar Sahay
			7. ,, Balaram Majumdar
			8. ,, B. P. Keshri
			9. ,, M. K. Singh
			10-11 Vacant
17	Laboratory Attendant	10	1. Shri Masidas Minz
			2. ,, Siba Baraick
			3. ,, Mangta Oraon
			4. ,, Gopeswar Misra
			5. ,, P. B. Sen
			6. ,, Md. Ghasheet
			7. ,, Chinmoy Sen Gupta
			8. ,, Dukha Oraon
			9. ,, Chhedilal
			10. ,, R. C. Tiwari
18	Peon	4	1. Shri Nathanial Kachhap
			2. ,, S. C. Gope
			3. ,, Dhadoo Mahto
			4. ,, Hari Ram
19	Durwan	3	1. Shri S. K. Deogharia
			2-3 Vacant
20	Factory Boy	1	Shri Hanuk Tigga
21	Melter	1	Shri Sukra Oraon
22	Stretcher	1	Shri Lohra Oraon
	Administrative and Audit and Accounts Section		
1	Administrative Officer	1	Shri Uma Datta
2	Accounts Officer	1	,, S. Prasad
3	Superintendent	1	,, K. K. Mustaufi
4	T.A. to Director	1	,, D. K. Jain
5	Assistants	8	1. Shri S. K. Sarkar
			2. ,, L. M. Nandy
			3. ,, S. N. Sharma
			4. ,, S. N. Prasad
			5. ,, R. K. Singh

Sl. No.	Name of the post	Sanctioned strength	Staff in position as on 31-12-1968
			6. Shri P. K. Chowdhury
			7. ,, D. P. Sen Gupta
			8. ,, M. Beck
6	Stenographer grade I	1	Shri M. T. Rughani
7	Librarian	1	,, R. P. Tiwary
8	Upper Division Clerk	6	1. Shri H. S. Munda
			2. ,, R. P. Singh
			3. Mrs. Shibani Pattadar
			4. Shri Musafir Singh
			5. ,, Md. Samiullah
			6. ,, A. K. Chowdhury
9	Store Keeper	1	Shri Enamul Haque
10	Lower Division Clerk	15	1. Shri E. Tirkey
			2. ,, A. Haque
			3. ,, S. K. P. Keshri
			4. ,, R. B. Singh
			5. ,, Kuldip Pandey
			6. ,, C. V. Joseph
			7. ,, K. N. Sinha
			8. ,, A. S. Prasad
			9. ,, R. B. Pradhan
			10. ,, Sudarshan Ram
			11. Smt. Sati Guha
			12-15 Vacant
11	Daftari	2	1. Shri Martin Beck
			2. Vacant
12	Peon	7	1. Shri Budhuwa Oraon
			2. ,, Jagdish Ram
			3. ,, Pahna Lakra
			4. ,, Mahadeo Mahto
			5. ,, Tota Ram
			6. ,, Elias Lakra
			7. ,, Jogeshwar Ram
13	Farash	2	1. Shri Mangra Oraon
			2. ,, Tutung Bihan
	Mechanical Section		
1	Chief Mechanic	1	Shri K. N. Sinha
2	Assistant Mechanic	1	Vacant
3	Instrument Maker	1	Shri M. Kujur
4	Turner	1	,, A. S. Manoranjan
5	Jeep Driver	1	,, Jagdish Ram
6	Boiler Attendant	1	Vacant
7	Tindal	1	Shri Tulsi Ram
8	Carpenter	1	,, Balku Lohar
9	Khalasi	1	,, Budhuwa Oraon
10	Gas Plant Attendant	1	,, Lachhan Oraon
	Estate		
1	Estate Care Taker	1	Shri D. N. Mahto
2	Labour Supervisor	1	Vacant
3	Armed Guard	1	Shri Jamun Jha
4	Chowkidars or Durwans	14	1. Shri Sahadeo Ram
			2. ,, Abdul Motalib
			3. ,, Hawaldar Singh
			4. ,, Mahadeo Oraon (Lodhama)

