INDIAN LAC RESEARCH INSTITUTE

NAMKUM, RANCHI, BIHAR, INDIA

ANNUAL REPORT

FOR THE FINANCIAL YEAR 1946-47

1948

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ADMINISTRATIVE SECTION

General.— Although war had ended in 1945, supply of chemicals and apparatus continued to be far from satisfactory throughout the period under review. As an index to conditions prevailing abroad, manufacturing firms are not yet in a position to supply a number of apparatus for which orders have been pending for quite a long time. Generally speaking, a slow improvement in the availability of materials could be noticed in the first quarter of the year, but this received a sharp setback, deteriorating rapidly, since certain abnormal developments in most of the principal trading centres of India. Despite these handicaps, on the whole, a satisfactory standard of work could be maintained throughout the period.

As usual, the Institute continued to attract a large number of visitors. Some of these deserving special mention were as follows :

(i) His Excellency Sir Hugh Dow, K.C.S.I., C.I.E., I.C.S., Governor of Bihar.

(ii) The Hon'ble Mr. Jaglal Chowdhury, Minister, Excise and Public Health Department, Bihar.

(iii) Dr. J. N. Mukherji, C.B.E., D.Sc., Director, Indian Agricultural Research Institute, New Delhi.

(iv) Dr. J. W. Whittaker, Director, Fuel Research Institute, Dhanbad.

(v) Dr. S. Siddiqui, Director, National Chemical Laboratory, C.S.I.R.

(vi) M. A. Srinivasan, Esqr., B.A., Vice-President, Executive Council, Gwalior State.

Roads & Buildings.— No new construction was undertaken. Urgent petty repairs and whitewashing were done. Roads, which had been in a bad state of repair for some time past, were thoroughly dressed up and rolled.

Library.— Supply of foreign journals improved considerably and became almost regular towards the end of the year. Quite a number of foreign as well as Indian societies and institutions that had to suspend exchange of their publications with the Institute owing to exigencies of war are slowly coming back to their own, necessitating in turn an expansion of our own mailing list which too had been drastically curtailed for similar reasons. Several important German periodicals are also expected to re-commence publication soon.

The Library registered a total accession of 163 volumes including bound volumes of journals, during the period under report.

Medical Aid.— While the staff continued to get free medical aid as usual, a notable feature under this head is that the Indian Lac Cess Committee, following the lead of the Central Government, decided in January 1947 to extend the benefit of free medical aid to the families of the staff with effect from 1 April, 1947. This benevolent move on the part of the Committee has been deeply appreciated by the staff.

Scheme for the Intensification of Demonstration of the Methods of Cultivation of Lac in Bengal, Bihar & U.P.— Detailed information on the working of the scheme during the year has been given under the heading ' Intensive Demonstration Scheme ' in the report of the Entomological Section.

Training in the Industrial Uses of Lac.— Four students completed their training at the Institute in March 1946. A fresh batch of students, due for training from October 1946, turned up, but ultimately had to leave without undergoing the training as they could not find accommodation in or about Ranchi or Namkum.

Inspection of the Chemical Section of the Institute.— As reported earlier (*vide* ANNUAL REPORT 1943-44, p. 1), the inspection of the Entomological Section had been completed in June 1943. The inspection of the working of the Chemical Section which had been postponed on account of the war at last materialized towards the end of the year under report. DR. S. SIDDIQUI, Director, National Chemical Laboratories, Council of Scientific and Industrial Research, who had been deputed for the purpose by the Government of India, completed his inspection in February last, and is expected to submit his report soon.

Staff.— MR. P. M. GLOVER, M.B.E., B.SC., Entomologist, who had been called to the army in 1941, reverted to the Institute on 3 March, 1947. MR. A. K. THAKUR, M.SC., Class I Research Assistant, Chemical Section, who had been on leave preparatory to retirement, finally retired from the services of the Committee on 16 August, 1946. MR. J. N. SINGH who had been on deputation to Dungarpur State reverted to his post of Senior Fieldman on 1 April, 1946.

An extremely sad news to report is the sudden death of MR. M. P. MISRA, Acting Assistant Entomologist, on 9 January, 1947, while out on tour in Malda. His death was very much unexpected and deeply mourned by all members of the Institute.

The following appointments were made —

1. MR. TUHIN KUMAR ROY, M.SC., as Class II Research Assistant, Chemical Section, on 12 October, 1946.
2. HANUK TIGGA, as Chowkidar, on 1 March, 1947.
3. BONIFUS RUNDA, as Factory Boy, on 1 March, 1947.
4. BUDHUA ORAON, as Khalasi, on 1 October, 1946.

The following members resigned —

1. MR. M. P. MISRA, M.SC., Acting Assistant Entomologist (died on 9 January 1947).
2. MR. S. R. HAIDER, M.SC., Class II Research Asstt., Entomological Section, on 6 November, 1946.
3. MR. J. P. RASTOGI, B.SC., Fieldman, on 23 April, 1946.
4. MR. P. R. DAS GUPTA, Demonstrator, on 1 January, 1947.
5. SOMRA URAON, Chowkidar, on 1 March, 1947.
6. JARAM MINZ, Factory Boy, on 1 March, 1947.
7. BUDHUA MUNDA (retired) on 1 January, 1947.

NATHANIAL KACHHAP was transferred to the Institute as a Chaprasi from the office of the Secretary, I.L.C.C., *vice* KHUDU ORAON, Chaprasi, I.L.R.I., transferred to Secretary's office, on 21 October, 1946.

The Staff Club.— With conditions gradually returning to normal, the activities of the Staff Club are expanding in every direction and may be expected to reach the pre-war level in a year or two. Tennis could be started towards the end of the year.

ENTOMOLOGICAL SECTION

General.— Mr. P. S. NEGI, Assistant Entomologist, had been in charge of the Department up to 3 March, 1947, when MR. P. M. GLOVER, Entomologist, took over, on being released from military service.

Of the four Research Assistants' posts in the Section, one was vacant for over six months and another for three months. The Department was short of one Fieldman throughout the period.

HOST TREES

1. IMPROVING CROP PRODUCTION ON *palas* (*Butea monosperma*, SYN. *B. frondosa*) BY ARTIFICIAL PARTIAL DEFOLIATION IN KUNDRI FOREST AREA

In 1945-46 lac was grown on *palas* at Kundri by the villagers' method (control), utilizing partial cutting in April-May and natural infection in July,— and by the Institute method (experimental) using artificial defoliation (omitting partial harvesting in April-May) and artificial infection in July,— on two equal coupes of trees. The saving in the amount of brood used for infection in October on the experimental trees due to the absence of leaf stalks which had been removed in course of defoliation, more than covered the cost of the labour charges for defoliation.

The estimated yield of brood in July from the experimental trees was six times that from the control.

The ratio of brood used to brood obtained in October in the case of the control trees was 1 : 1·8, the same ratio in the case of the experimental trees being 1 : 3·4 for the *Baisakhi* crop and 1 : 3·7 for the *Katki*.

Thus this year's results further confirm the advantage of using the Institute methods of lac cultivation on *palas*.

In view of the satisfactory results obtained as a result of partial defoliation during the preceding five years, it was decided to advise the Forest Department, Bihar, to introduce artificial partial defoliation in Kundri Forest Area. A scheme was prepared by which an area of 456 acres in the forest was divided into three coupes (one *Katki* and two *Baisakhi* coupes) where defoliation was to be practised. This scheme was put into operation in Kundri as from October 1945.

As a result, for the first time for over 20 years, Kundri has not only been self-supporting in brood production, but has in addition been able to sell 104 maunds of surplus brood. The year, in so far as the climatic factors are concerned, has been admittedly favourable to lac propagation, but this alone cannot account for the increased yield, as during the last 20 years other equally favourable years must have occurred. The success in Kundri appears therefore in the main to be attributable to up-to-date methods of cultivation. Table I shows Receipts and Expenditure for 1946-47.

TABLE I

Estimated Receipts and Expenditure, Kundri Forest — 1946-47

Item	Approx. Receipts	Approx. Expenditure
	Rs.	Rs.
By sale brood, stick & scraped lac upto January 1947	12,900/-	...
To cost pruning, defoliation, infection, cropping, scraping, etc.	...	7,000/-
Scraped lac in hand 130 maunds estimated @ Rs. 60/- per maund	7,800/-	...
Dust lac in hand 9 maunds estimated @ Rs. 10/- per maund	90/-	...
TOTAL ...	20,790/-	7,000/-

It will be seen that the approximate estimated net profit of the year amounts to nearly Rs. 14,000/-.

Kundri has also served as an excellent training ground for Institute trainees, where they can learn improved methods of lac cultivation as applied to large-scale cultivation.

2. Determination of the most suitable Pruning Methods and Seasons for *kusum* and *palas*

Kusum. — Two experiments on pruning of *kusum* at respective intervals of one year and six months were being conducted at Berwari. But as this area had been given up in January 1946, these experiments had to be replanned and restarted in Hesal where the pruning cycle has been on an 18-month basis. It will take some time before the six-month coupes at Hesal show satisfactory results, owing to the difficulty of imposing a six-month cycle on an 18-month cycle. This may explain why the brood to yield ratios from six-month-old shoots, *vide* Table II, do not compare favourably with those obtained in previous years.

Table II

Brood to yield ratio from kusum shoots of varying age

Age of shoots	Ratio of brood to yield of scraped lac	
	Jethwi 1946	*Aghani 1946-47*
18 months ...	1 : 4·2	1 : 1·6
12 months ...	1 : 1·6	1 : 0·6
6 months ...	1 : 2·2	1 : 1·1

It will be seen that the best results were obtained from 18-month-old shoots, and the poorest from one-year-old shoots.

In the case of the six-month pruning cycle, the normal system of pruning branches and shoots apically has been replaced by surface pruning only, which, it is believed, will give rise to a greater number of suitable shoots, six months after pruning.

Growth of Shoots on kusum.— Studies on the growth of shoots indicate that new shoots normally appear on *kusum* during the period January to April and that they continue to grow linearly until June, when linear growth for the year ceases. From then onwards such shoots mature and thicken only. Further linear growth takes place again the following year.

If the growth of such shoots is interfered with by outside agency, as for example pruning, crop cutting or attack by insect enemies, either during the linear growth period or during the maturation period, new secondary growth arises as lateral shoots from several points on the primary shoot.

Ten trees have been selected at Hesal for detailed study of the growth of shoots resulting from January-February and June-July pruning or crop cutting. Two of these trees are in coupes where the lac crop is grown on six-month-old shoots, three in coupes where one-year-old shoots are being used and four in coupes where 18-month-old shoots are being utilized. These studies are being conducted with a view to investigating the preference of the lac insect for shoots of varying ages and types for settlement and growth in the *Aghani* and *Jethwi* crops.

Palas.— Trees in the Namkum plantation in their present condition are not entirely suitable for pruning experiments. In spite of this, trees pruned in February for the *Katki* crop and in April for the *Baisakhi* crop have put forth fairly satisfactory shoots.

Trees pruned in Kundri by the Bihar Forest Department, under Institute supervision, have produced excellent shoots. Shoots from February pruning produced a good *Katki* crop and shoots resulting from April pruning are carrying a satisfactory *Baisakhi* crop.

Unfortunately, owing to the great distance of Kundri from Namkum, it is not possible to make frequent and detailed observations on the growth of shoots at Kundri.

3. Investigation into the Economics of Utilizing *Palas* for the *Baisakhi* Crop only and *Ber* for the *Katki* crop only

Climatic conditions during the *Baisakhi* 1945-46 crop were definitely favourable to lac production ; even so, in all areas where both *palas* and *ber* were used for the *Baisakhi* crop, brood survival was better on *palas* than on *ber*. Conversely, judging by the value of the ratio of brood to yield in scraped lac, the *Katki* 1946 crop was better on *ber* than on *palas*. On the same basis, *ber* was almost 100% better as a *Katki* than as a *Baisakhi* host.

4. Investigation of the Possibilities of *Ficus bengalensis*, *Albizzia lucida* and *Ougeinia dalbergioides* as *Baisakhi* Brood-producing Hosts

As far as brood production is concerned *F. bengalensis* and *A. lucida*, without any special treatment, carried the *Baisakhi* crop well yielding more brood than either *palas* or *ber*. Ratio of brood used to yield of brood lac obtained is given in Table III.

Table III

Ratio of Brood used to Brood yield obtained from Baisakhi Brood-carrying Hosts.

Ficus bengalensis (Barh) ...	...	1 : 1·6
Albizzia lucida	...	1 : 1·16
Ougeinia dalbergioides (Panyan)	...	1 : 0·3

INSECT ENEMIES OF LAC

5. (a) Proper Harvesting, Storage and Disposal of Lac

Ari lac (immature lac) was cut from some trees and driage experiments were conducted as in the preceding years. Results are shown in Table IV. These results confirm previous observations that the cultivator actually loses a considerable sum in almost every instance by cutting his crop *ari*.

Table IV

Type of lac	Fresh *ari* sticklac		Dry *ari* or *phunki* sticklac		Approx. driage per md.	Loss per maund fresh *ari* due to driage	Gain per maund fresh *ari* due to higher price of dry *phunki* or dry *ari* lac	
	Wt. on	Price	Wt. on	Mkt. price				
	Mds. srs. ch.	Rs.	Mds. srs. ch.	Rs.	Srs. chtts.	Rs. as.	Rs.	as.
Baisakhi ber ari	5 0 0 15-5-46	40	4 3 0 1-7-46	85	7 6	7 6	7	6
Jethwi kusum ari	2 27 10 4-6-46	60	2 17 0 1-7-46	95	4 0	6 0	35	0
Katki palas ari	2 19 8 26-9-46	50	1 35 0 20-12-46	56/8	9 13	12 4	6	8
Aghani kusum ari	1 11 0 25-11-46	40	1 0 8 10-3-47	80	8 6	8 6	40	0

(b) Use of Wire-gauze Baskets as Brood Containers during Infection as a Control against Insect Enemies of Lac

Semi-cylindrical tin baskets $12'' \times 2\frac{1}{2}''$ with one end closed, the other having a tightly fitting slip on cover, were prepared. Each had 18 slits across its length on the flat side, each slit being $\frac{1}{4}''$ broad. Over the inner surface of the 18-slitted side was soldered 60-mesh brass wire-gauze.

3 seers of *kusum* × *khair* brood was placed in 12 such baskets and used to infect a *kusum* tree in the Namkum plantation, to observe the emergence of lac larvae, and of other insects, particularly predators and parasites of lac, which emerging from the lac, are caught in the baskets during the infection period.

Lac larvae emerged freely and there was no fungus attack in spite of considerable rain during the infection period. Towards the lid of the basket, however, a number of dead lac larvae were observed. The number of other insects caught was as follows :

E. amabilis ...	... 201
H. pulverea ...	... 107
Chalcids ...	... 114 (some escaped while opening the baskets)

Similar baskets will be used again during the July 1947 infection, and modifications will be made in them as a result of the data then obtained.

6. Control of Insect Enemies of Lac

(a) *By cold water immersion*

Repeat experiments support the conclusions already published in Institute *Bulletin No. 50* that the quality of seedlac and shellac made from cold-water-immersed sticklac is not in any way adversely affected. Refraction (yield) of seedlac and shellac from treated lac was in general better than from untreated lac (*vide* Table V).

The comparative cost of handling and scraping treated and untreated lac on the stick is given in Table VI. Cold water treatment reduces labour and scraping costs by as much as 50%.

(b) *By hot water immersion*

Bundles of sticklac were kept submerged in water previously raised to a temperature of 50°-60°C. Temperature was maintained by a regulated supply of steam. It was observed that the lac softened during the operation. Control of insect enemies are satisfactory, and yield and quality of seedlac and shellac from treated lac are also satisfactory though not as good as from cold-water-treated lac (*vide* Table V). This method, however, is not in any case a practical one for the cultivator.

(c) *By hot air treatment*

Lac was stored in a closed room maintained at a temperature of 50°-60°C for 8 hours. The heat was provided by *anguthees* containing burning coke. Control of insect enemies by this method was satisfactory. The yield and quality of seedlac and shellac from treated lac, though not as good as from cold-water-treated sticklac, is satisfactory (*vide* Table V).

This method again is not very suitable for use by uneducated cultivators.

TABLE V

Effects of Treatments on Emergence of Insects and Properties of Lac

Emergence of Insects & Treatment	Emergence of Insects per pound of sticklac			Conversion of sticklac into shellac and its analysis								Remarks
				Conversion %		Seedlac		Shellac				
	Predators	Parasites & others	Total	Sticklac to seedlac	Seedlac to shellac	Hot alcohol insolubles %	Colour iodine Stand. No. 3	Hot alcohol insolubles	Colour iodine Stand. No. 3	Fluidity 5" Westings in sec.	Life under heat at 150°	
1	2	3	4	5	6	7	8	9	10	11	12	13
Aghani 45-46 *kusum* fresh control to 2 to 5.	70	101·5	171·5	77	83	3·48	9·8	0·86	6·5	48	58	(1) The analysis of the samples shows that the treatments do not adversely affect the properties of treated lac. (2) Dealers in lac pay prices for sticklac on the basis of percentage of seedlac likely to be obtained from it. The percentage yield of seedlac and shellac from the treated samples in general and especially from cold water treated compare favourably with those from control (untreated) ones but the local dealers were not prepared to pay a higher price for them.
Aghani 45-46 *kusum* fresh hot-water treated at 50°C for 5 hrs.	nil	0·5	0·5	73	81	3·27	7·6	0·41	6·4	50	54	
Aghani 45-46 *kusum* fresh hot-water treated at 60°C for 3 hrs.	nil	nil	nil	76	84	3·27	7·4	0·42	6·3	52	56	
Aghani 45-46 *kusum* fresh cold water treated 5 days in cement tank.	nil	13·5	13·5	80	83	3·15	7·5	0·76	6·0	48	58	
Aghani 45-46 *kusum* fresh heat-treated in a room 50° to 60°C for 8 hrs.	21·5	38	59·5	80	73	2·62	12·4	0·70	5·9	47	55	
Baisakhi 45-46 *ber* control to 7 to 9.	Not caged			51·5	67	2·78	6·5	1·03	6·6	119	48	
Baisakhi 45-46 *ber* hot-water treated at 50°C for 5 hrs.	,,	,,		49	60	3·48	6·3	1·11	6·4	102	48	
Baisakhi 45-46 *ber* cold water treated in a cement tank for 6 days.	,,	,,		57	66	3·54	7·8	1·15	5·7	84	49	
Baisakhi 45-46 *ber* heat treated in a room at 50° to 60°C for 8 hrs.	,,	,,		42	61	3·01	7.6	1·13	6·5	108	47	
Katki palas ari control to 11 and 12.	27	208·5	235·5	65	62	6·04	—	1·25	11·5	150	38	
Katki palas ari treated with Gammexene (666) powder @ ¼ ch. per sr. of sticklac.	5·5	25·5	31	60	66	5·66	—	1·54	10·8	119	41	
Katki palas ari dipped in an emulsion of 370 cc. Turkey red oil, 10 ch. of 666 powder in 10 gal. of water for 4 hrs.	0·5	1·5	2	50	67	5·4	—	1·14	11·6	131	39	

TABLE VI

Cost of Handling and Scraping of treated Lac Sticks

Description of lac	Nature of treatment	Wt. of lac sticks treated Md. sr. ch.	Wt. of dry scraped lac Sr. ch.	No. of coolies required for handling & scraping	Cost of labour @ -/14/- a day Rs. as. p.	Remarks
Katki 1946 palas phunki	Control to 2 to 4	3 20 0	34 14	21	18 6 0	The heap of lac sticks was carefully sorted in four equal lots so that each lot contained similar sticks and encrustation.
Do	Heat-treated in a room at 50° to 60° for 8 hours	3 20 0	37 8	19	16 10 0	
Do	Immersed in cold water in a cement tank for 4 days	3 20 0	39 4	11	9 10 0	
Do	Immersed in hot water at 50°C for 5 hours in a cement tank	3 20 0	40 4	9	7 14 0	

(d) *By the use of Gammexene*

Gammexene (D. 025) dust marketed by Imperial Chemical Industries containing 5 per cent. benzene hexachloride, of which 13 per cent. consisted of gamma isomer, was used in all experiments. Preliminary investigation indicates that this insecticide affects the nerves and muscles and causes death by paralysis.