Sl. No.	Name of the post	Sanctioned strength	Staff in position as on 31-12 1968
			5. Shri Mahadeo Oraon (Khijri)
			6. ,, Premdas Banerjee
			7. ,, Prayag Mahto
			8. ,, Deolal Singh
			9. ,, Mohan Bahadur Chhatri
			10. ,, Ramdas Misra
			11. ,, Chattur Oraon
			12. ,, Sanicharwa Oraon
			13. ,, Ramgulam Singh
			14. ,, Jogendra Pathak
5	Sweepers	5	1. Shri Sanicharwa Ram
			2. ,, Phuneshwar Ram
			3. ,, Budhu Ram
			4. ,, Patras Bando
			5. Smt. Mundri
6	Bullock Keeper	2	1. Shri Phekuwa Munda
			2. Vacant
7	Monthly rated Majdoor	11	1. Shri Bhandoo Mahto
			2. ,, Kena Oraon
			3. ,, Bhikham Ahir
			4. ,, Sukra Oraon (Ulatu)
			5. ,, Bigal Oraon
			6. ,, Sampat Singh
			7. ,, Jaimashih Christan
			8. ,, Fagu Oraon
			9. ,, Budhuwa Oraon
			10. ,, Ribuwa Lohar
			11. ,, Phekuwa Munda
	Medical Unit		
1	Authorized Medical Attendant	1	Dr. S. S. Sahay
2	Pharmacist	1	Shri B. N. Munda
3	Part time clerk	1	Shri Sant Kumar

APPENDIX

HEAVY MACHINE BUILDING PLANT PROCESS DEPARTMENT

No. HMB/PD/151/69- Dated, the 10th February 1969

Sub: Report on Insulating Material for Induction hardening equipment.

For the hardening of surfaces of certain components of machines the method H.F. Induction Hardening is used in our factory.

For the purposes of efficient heating of the components the Inductors are manufactured with core plates made of transformer steel.

To prevent the inductor itself from getting heated it is necessary that the core plates are insulated from each other efficiently.

The insulation on the plates provided by the suppliers used to get destroyed while machining the core plates, thus giving rise to shorting.

To overcome this difficulty our Tool Shop tried coating the cores, after machining, with various types of insulating varnishes. They tried methods of dipping into varnish and also painting the varnish. These methods, however, failed to produce good results as the varnish burnt at low temperatures.

To overcome this difficulty the Lac Research Institute at Namkum was approached by us to try and get some varnish, that could be efficiently coated on the core plates and that could withstand higher temperatures.

The research institute, was very helpful and they showed us two methods of coating the plates with a special varnish capable of withstanding temperatures upto 500°C.

The first was an electrical method wherein the varnish (water based Urea)* was made the Cathode and the core plate dipped into it the Anode. A current was slowly passed and in a matter of 20 seconds the core plate was uniformly coated by a layer of the varnish. The rise in the voltmeter reading showed the potential of insulation and could be adjusted to any required degree. The core plates were then washed in running water and baked in an oven at 200°C for 1 hour to make the coating permanent.

The other method used was the mechanical dipping method the core plate being dipped in spirit based urea** and then baked in the furnace.

The former method had the advantage of high speed and uniform coating. The second method was, however, cheaper, not needing any electrical apparatus.

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*This was actually aqueous dewaxed lac varnish in water containing triethanolamine.
**This was a spirit based dewaxed lac/urea resin varnish.

In our shops due to the need of a large number of core plates both methods were used, the former yielding better results. The potential across the core plate was tested and found to withstand 1000 volts.

The regime of work on the machine is as follows:

Potential	60 V
Temperature	200°-300°C
Frequency	800 Cy/Sec

The method of coating of core plates has been found entirely satisfactory for the above regime of work.

Sd/-
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