Light-dusting caused death of exposed *E. amabilis* larvae in 3-5 days, and *H. pulverea* larvae in about 11 days. *E. amabilis* and *H. pulverea* moths died in about 24 hours after dusting. Pupae and larvae concealed within the lac encrustation, of both moths, were unaffected.

Trials were made (1) by mixing scraped lac with gammexene powder at the rate of $\frac{1}{4}$ chattack powder per seer, and (2) by immersing scraped lac for 4 hrs. in an emulsion made with 370 cc. Turkey Red Oil, 10 gallons of water and 10 chattacks of gammexene powder.

Preliminary methods show that method (1) above is not satisfactory in the control of insect enemies. Immersion in gammexene emulsion gave satisfactory control results. Too few samples have yet been examined to give more than preliminary results, but indications are that resulting seedlac and shellac from treated lacs are not in any way adversely affected (*vide* Table V).

7. Biological Control

(1) To discover suitable alternative hosts for breeding Bracon (Microbracon) greeni in the laboratory

(a) About 10 maunds of infested cotton seeds were received through the kind co-operation of the Deputy Director of Agriculture, Meerut, U.P. This material together with the material collected last year served as a source of *Platyedra gossypiella* (the pink boll-worm of cotton). Larvae of the sugarcane top borer (*Scirpophaga nivella*) were obtained through the kindness of the Sugarcane Specialist, Bihar. Local hosts were also collected. Results obtained are given in Table VII and indicate that of the hosts tried the pink boll-worm of cotton and the *Amaltus* borer appear to show definite promise as alternative hosts.

(b) *Laboratory breeding of suitable alternative hosts*

Some 200 *P. gossypiella* moths were caged to lay eggs on cotton bolls, and about 500 first instar larvae were obtained. Further rearing was handicapped for want of an insectary where these larvae could be reared on green plants.

Corcyra cephalonica can be bred in satisfactory numbers on old cotton-seeds in boxes having a 60-mesh brass wire-gauze top.

(c) *Rendering host larvae inactive to facilitate parasitisation by* B. (M.) greeni.

A number of host larvae offered were found to be too active and effected their escape from tissue domes. Such larvae were treated by coddling in hot water in some instances and in others by amputating the mouth parts.

Larvae requiring such treatment were :

Enarmonica perfricta,
Trachylepidia fructicassiella,
Chilo Zonellus,
Corcyra cephalonica.

Other hosts used (*vide* Table VII) remained quietly in domes without the need of any special treatment.

TABLE VII

Breeding of **B. (M.) *greeni*** *on unnatural hosts*

Host & No. of larvae introduced	Presentation conditions	No. parasitised	% parasitism	*B. (M.) greeni* bred			Adult bred per host
				Males	Females	% of females	
1. *Platyedra gossypiella* (pink bollworm) 19,407	Tissue domes with and without *Eublemma* excreta and *chauri*	4,965	25·5	2,461	2,701	52·3	1·03
2. *Scirpophaga nivella* (top borer of sugarcane) 6,439	Tissue domes with *Eublemma* excreta and *chauri*	762	11·9	328	548	62·5	1·2
3. *Trachylepidia fructicassiella* (*amaltus* pod borer) 1,506	Amputated & coddled, under tissue domes with *Eublemma* excreta and *chauri*	339	22·5	59	104	63·8	0·4 The no. of adults per host is low because large no. of parasitized larvae were destroyed by rats.
4. *Enarmonica perfricta* (early seed borer of *Karanj*) 252	Tissue domes coddled and uncoddled with *Eublemma* excreta and *chauri*	32	12·6	Infestation of mites which came along with the host larvae destroyed the developing parasites.			
5. *Corcyra cephalonica* (rice moth) 1,561	Coddled and uncoddled under tissue domes with *Eublemma* excreta and *chauri*	256	16·3	44	56	56·0	0·4
6. *Etiella zinekenella* (pea pod-borer) 177	In tissue domes with *Eublemma* excreta and *chauri*	29	16·3	9	33	78·5	1·4
TOTAL : 29,342		6,383	21·7	2,931	3,442	54·3	0·9

(d) *Presentation of alternative hosts*

Results obtained confirm previous findings that it is the odour and texture of the covering surface which are the major factors in the initial attraction of the parasite to the host. The tissue coverings of domes were therefore powdered with *E. amabilis* larval excreta and finely powdered lac.

(2) Breeding of B. (M.) greeni

(a) *Control of mites*

Sterilization of domes and cages at 56°C for six hours was found to prevent the appearance of fungus and mites. This confirms previous results.

(b) (i) *Breeding of B. (M.) greeni on a mass scale on alternative hosts*

Only *P. gossypiella* and *T. fructicassiella* showed promise (*vide* Table VII).

(ii) *Mass breeding of B. (M.) greeni on E. amabilis*

E. amabilis larvae were offered for parasitisation in lac sticks as they occur in nature — in natural domes — and in tissue covered domes. Parasitism was highest when larvae were presented under natural conditions in the lac stick, and lowest when presented in tissue-covered domes. Number of adults bred per host was 0·84 (*vide* Table VIII).

TABLE VIII

Mass breeding of B. (M.) greeni on E. amabilis

No. Larvae introduced	How presented	No. parasitised	% Parasitism	*B. (M.) greeni* bred			No. of adults bred per host parasitised
				Males	Females	% Females	
6,200	In lac stick ...	4,580	73·9				
27,036	In natural domes	15,369	56·8	8,128	13,335	62·2	0·84
12,992	In tissue covered domes	5,721	44·0				
46,228		25,670					

8. DEMONSTRATION

(1) (a) *Advice and training*

Advice on lac cultivation was given to cultivators all over India, and good quality brood was supplied through the Institute on request on payment to the extent of over 88 maunds valued at more than Rs. 5,700.

Three supervisors and 16 demonstrators of the Intensive Demonstration Scheme were under training during the period under review. In addition, a trainee from Nepal, a Forest Ranger from Jaipur State, two Forest personnel from Palanpur State and a trainee from Mewar underwent training; of these, three candidates are still under training.

Supply of pruning instruments and free brood lac.— Pruning instruments were distributed and free brood lac was used in the demonstration areas, under the control of the Lac Supervisors as shown below:

TABLE IX

Distribution of Free Brood and Pruning Instruments

Item	Demons. Compaign		Intensive Demonstration Scheme	
	Amount Mds. srs.	Cost Rs.	Amount Mds. srs.	Cost Rs. As.
Rangeeni brood lac ...	17 11	1,117	Bihar : 28 29 U.P. : 10 0 Bengal : Local purchase	1,854 0 700 0 812 6
Kusmi brood lac ...	4 32	432	Bihar : 15 2 U.P. : 0 30	1,354 8 67 8
Pruning instruments ...	...	...	Bihar : 93 U.P. : 4 Bengal : 3	393 8 14 0 12 8

(b) *Demonstration*

Demonstration included taking part in exhibitions throughout India, and sending exhibits to educational institutes and museums, in addition to the actual demonstrations of improvements of lac cultivation using the villagers' own trees.

The Institute Demonstration Scheme

Four demonstrators were at work during the year, they were sited as follows :

Khunti ... ... Ranchi Dist.
Silli-Jhalda ... ... Ranchi and Manbhum Dists.
Latehar, Chandwa ... ... Palamau.

One demonstrator has resigned and arrangements have been put in hand to replace him.

Intensive Demonstration Scheme

In Bihar — eight supervisors and eighteen demonstrators are actually at work in their respective areas and one is under training. Five demonstrators' posts are at present vacant and the Provincial Entomologist has been asked to recruit suitable men to fill these vacancies as soon as possible.

In Bengal — three supervisors and seven demonstrators are at work, There are two vacancies for demonstrators and the Bengal Government is being approached to select suitable men for training.

In U.P.— one supervisor and three demonstrators are at work. There are no vacancies.

The main subjects of demonstration are as follows :

(1) Systematic cultivation using regular coupes in rotation, thereby allowing rest to the trees and facilitating control and guarding against theft.
(2) Means of ensuring the production of *Baisakhi* brood, by partial pruning of *ber* and artificial defoliation of *palas*.
(3) The use of *palas* as a *Baisakhi* host and *ber* for the *Katki* crop only in areas where both are plentiful.
(4) Adoption of the four-coupe system for *kusum*, utilizing complete cropping and correct methods of pruning.
(5) The avoidance of self-infection in the case of the *Baisakhi* crop, self-infection to be used for the *Katki* crop only in areas where it is found to be necessary.

Baisakhi 1945-46 Crop. — Using *ber* as a host, it was observed particularly in Ranchi and Palamau Districts that partial pruning improved the brood lac yield in July. In Bengal, where the *Baisakhi* crop seldom survives to provide brood for the next infection, some brood was obtained as a result of partial pruning.

Using *palas* both in Bihar and U.P. it was noticeable that where artificial defoliation was used, it was possible to produce good July brood, whereas from non-defoliated trees it was only with difficulty that any brood at all could be produced.

Aghani and Jethwi Crops. — Particularly in U.P. and Bihar, good brood to yield ratios were obtained by following Institute methods. Cultivators who followed the systems shown, were not only able to be self-sufficient in brood production, but were also able to produce surplus brood for sale.

Katki 1946. — Good brood in July and the use of artificial infection enabled cultivators who followed the methods advocated for the production of *Baisakhi* brood, to get good *Katki* crop yields.

(2) *Improved Cultivation in Forest Areas*

This is the second year of the second three-year extension of the Mako-Orya Lac Cultivation Scheme, jointly worked by the Bihar Forest Department and the Lac Research Institute.

In Mako orchard *O. dalbergioides* (Panyan) and *F. bengalensis* again proved to be good *Baisakhi* brood carrying hosts. Defoliation of *palas* also gave good results at Mako. Results further indicate that *O. dalbergioides* and *F. bengalensis* can be satisfactorily alternated with both *palas* and *ber*.

Jethwi and *Aghani* crops were grown in Orya. The *Jethwi* crop was satisfactory. The *Aghani* crop by comparison with other *Kusumi* areas was also most promising. Unfortunately, some 12 maunds of lac was stolen from the infected trees between December and February. This was a serious loss and it was possible only to infect 76 trees for the *Jethwi* 1947 crop.

Theft and the shortage of suitable *Baisakhi* hosts in Mako are at present handicapping the scheme. Every effort is being made to counter theft, and to introduce satisfactory *Baisakhi* hosts into the Mako plantation.

9. Namkum Plantation

As far as funds permit, the general upkeep of the plantation was maintained.

Mr. C. M. Chaudhri, I.F.S., Research & Planning Officer, Forest Department, Bihar, and Dr. P. K. Sen, Horticulturist to the Govt. of Bihar, inspected the plantation. Their reports are being placed before the Committee.

Sugarcane, cotton, pea, brinjal, hibiscus and maize were grown in a small area in order to collect their caterpillar pests for use as alternative hosts in the *B. (M) greeni* cages. Sugarcane, however, proved to be practically pest-free and cotton boll-worm larvae were already heavily parasitised by *Microbracon lefrogi*.

Replanting of trees was carried out as necessary to replace casualties. *Kusum, Panyan* and *A. lucida* were extended.

A statement of lac produced in the Institute plantations and showing its disposal is given in Appendix A. It will be seen that the proceeds of sale of lac from Namkum and Hesal amounted to over Rs. 900. Sales of miscellaneous products, such as grass, firewood, etc., brought in a further return of just over Rs. 300.

It is clear that early infection of young host trees with lac is extremely detrimental to their growth, and that if good results are to be obtained from plantation-grown trees, they must not be lac-infected before they are from 10-20 years old according to species.

It is further clear that if the Namkum plantation is to be of value as an experimental plantation, a good deal of work is necessary on it, which will entail expenditure above the usual provision.

CHEMICAL SECTION

The Committee after full consideration of all facts concerning the development of lac-urea-formaldehyde moulding powders in this Institute, came to the conclusion that a stage has been reached when greater emphasis should be laid on the fundamental aspects of chemistry of shellac. The research programme of the chemical section is being modified accordingly and the existing programme of work on shellac-urea-formaldehyde moulding powders is being restricted to a few essential details not previously studied.

1. Moulding Powders

(A) Effect of inorganic extenders on standard lac-urea-formaldehyde compositions

It has been observed in the field of phenolic resins that the proportion of resin in moulding compositions may be reduced without any deleterious effect whatsoever on the qualities of the moulded articles by incorporating inorganic extenders like titanium oxide, precipitated calcium oxide, iron oxide, etc. With a view to find out if this also holds good in the case of standard lac-urea-formaldehyde compositions, a few moulding powders containing various proportions of L-U-F resin, *Haldu* wood meal and titanium oxide were prepared and tested. A typical composition having 37·5 per cent. L-U-F resin, 50 per cent. wood meal and 12·5 per cent. titanium oxide was found to possess good flow. Moulded articles derived from this composition possessed satisfactory impact strength and heat-resistance. A series of compositions were made using 30 per cent. L-U-F resin and varying proportions of wood meal and titanium oxide. These were tested for flow, finish and impact strength ; the results are given in Table I.

Table I

Moulding Powder composition			Impact strength cm. kg./cm².	Remarks
L-U-F %	Titanium oxide %	*Haldu* wood meal %		
30	—	70	3·40	Poor flow, filler shows out.
,,	10	60	3·74	Good flow and finish.
,,	20	50	3·26	do
,,	30	40	3·28	do
,,	40	30	2·94	do
,,	50	20	2·90	do

(B) Standardization of L-U-F moulding powders

On completion of the work on the optimum mesh size of the powder required to ensure good flow and finish (*vide* Annual Report 1945-46), investigations were carried out to determine the optimum moisture-content of the powders that would give blister-free samples without loss of flow and finish. Two compositions were tested including the one containing 25 per cent. cashew-nut shell liquid in addition to the usual proportions of urea and formaldehyde. The results indicated that the optimum amount of volatile matters including moisture should be in the neighbourhood of 2·8 per cent., if blister-free mouldings with satisfactory strength and heat-resistance are to be obtained.

Investigations were also made to find out the optimum temperature and pressure required to ensure maximum possible impact strength and heat-resistance in mouldings.

Comparative studies with standard L-U-F compositions and those containing 25 per cent. CNSL showed that maximum strength (5·0 cm. kg./cm².) and maximum heat-resistance (79-80°C Martens) would be attained in the case of standard composition at 120-130°C under a pressure of 2-3 tons per sq. inch. Compositions containing CNSL, however, required a higher temperature, normally 140°C, to give the best possible results.

(C) Effect of heat-cure on the moulded samples

A few test bars made from standard L-U-F moulding powder were baked at 70°C for various periods and then tested for strength and heat-resistance. The results which are given in Table II show that baking for 24 hours at 70°C improved both the impact strength and heat-resistance.

TABLE II

	Impact strength cm. kg./cm².	Heat-resistance Martens (°C)
Control (without baking) ...	3·27	82
Baked for 24 hours at 70°C ...	4·00	92
Baked for 48 hours at 70°C ...	3·80	96
Baked for 96 hours at 70°C ...	3·76	102

(D) Lac-formaldehyde-phenol combinations

A few experiments were carried out in which lac was first combined with formaldehyde and then reacted with phenol in presence of alkaline catalysts. In a typical experiment, 50 gms. of lac were first reacted with 50 cc. of 40 per cent. formalin at 120-125°C for 3 hours and then with 50 gms. of phenol in presence of 3 cc. ammonia (d, 0·880) as catalyst. On vacuum distillation of the product after separation of the aqueous layer a clear resin was obtained which was found to harden at 130-140°C. This resin is soluble in alcohol or in a mixture of alcohol and benzene giving a clear varnish, the films from which become water-resistant but brittle after baking for one hour at 100-105°C. The varnish is considered suitable for making laminated boards. Moulding compositions made from this resin were found to be too soft for ejection from the mould. Curing at 140-145°C for 15 minutes or at a higher temperature (150-160°) did not improve the hardness. The use of a larger quantity of ammonia in reaction produced resins with thermohardening properties. Thus, 50 gms. lac, 50 gms. phenol, 50 cc. formalin (40 per cent.) and 12·5 cc. ammonia (d, 0·880) gave a moulding composition which could be worked up at 150-160°C under 1-1·5 tons pressure per sq. inch, the curing time being 3-4 minutes.

(E) Lac-dimethylol-urea compositions

This line of investigation was designed to simplify, if possible, the preparation of lac-urea-formaldehyde moulding compositions and to throw light on the mechanism of reaction involving lac, urea and formaldehyde which is obscure at the present moment. Dimethylol-urea, a commercial product, being not available, small quantities were prepared in the laboratory for our experiments. As usual, compositions were prepared both by the wet and the dry process.

(i) *Wet process.*— 100 gms. of shellac were mixed with varying proportions of dimethylol-urea and refluxed with 200 cc. methylated spirit at 130-140°C for 3 hours. 100 gms. of *Haldu* wood meal and 2 gms. of aluminium stearate were then added. The resulting composition was dried in the sun and preheated at 95°C for 2 hours, unless otherwise mentioned, before moulding. The results are given in Table III. In a few cases the effect of addition of calcium hydroxide and aluminium chloride was also noted.

TABLE III

Dimethylol-urea used per 100 gms. of shellac	Hardeners	Moulding quality	Impact strength in cm. kg./cm^2	Water absorption in 24 hrs. (%)	Remarks
5 gms.	—	not good	—	—	Though the powder was preheated for 6 hrs. before moulding yet it was too soft during ejection and the test bars showed blisters.
5 gms.	$Ca(OH)_2$—2 gms.	good	1·75	7·70	No cracking like the following sample.
5 gms.	$Ca(OH)_2$—2 gms. $AlCl_3$—1 gm.	good	2·77	—	Cracks during ejection on the application of slight pressure.
5 gms.	$Ca(OH)_2$—5 gms.	good	1·70	—	—
10 gms.	—	not good	3·07	—	The product is soft during ejection.
15 gms.	—	good	4·17	3·12	Requires 140°C & 1 ton/sq. in. for good fusion.
20 gms.	—	good	4·29	—	Requires 140°C & 1·5 tons/sq. in.
30 gms.	—	good	4·19	3·31	Requires 140°C & 1·5 tons/sq. in.
35 gms.	—	good	4·38	3·16	Requires 145°C & 2 tons/sq. in. for good fusion.

(ii) *Dry process*.— The ingredients were intimately mixed without the addition of any solvent and then hot-rolled for 6-10 minutes. During hot-rolling, elimination of formaldehyde was noticed in compositions containing lime. The hot-rolled mass was then powdered and preheated at 95°C for 1 hour before moulding. The results are given in Table IV.

TABLE IV

Dimethylol-urea used per 100 gms. of shellac	Hardener $Ca(OH)_2$	Impact strength in cm. kg./cm^2.	Remarks
5 gms.	—	—	Too soft ; bars could not be prepared for strength test.
5 gms.	1 gm.	2·0	Less soft than the previous one.
10 gms.	1 gm.	3·32	Requires 140°C at 1 ton/sq. inch for good fusion.
15 gms.	—	4·63	,, 135°C at 1 ton/sq. inch for good fusion.
15 gms.	1 gm.	4·40	,, 135°C at 1 ton/sq. inch for good fusion.

It will be seen that a composition containing 100 gms. of shellac and 15 gms. of dimethylol-urea gives good impact strength as also satisfactory flow and finish.

Further work is in progress.

2. Fillers

(A) Wood-flour from *Cryptomeria Japonica*

A sample of this light-coloured wood received from Darjeeling was cut into small bits which were then flattened by hammering. The flattened bits were boiled in water and kept overnight. These were then crushed in a mortar and allowed to dry in an oven. When perfectly dry, they were powdered in a C.N. disintegrator. The yield of 100-mesh flour by single grinding was only 8 per cent. on the total weight of wood disintegrated. Ash content of 100-mesh wood-flour thus prepared was found to be 1·82 per cent. and the specific volume (25 g.) 140 cc. (too high for use in lac-moulding compositions). The impact strength of a sample of standard lac-formaldehyde-urea composition containing this filler was found to be 3·70 cm. kg./cm².

(B) A sample of wood meal obtained in the process of polishing wood veneers was received from Madras and examined. It was fibrous in structure and had a specific volume of 135 cc. and an ash-content of 34 per cent. Acetone-soluble matters were 1·52 per cent. Moulding powder prepared with this filler gave the following results :

Impact strength	...	3·1 cm. kg./cm².
Heat resistance		78° (Martens).
Water absorption : 24 hrs.	...	2·4 per cent.
Specific volume of the moulding powder	... ...	64 cc.

This by-product does not appear to be suitable for use as filler in moulding compositions.

(C) Jute-stick dust

Jute-sticks were first soaked in water for about 24 hours and then flattened by hammering. When thoroughly dried, they were powdered in a C.N. disintegrator. The dust so prepared, while satisfactory as regards yield and comparable with foreign wood-flour in other respects, had too high a bulk factor, the actual value being about 160 cc. as against 90 cc. for foreign wood-flour. Impact strength of moulded rods made from standard L-U-F powders incorporating various proportions of this dust as filler ranged from 3·44 to 4·83 cm. kg./cm².

Attempts were made to reduce the high bulk factor which is a serious disadvantage. It was found that samples of jute-stick dust dipped in weak alcoholic or ammoniacal solutions of shellac do not show any appreciable reduction in bulk on drying. But this lac-impregnated dust could be admixed with various proportions of lac (10-30 per cent.) and moulded at a very low pressure in simple-shaped articles that could be removed hot from the mould at 130-145°C. Impact strength, however, was weak, being in the region of 1·83-2·75 cm. kg./cm² depending on the percentage of shellac used. An interesting feature of these moulded articles was that they could be repowdered to a specific volume of 90 cc. which is about the same as that of foreign wood-flour. This observation was pursued and it was found that a filler of the requisite bulk factor could be obtained from jute-stick simply by hot-rolling water-soaked dust of 100-mesh size.

The properties of the filler and of the moulding powders derived therefrom were tested with the following results :

TABLE V

	Jute-stick dust	Foreign wood-flour
1. Water solubles	2·24%	4·35%
2. Alcohol solubles	5·10%	6·01%
3. Petroleum ether solubles ...	1·87%	3·14%
4. Acetone solubles	5·18%	0·20%
5. Ash-content	2·62-2·10%	0·91%
6. Specific volume (25 gms.) ...	158-160 cc. (could be reduced to 60-70 cc. by hot-rolling)	90 cc.
7. Lignin	32·5%	33·4%

TABLE VI

Properties of moulding powder

	Powder with jute-stick dust	Powder with foreign wood-flour
1. Impact strength ...	4·83 cm. kg./cm ^{2}.	5·21 cm. kg./cm ^{2}.
2. Specific volume ...	47 cc.	50 cc.
3. Water-resistance (24 hours)	0·97%	0·8%
4. Heat-resistance ...	82°C	80-85°C
5. Dielectric strength ...	428 volts/mil.	400-450 volts/mil.

The results indicate that jute-stick dust is quite suitable as a filler in moulding compositions.

3. VARNISHES

(A) Lac-CNSL varnishes

Lac initially condensed with cashew nut shell liquid (CNSL) and then modified further with formalin and urea results in resins of improved quality capable of giving alkali-resistant varnishes of high dielectric strength (*vide* ANNUAL REPORT for 1945-46). These varnishes while satisfying all the standard requirements of a baking electrical insulating varnish failed in one respect in that they did not comply with the ageing tests as per British Standard Specifications. Attempts to improve their ageing qualities by various means, such as incorporation of plasticisers like linseed oil or castor oil fatty acids, partial substitution of lac by hydrolysed lac, addition of fusel oil esters of lac, etc., did not prove successful although some improvement was noted in a few cases. Ultimately it was observed that by initially combining CNSL with 30 per cent. linseed oil mono- and di-glycerides and then treating the resulting product with lac at 190-200°C for 20 minutes and further condensing with requisite proportions of formalin and urea, varnishes were obtained which passed the ageing tests. Films at the end of the ageing period, however, were noticed to become dark brown in colour. Samples of these varnishes are being tested for their electrical insulating properties before being recommended to the trade.

(B) Lac-formaldehyde-urea varnishes

Work on further improvements of these varnishes, particularly with regard to their elasticity, adhesion, etc., on ageing was continued. It was observed that incorporation of about 20-30 per cent. dibutyl phthalate or tricresyl phosphate as the plasticiser improved markedly the elasticity of the films which required 2 hours' baking at 95-100°C, to gain a sufficient degree of hardness. Further, films obtained from such varnishes were observed

to become brittle and to lose their elasticity and tensile strength on exposure to room temperature and high humidity. On account of these defects the method of preparation was modified. A mixture of dewaxed blond shellac (100 gms.), *n*-butyl alcohol (400 cc.), formalin, 40 per cent. (25 cc.) and urea (8 gms.) was refluxed in an oil-bath for 4 hours and phthalic anhydride (17 gms.) was added to the resulting product. The mixture was further refluxed for 6-8 hours. Excess butyl alcohol and water were then distilled off initially under ordinary pressure and subsequently under vacuum at about 100°C. The thick clear resin thus obtained was dissolved in rectified spirit to give a 40 per cent. solution. Films from such a varnish dry to touch overnight and attain perfect hardness, elasticity, adhesion, water-resistance, etc., after baking at 95-100°C for 2 hours. The varnish can also be used for making baking enamels. A typical enamel made by mixing the resin with titanium oxide has given satisfactory coats on tin and iron sheets. A coated tin panel exposed to weather conditions for 4 months did not show any marked deterioration in gloss or adhesion. Loss in gloss and chalking of the surface were, however, noticed after the test panel had been exposed for about 9 months. No appreciable change in adhesion or elasticity was noticed. A similar panel kept inside the room showed no change in any of the properties.

(C) Lac-linseed oil-glycerine air-drying varnish

An air-drying varnish composition based on lac has been prepared as follows :

100 parts of double boiled linseed oil are heated with efficient mechanical stirring in a closed system with 20 parts of glycerine at 220°C for 1 hour. The linseed oil glyceride thus formed is freed from any unreacted glycerine by washing with hot water and then dried by heating in an open kettle to about 140°C. The dried product (600 gms.) is then heated up in an open kettle to 170°C and powdered dewaxed lac (360 gms.) added. The temperature is then quickly raised to 260°C and maintained for half-an-hour. A fresh batch of boiled linseed oil (300 gms.) separately heated to about the same temperature is now added and the cooking continued at 260°C for another half-an-hour. The product is then cooled to 170°C and dissolved in 1,200 cc. white spirit. To the resulting solution are added 3·6 gms. of cobalt naphthenate dissolved in 60 cc. white spirit. The varnish is then allowed to stand for a few days for clarification and then carefully filtered.

TABLE VII

	Properties of the varnish	I. S. D. Specifications for interior oil varnishes
1. General physical characteristics	Clear and transparent. Gives on air-drying a glossy film free from runs or specks.	—
2. Viscosity	1·57 at 85°F.	Not more than 2 Not less than 1 at 85°F
3. Flexibility and adhesion	Satisfactory.	—
4. Colour	No. 7 of Lovibond lubricating oil standards.	Not darker than No. 4
5. Volatile matter	44·5%	Not more than 50%
6. Acid value	3·2	Not higher than 25
7. Time of "Surface-drying"	Less than 4 hrs.	Not more than 6 hrs.
8. Time of "Hard-drying"	Less than 18 hrs.	Not more than 18 hrs.
9. Flash point	110°F	Not lower than 95°F
10. Ash	0·055%	Not more than 0·5%

The composition fails to conform to the I.S.D. Specifications on two counts, namely, colour and tackiness. Further experiments are being continued to minimize these defects.

It is of interest to note that air-dried films of this composition (aged for one week) show no blush on immersion in cold distilled water for 24 hours. Dewaxed lac is definitely superior to ordinary shellac for the preparation of oil varnishes as the wax in the latter case, even after the most careful filtration of the varnishes, separates out as distinct tiny particles from an otherwise clear film and hence interferes with the final properties of these air-dried films.

(D) Lac-linseed oil-lime varnishes

In the previous ANNUAL REPORT, conditions for the preparation of lac-linseed oil varnishes using lead oxide as the incorporating agent have been described. It has been pointed out that the varnishes thus produced are unsuitable for use as air-drying compositions in view of the very uneven film they form on air-drying, presumably because an excessive quantity of the powerful drying metal is present. It was thought that substitution of lead oxide by other metallic oxides of the non-drying type would eliminate this defect. Accordingly calcium oxide (lime) was chosen.

Lime as an incorporating agent for lac-linseed oil varnishes has been described by ALDIS (*I.L.R.I. Bulletin No. 12*) but the film properties of the resulting varnishes do not appear to have been studied. Detailed experiments have now been carried out and the following observations are made :

(i) The most satisfactory proportions to be used are 50 parts of dewaxed lac and 2·5 parts of calcium hydroxide for every 100 parts of linseed oil.

(ii) The temperature of incorporation is about 290°C. After cooking the lime into the oil, the lac may be introduced in small lots at 290°C, or alternatively, the limed oil may be cooled to 170°C, the whole of the lac added, and the temperature then raised to 290°C when a clear melt will be obtained.

(iii) With larger proportions of lime the temperature of incorporation of lac is lowered but the resulting varnishes are found to possess poor drying properties and yield relatively soft films.

(iv) Precipitated calcium linoleate or even calcium stearate may be used in place of lime.

(v) The lac-oil compositions thus produced are completely soluble in the usual varnish solvents like turpentine and white spirit.

(vi) The films from the varnishes do not air-dry even on 72 hours' exposure and require 0·8-1 per cent cobalt naphthenate (on non-volatiles) to dry in less than 18 hours. Even with this amount of drier, there is no surface-drying in less than 6 hours.

(vii) The air-dried films are hard, bright, glossy and practically non-tacky, being definitely superior to lac-linseed oil-glycerine varnish films in the last respect.

(viii) On immersion in cold water, however, these films develop extensive blush within 1-2 hours and in this respect are distinctly inferior to the lac-linseed oil-glycerine varnish fims.

(ix) As a baking insulating varnish, the baked films show a B.D.V. of 900 volts/mil. at 90°C, thus satisfying the British Standard Specifications. They also successfully withstand the stipulated accelerated ageing tests, and generally satisfy other required specifications.

(x) Another remarkable property of this composition for use as a clear baking insulating varnish lies in the fact that it shows absolutely no tendency to "skin" on storage.

(E) Lac-linseed oil-lead oxide-lime varnish

It has just been pointed out that lac-linseed oil-lead oxide compositions are not suitable for use as air-drying varnishes on account of the uneven film surface which they produce on air-drying. On the other hand, lac-linseed oil-lime compositions, though otherwise satisfactory, fail to surface-dry in less than 6 hours' time as required by the I.S.D. Specifications. It was therefore hoped that by partial replacement of lime by lead oxide, a composition might be evolved which would surface-dry in less than 6 hours and at the same time yield smooth and homogeneous films. This expectation was realized, the method of preparation of the particular composition being as follows :

200 gms. linseed-oil are heated with efficient mechanical stirring to 170°C and 6 gms. litharge and .3 gms. calcium hydroxide added. The temperature is raised to about 250°C and maintained for 5 minutes when the oxides completely dissolve. The product is then cooled to 170°C and 100 gms. dewaxed lac are added in small lots. After the addition is complete, the mixture is raised to a temperature of 270°C when the characteristic frothing is noticed and lac goes into solution giving a clear melt. After further heating for 5 minutes at the same temperature for completion of the reaction, the mass is allowed to cool down to 170°C and finally dissolved in 300 cc. white spirit. 1·5 gms. of cobalt naphthenate dissolved in a small amount of white spirit is now added. The varnish is allowed to stand overnight and then filtered. Films produced on a non-absorbent surface from such a varnish surface-dry in less than 6 hours and dry hard in less than 18 hours. The air-dried films are smooth, hard and glossy. Further tests of the compositions are being continued.

(F) Manufacture of "oil-cloth" using air-drying compositions

Experiments were conducted to prepare "oil-cloth" using lac-linseed oil-glycerine combinations as the dressing material so that the product would need only to be air-dried, thereby eliminating the troublesome after-baking operations which are necessary with our earlier compositions. The composition as described under (C) above could be easily mixed with fillers and pigments in an edge-runner in absence of solvents. The drier for this purpose was dissolved in a very small amount of white spirit and incorporated into the oil-resin combination while still hot and the product filtered through muslin before cooling down. One serious difficulty was the tendency of the oil-lac combination to soak into the fabric. This has been overcome by the addition of zinc stearate into the dressing composition. The following composition is recommended :

Lac-oil combination*	...	100 parts
Kaolin ...	...	100 parts
Zinc stearate	...	15-20 parts
Pigment ...	...	15-20 parts

These components are thoroughly mixed in an edge-runner for 6-8 hours and then applied to the cloth-surface by passing under a "Doctor" blade. The films surface-dry overnight and become quite hard in the course of 3-4 days. The surface is quite glossy and non-tacky. Samples prepared six months ago have retained their suppleness and appearance.

Air-drying "oil-cloth" compositions have also been prepared using lac-linseed oil-lead oxide and lac-linseed oil-cloth compositions. These are being further examined. Many samples of our oil-cloth varnish were supplied to enquirers.

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* For this particular purpose, either dewaxed lac or ordinary shellac may be used as the wax gets finely dispersed along with the fillers and pigments and therefore does not interfere with the film properties or "finish" of the resulting material beyond reducing the gloss to a negligible extent.

(G) Lac-linseed oil-red lead insulating varnishes

Insulating varnishes prepared from lac-linseed oil-red lead in the ratio of 50:100:7·5 have been found to have properties substantially similar to those of lac-linseed oil-glycerine compositions described in the previous ANNUAL REPORT. A reputed electrical engineering works of Calcutta have prepared " Empire Cloth " samples with this composition as well as with an imported varnish. The samples were sent to us for electrical insulation tests. The following results were obtained :

TABLE VIII

	Thickness of sample	B.D.V. of samples as received	B.D.V. after drying in the desiccator for 24 hrs.	B.D.V. after conditioning in saturated humidity for 24 hrs.
1. Empire cloth from lac-oil varnish ...	10 mils.	8·5 K.V.	7·4 K.V.	1·7 K.V.
2. Empire cloth from imported varnish ...	10 mils.	6·8 K.V.	7·4 K.V.	2·2 K.V.

4. MEDICINAL USE OF LAC-DYE

Recovery of lac-dye and tincture lacca

The results of recovery of lac-dye (from the washings of sticklac) after preliminary precipitation of the coagulated matters have been recorded in ANNUAL REPORT for 1945-46.

Tincture prepared from the lac-dye was pharmacologically harmless and therefore could be used for colouring Tr. Card. Co. and other medicinal preparations for which Tr. cochineal is officially recommended. It was noticed, however, that the tincture prepared by the acid decomposition of the calcium salt is incompatible with Tr. Card. Co. due to the presence of small quantities of calcium sulphate in solution. Tincture lacca prepared from the pure dye was, however, free from this defect. Consequently, the precipitated dye, and not its calcium salt, is recommended for the manufacture of Tr. lacca.

The process of FOWLER and O'MEARA (B.P. 12,877) for the isolation of the lac-dye was compared with the process developed earlier at this Institute. Results indicate that yields varying between 1·08 and 1·13 per cent. could be obtained by FOWLER and O'MEARA's method as against 0·6-0·7 per cent. obtained by other methods (ANNUAL REPORT 1945-46). The disadvantageous feature of FOWLER and O'MEARA's method is that it involves the use of large volumes of solvents and therefore is not economical.

A technical note incorporating the results of investigations will shortly be circulated to the referees.

5. FUNDAMENTAL RESEARCHES

(A) Chemical composition of the hard lac resin

Although work on the chemistry of pure lac resin was begun early this century, yet only about 50 per cent. of its constituent acids could be isolated in pure form. With a view to investigate the nature of the unknown acids and also to correlate the existing data reported

from time to time, work on the composition of hard lac resin was taken up in the beginning of 1947. Pure lac resin used for the investigation was prepared from fresh *kusmi* shellac. The hard resin prepared in the usual manner was completely freed from wax and soft resin by repeated extraction with ethyl-acetate and diethyl ether. Pure lac resin was then saponified with N/2 alcoholic caustic potash. The clear solution was evaporated to dryness, the residue was taken up with absolute alcohol and a current of carbon dioxide passed into the solution in the cold. The precipitated potasium carbonate was then filtered off, the alcohol removed by distillation and finally by blowing steam. The product (potassium salts of the constituent acids of hard resin) was then taken up in 500 cc. of water and then treated with 13·5 gms. barium chloride ($BaCl_2 2H_2O$) solution (50 per cent.) in cold and left for 48 hours at 10°C. The insoluble barium salt (B1, 2·5 gms.) was a dark-brown tacky mass. This was filtered off. To the filtrate were added 9 gms. of barium chloride (i.e. 2/5ths of the total) and allowed to stand overnight at 5°C. A light yellow insoluble barium salt (B2, 16·1 gms.) was obtained. The filtrate which contained excess barium chloride was then treated with concentrated sodium sulphate solution till precipitation of barium sulphate was complete. The barium sulphate was removed, the filtrate made up to 500 cc. and then treated with 16 gms. of zinc sulphate ($ZnSO_4$, $7H_2O$) and kept overnight at 5°C. The cream-coloured insoluble zinc salt (Z1, 3·7 gms.) was filtered off. The filtrate was heated up to boiling point and filtered hot. The process was repeated till little turbidity was noticed on heating. In this way 3·6 gms. of zinc salt insoluble in hot water (Z2) were obtained. To the boiling filtrate was then added solid sodium carbonate till alkaline to litmus. The precipitated basic zinc carbonate was filtered off, and the filtrate evaporated to dryness. The residue was extracted with absolute alcohol and the volume made up to 150 cc. Water (6 cc.) was added followed by lead acetate (12 gms.) dissolved in 60 cc. of 96 per cent. hot alcohol. The mixture was cooled and kept overnight at 10°C. The alcohol insoluble lead salt (L1, 7·5 gms.) was removed and the filtrate (L2) kept aside for further examination.

The insoluble barium salt (B1) contained most of the colouring matter of pure resin and was not examined in detail. The fraction, B2, was crystallized from hot water. The mother-liquor, containing the most soluble barium salts, was decomposed with 100 cc. of N/10 hydrochloric acid. The resulting precipitate was found to consist mostly of crude aleuritic acid ; the filtrate, after removal of the acid, was extracted with ether. Removal of ether left a solid product which on slow crystallization from ether deposited two crops of crystals. The first crop had m.p. 93-94° and was impure aleuritic acid, while the second crop (0·5 gms, m.p. 78-79°) was found to be soluble in petroleum ether, ethyl alcohol and ethyl acetate, but insoluble in benzene and toluene. This fraction is being further examined. The crystalline and less soluble barium salt, referred to above, yielded, on treatment with mineral acids, aleuritic acid.

Aleuritic acid was again found to be the chief constituent of the cold water insoluble zinc salt (Z1) but the product Z2 was more interesting. BHATTACHARYA (*J. Soc. Chem. Ind., 1935,* **54,** *82T*) had previously obtained an amorphous hygroscopic substance by breaking up the hot-water insoluble zinc salt (derived from whole shellac) with sulphuretted hydrogen. This acid was reported to melt at 90-91°C but resembled in almost all other respects NAGEL'S shellolic acid (m.p. 206°). In our investigation, decomposition of fraction Z2 with sulphuretted hydrogen yielded a crystalline acid which on recrystallization from hot water formed four-sided plates having m.p. 93·5°. On direct esterification of the hot-water insoluble zinc salt with methyl alcohol containing 3 per cent. dry HCl at ordinary temperature and final crystallization of the resulting ester from ether at 10°C, an ester (m.p. 146-148°C) was obtained. Mixed with an authentic specimen of shellolic acid dimethyl ester* (m.p. 149°C), the m.p. observed was 144-148°C. Obviously the ester obtained by us from the acid (m.p. 93·5°C) is the methyl ester of shellolic acid. The acid (m.p. 93·5°C) is presumed to be a precursor of shellolic acid.

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* Received by courtesy of Prof. J. W. Cook to whom we offer our best thanks.

Treatment of the insoluble lead salt (L1) with sulphuretted hydrogen in alcohol suspension gave eventually an amorphous white substance with an extending melting point (110-115°C). Attempts to crystallize it from hot water resulted in the isolation of fractions having melting points varying from 220° to 245°. These fractions are being further studied in the hope of isolating new acids. It is interesting to note, however, that esterification of the dry lead salt (L1) with methyl alcoholic hydrochloric acid gave a crystalline ester melting at 145-146° which showed no depression in m.p. when mixed with the ester prepared from Z2. The alcohol soluble lead salt (L2) was decomposed with H_2S in alcohol and the filtrate concentrated to a small volume. A precipitate was formed on the addition of water to it ; the quantity being, however, too small, it could not be properly examined. The filtrate was evaporated to dryness under reduced pressure and a light yellow soft transparent acid was obtained. It had a refractive index 1·480 at 40°C and decolorized permanganate solution in the cold and absorbed bromine quite readily. It has an iodine value of about 10·4. The compound is obviously unsaturated. Further detailed examination of the product is indicated.

In view of the fact that aleuritic acid interferes with the isolation of the minor acid constituents of hard lac resin, as will be evident from the details given above, the method is being modified by the removal of the aleuritic acid at its sodium salt in the early stage.

(B) Constitution of soft lac resin

The work was continued. Of the three fractions of hydrolyzed soft resin (*vide* ANNUAL REPORT 1945-46), the ether-soluble fraction which formed the major part was further studied. It had the following characteristics :

TABLE IX

Refractive index	... 1·4778 at 40°C.
Acid value	... 130-138
Saponification value ...	... 203-207
Hydroxyl No.	... 1·3
Unsaturation by bromine method	... 1 double bond

Molecular weight calculated from the acid value, assuming the acid to be monobasic, is 430·7, whereas on the basis of saponification value it is 490·8. Direct determination of molecular weight by RAST's or BECKMANN's cryoscopic method did not give concordant results. Results so far obtained indicate that this ether-soluble fraction is mainly a lactonic acid with one free OH-group. Attempts to prepare an anilide resulted in the formation of a deep-brown tacky mass which could not be induced to crystallize.

From the ether-insoluble fraction two components have been separated in small quantities. These are acidic in nature and have the m.ps. 93° and 124-125°C respectively. It is too early to say if these are pure and individual compounds.

(C) Hydrogenation of shellac and shellac components

Catalytic hydrogenation of shellac and shellac components has been carried out in alcohol medium with palladium-charcoal as catalyst. Results obtained do not agree with those recorded by previous workers. Further data have to be collected before any definite conclusions could be drawn.

(D) Effect of infra-red heat on lac and lac films

The advantages of heat-curing by means of infra-red lamps are fast being recognized in industry and this comparatively new technique is being accepted as an essential feature in many industrial operations. For example, in many types of compounds and varnish films,

the time of baking can be considerably reduced by exposing to infra-red rays. It was thought that an investigation on the effect of infra-red heat on lac and lac films would lead to interesting results. To start with, the effect of infra-red heat on lac films deposited from alcoholic solutions was studied. The results obtained so far show that an exposure for 15 minutes to the rays from an infra-red lamp (700 watt.) placed at a distance of 8 inches from the films is equivalent to 2 hours' oven-drying at 90-95°C. Comparative studies of the properties of the films are in progress.

(E) Studies on the slow and accelerated heat polymerization of lac

This investigation was undertaken mainly with the idea of finding if any change in the physical properties occurs when plain lac is polymerized by heat either slowly or rapidly. In a preliminary experiment it has been found that test-samples made from lac which has been slowly polymerized at 70-75°C for 10 days possess better mechanical strength than those made from lac which has been polymerized quickly at higher temperatures (170-180°C) for half to one hour. This is perhaps due to the fact that the polymerization of shellac molecules as brought about in the two processes differs in both nature and degree. Further, it has been noticed that addition of 1-2 per cent. of maleic anhydride not only accelerates the rate of polymerization at lower temperatures but also improves the toughness and elasticity of the lac. A similar observation has been made when phospheric acid is used in place of maleic anhydride.

(F) Accelerators in the heat-curing of shellac

The formation of lac-urea-formaldehyde powder is based on the important observation of ALDIS and RANGANATHAN (*Bull. No. 14*) that urea, among other chemicals, shortens the life of shellac under heat, or in other words, accelerates polymerization of shellac. Although the L-U-F powder gives a fairly good performance under the compression moulding technique, as regards flow and finish, its time-cycle is nearly twice as much as that of bakelite powder. It was therefore thought desirable to further investigate the influence of chemicals, both organic and inorganic, on the heat-polymerization of shellac, with the ultimate object of developing better types of moulding compositions. 1 per cent., 2 per cent. and 5 per cent. concentrations of some chemicals were used and the technique of ALDIS and RANGANATHAN (*loc. cit.*) was generally followed, the temperature being 150°C$\pm$2°C. Results are given in the following table, the figures indicating the ratio of ' life under heat ' of shellac to that of intimate mixture of shellac and accelerators.

TABLE X

Chemicals	Efficiency of hardening with		
	1 %	2 %	5 %
Aluminium chloride	...	too rapid to estimate	
Aluminium sulphate	1·12	1·32	2·85
Aluminium hydroxide	1·02	1·06	1·18
Barium chloride	1·44	1·53	1·77
Cadmium chloride	2·90	3·87	4·83
Copper chloride	6·33	8·14	14·25
Copper sulphate	1·06	1·11	1·79
Copper sulphate (anhydrous) ...	1·04	1·32	3·33
Ferric chloride	9·50	11·40	19·00
Ferric sulphate	4·75	7·13	11·40
Lithium chloride	5·70	7·13	9·50
Lead chloride	1·51	1·55	1·64
Lead sulphate	1·04	1·04	1·04
*Litharge	0·93	0·83	0·67
Potassium chloride	1·24	1·97	2·20
Potassium bisulphate	1·08	1·33	1·48
Potassium bihydrogen phosphate ...	1·02	1·11	1·29
Plaster of Paris	1·04	1·06	1·11
Stannous chloride	11·40	14·25	28·50
Sodium chloride	1·22	1·51	1·87
Sodium sulphate (anhydrous) ...	1·08	1·15	1·19
*Sodium bisulphite	1·00	0·98	0·92
*Sodium bisulphite compound of formaldehyde	1·00	0·97	0·93
Sodium bisulphite compound of acetone ...	1·04	1·07	1·21
Urea	2·38(2·1)	3·17(3·6)	8·14(9)
Urea nitrate	9·33	18·67	28·00
Urea oxalate	4·75	7·13	9·50
Monomethylol urea	1·33	1·65	2·15
Dimethylol urea	1·10	1·15	1·26
Dicyandiamide	2·15	3·50	5·60
Guanyl urea sulphate	1·36	1·50	1·68
Oxalic acid	7·25(8·9)	11·60(10)	19·33(13·3)
Malonic acid	2·59	4·75	7·13
Succinic acid	1·22	1·24	1·47
Glutaric acid	1·06	1·10	1·22
Adipic acid	1·06	1·08	1·16
Suberic acid	1·00	1·00	1·00
Sebacic acid	1·00	1·00	1·00
*Aleuritic acid	0·96	0·93	0·89
Malic acid	1·39	1·90	3·17
Tartaric acid	2·0(2·00)	2·90(2·8)	4·46(3·8)
Amidoacetic acid	1·17	1·26	1·50
Oxamide	1·06	1·14	1·30
Succinamide	1·47	1·75	2·08
Salicylic acid	1·25	1·61	2·13
Phthalic acid	2·00	2·95	4·31
Phthalic anhydride	1·83	2·50	3·67
*Pentaerythritol	0·96	0·93	0·88

NOTE — Figures in parenthesis are those recorded by ALDIS and RANGANATHAN.
The chemicals marked with asterisks act as retarder of polymerization.

(G) Physico-chemical studies

(a) *Osmotic pressure of shellac solutions.*— In continuation of the previous work on the subject, osmotic pressures of dilute-solutions of shellac and its constituents were studied. Measurements were done by static elevation method employing HERZONG'S osmotic cell for the purpose. Membranes used were cellophane papers swollen in 60:40 alcohol-water mixture. Molecular weights as determined for hard resin and soft resin using VAN'T HOFF'S equation, were respectively 1841 and 489. These figures generally agree with previous findings.

From the slope of the curves obtained by plotting osmotic pressure/concentration against concentration, the extent of solvent-solute interaction was ascertained. Thus, with single solvents, such as ethyl alcohol and *n*-butyl alcohol, the slope was very low, though not zero, showing that the interaction between the solvent and the solute was not significant. On the other hand, for acetone solutions containing 5, 10 and 15 per cent. water, the slope was 3 to 4 times greater than in the case of the previous solvents (*viz.*, ethyl alcohol, etc.). This is to be expected since (as it has been shown in the previous work) water causes solvation of shellac molecules in solution and hence greater solvent-solute interaction.

(b) *Melt viscosity.*— Melt viscosity measurements have been extended to plasticized shellac. The presence of plasticizers has been found to bring about a lowering of activation energy for viscous flow. This may be understood on the consideration that, as these plasticizers have high dielectric constants, their presence is bound to cause a lowering of intermicellar forces which are electrical in origin.

Further, plasticizers which are miscible with shellac have been found to increase the viscous volume, while those which are incompatible or immiscible lower the viscous volume. This may be explained as follows : In case of the miscible plasticizers, the molecules of these tend to penetrate inside the shellac micelles and sometimes interpose themselves between the polar groups of the micellar units, which would naturally account for the increased viscous volume ; the molecules of the non-miscible plasticizers on the contrary have no tendency to get inside the shellac micelles (being without any attraction for the polar groups in the latter) but merely to interpose themselves in the regions between the micellar units ; this would naturally lead to a somewhat compact structure with a lowered viscous volume.

(c) *Depolarization of scattered light.*— In order to elucidate the nature of shellac solution more clearly, measurements of depolarization of transversely scattered light by solutions of shellac in various solvents and solvent-mixtures were done. Three factors, namely, depolarization respectively with unpolarized light, vertically polarized light and horizontally polarized light were measured and the changes with concentration followed. The results analysed on the basis of various theories of light scattering consistently indicate that the scattering units are large compared to the wave-lengths of light, there being an initial diminution followed by an increase in the size as also the sphericity of the units with concentration. The results are best explained by assuming the existence of an isotropic scattering units similar in nature to the cybotactic groups in liquids, that is, loose clusters or swarms of molecules. The variation in size, shape, etc., of the clusters has been found to be a continuous process, not subject to any abrupt change corresponding to sol-gel transitions. This follows from the observation that there is no abrupt change in any of the factors measured at the gel point. The relation has thus been assumed to be the coalescence of the solvation layers of the clusters giving a continuous structure *en masse* without affecting the nature of the individual scattering centres.

(H) Dielectric properties

(a) *The dielectric strength of some lac varnishes.*— Comparative study of the dielectric strength of a number of lac varnishes, a reference to which was made in the last ANNUAL REPORT, continued during this year. It was observed that although the incorporation of cashew-nut-shell-liquid increased the dielectric strength of a lac varnish, its baked films had the defect of low flexibility. The film of shellac-urea-formaldehyde varnish also

becomes somewhat brittle on baking although its dielectric strength is high. Varnishes containing various mixtures of mono- and di-glycerides of linoleic acid and lac may, however, be classed as general-purpose insulating varnish, since their dielectric strength is good irrespective of whether the films are baked or air-dried.

The details of this investigation have recently been published in a paper entitled " A study of the dielectric strength of some lac varnishes " in the *Journal of Scientific and Industrial Research.*

(b) *The dielectric properties of lac-glycerine-linseed oil resin.*— It was mentioned in the last ANNUAL REPORT that the new lac-glycerine-linseed oil composition had a very low acid value and might therefore be expected to have low dielectric loss. It was subsequently found, however, that the acid value depends on the period of heating and presumably therefore on the extent of polymerization. It was therefore considered desirable to study the dielectric properties of this compound at various stages of polymerization. To this end, five samples were drawn at equal intervals of time during the course of reaction, representing different stages of polymerization of this resin. The acid and hydroxyl numbers of these samples were not widely different, but there was a marked change in viscosity as it progressed from one stage to another. The conductivity also decreased enormously with the progress of polymerization. The true dielectric loss, i.e., the figure obtained after deducting the calculated d.c. conductivity loss from the total observed loss, did not show much variation with polymerization-time. Owing to the increase in internal viscosity of the resin with polymerization, however, the loss curves, the power factor curves as well as the dielectric constant curves, all gradually shift towards the higher temperature side. A short note is being compiled including the results of this work.

(c) *The dielectric properties of w-w. rosin.*— The dielectric properties of a sample of water-white rosin were studied in order to get its electrical characteristics in relation to those of lac. It was observed that the dielectric constant of this resin was low and remained within the limits 2·7 to 3·2 for the temperature range 20°-150°C at any frequency between 1-500 kc/s. The dielectric loss was also low and remained within the range 0-0·1 for all temperatures and frequencies mentioned above. This resin gave some typical resin curves which could be obtained without any difficulty, as its d.c. conductivity was not high. In fact, although rosin is an inferior natural varnish resin, its electrical characteristics, e.g., dielectric constant and dielectric loss, are not in any way inferior to those of lac. The results are being included in a short note.

(d) *The dielectric properties of ester gum.*— The effect of esterification of resin on its dielectric properties formed the subject of a separate investigation. Ester gums, as is well known, are rosin glycerides prepared by condensing rosin with glycerol. There are two types of this gum ordinarily available, one type having high acid value and the other low acid value. The sample used for this investigation had low acid value and was meant for lacquers. Its dielectric constant varied within the limits 2·8 to 4·0 for the temperature range 20°-150°C at any frequency between 1-500 kc/s. Its dielectric loss was, however, high compared to that of rosin, the maximum value at any frequency being about double the corresponding figure for rosin. Its d.c. conductivity, however, was lower than that of rosin at any temperature, and hence the amount of correction required for dielectric loss was less. But notwithstanding the stated high loss values of ester gum when compared with those of rosin, the general dielectric properties of the former are better than those of lac. A short note is being compiled incorporating details of this work.

(e) *The dielectric properties of hydrolysed lac.*—The measurement of the dielectric properties of hydrolysed lac was undertaken to see if certain theoretical ideas evolved out of our earlier measurements on the dielectric properties of lac were correct. Thus, it had been concluded from theoretical calculations that the hydroxyl group was mainly responsible for dielectric loss in lac. A direct confirmation of this point might be obtained if an increase in the dielectric constant as well as loss values were obtained by increasing the number of OH groups in the lac molecule. The dielectric measurements on hydrolysed lac provided

such an opportunity. As expected, the dielectric constant as well as dielectric loss values were observed to be very high in this case. Precise measurement, however, was difficult at certain temperatures and frequencies, owing to its high d.c. conductance, but that could not mask the general character of the dielectric curves.

(f) *Lac laminated boards for electrical purposes.* — Some laminated boards were made using paper and various lac compositions and a comparative study was undertaken to determine the effects of the varnish-composition. The same quality of paper and the same method of preparation were used for all the boards varying the composition of the varnish only. None of the samples tested was found to pass the relevant B.S. Specifications and some of them disintegrated in hot oil. It appeared, however, that sheets of paper bonded by simple lac-alcoholic solution gave quite high values of breakdown voltage. Dry lac powder and paper when pressed under heat gave still higher breakdown voltage values.

6. Garnet Lac

To minimize the loss of spirit in the manufacture of garnet lac, some alterations were made in the pilot plant of the Institute. The same vessel was used both for dissolution of *kiri* in spirit and for subsequent distillation of the sludge. But as the vessel has neither a heating arrangement at the bottom, nor any stirring arrangement to break up the lumps of settled sludge, the total recovery of the solvent could not be accomplished in a single operation. The alcohol from the sludge was distilled as far as possible under reduced pressure with side heating of the vessel and the residue, while still wet and soft, transferred to a Baker-Perkins Kneader where complete recovery of solvent was effected by distillation under reduced pressure with stirring. The net loss of solvent per maund of garnet lac prepared was found to be 6 gallons.

In the report submitted by W. E. Suter and B. S. Gidvani (*The Shellac Industry in Germany*) it is stated that " the alcohol loss varied from 6-12 per cent. by weight of the total quantity employed in the whole process ".

7. Making of Shellac

The report of the British Intelligence Committee on the shellac industry in Germany submitted by Mr. Suter and Dr. Gidvani describes *inter alia* a method for the extraction of lac resin from sticklac or seedlac by autoclave process. A few experiments have been conducted on essentially the same principle. Fresh *kusmi* seedlac was suspended in a brass cage of 50-mesh inside an autoclave and the latter was heated at 3 atmosphere pressure for 1 hour in presence of steam. The yield of resin was 80 per cent. as against 83 per cent. by the cloth-bag process. Comparative data of the properties of shellac prepared by the cloth-bag process and autoclave process are given in Table XI.

Table XI

	Seedlac	Shellac by cloth-bag	Shellac by autoclave
Moisture %	1·3	1·27	2·0
Hot alcohol insoluble % ...	4·16	0·77	0·29
Cold alcohol insoluble % ...	8·1	3·67	1·51
Flow, secs.	—	40·0	72·0
Life, mins.	—	50·0	34·0
Colour	8·5	6·0	7·1
Acid value	—	73·6	76·5
Iodine value	—	14·6	16·88
S.P. °C	—	61-62°C	65-66°C
M.P. °C	—	74-75°C	75-76°C
Wax %	4·84	5·02	2·97

The cold alcohol insolubles and wax-contents of shellac prepared by the autoclave process are lower because during the melting operation wax separated out from the molten lac. Shellac prepared by the autoclave process is definitely inferior to that made by the country process as regards life, but has a higher flow. Further investigations are being continued with sticklac and other qualities of seedlac.

8. Shellac Wax

A preliminary analysis of the lac factory sludge reported in the last Annual Report, has been followed up by a detailed analysis with the following results :

Wax (by benzene method)	12-13%
Wax (by kerosene method)	8-8·5%
Nitrogen	2·8-3·5%
Methyl alcohol soluble	11-13%
Water soluble	5-5·5%
Rect. spirit soluble	22-24%
Rect. spirit soluble after benzene extraction ...	16-19%
Dye (colorimetrically)	6·5%
Dye extracted by ethyl acetate ...	3-3·2%

The wax recovered by the benzene method had a dark-grey appearance and melted at 80-84°C. Recrystallization from kerosene or filtration through beds of activated alumina improved the colour, the percentages of recovery of wax being 70 and 20 respectively.

The pitch-black resin recovered from the alcoholic extract had A.V. 64·9, S.W. 205·4, softening point 65-66° and m.p. 75-76°C. It does not form a film.

The dye is present in the form of a salt and the free dye had to be liberated by treatment with mineral acids before extraction with ethyl acetate. The dye obtained on removal of the solvent, however, appeared to have dull colour and tended to lose its solubility and tinctorial properties on keeping.

A few samples of lac factory waste collected from a factory at Ranchi were found to contain 5 per cent. of wax as against 12-13 per cent. previously recorded. Further samples are being collected from different localities to determine the average wax-content.

9. Instantaneous Sound-Recording Discs

Lac compositions so far tried for this purpose have been found to be extremely sensitive to climatic conditions, particularly to humidity. Thus, compositions that gave quite satisfactory results during the monsoon proved totally unsuitable during the dry winter months, the films becoming extremely brittle. Again compositions that work well during the winter become badly sticky during the summer and rainy seasons. Apparently, lac may not be quite suitable for purposes of instantaneous recording compositions. Further experiments are being continued to evolve, if possible, some composition which would give satisfactory recording qualities at least under strictly controlled conditions. For this purpose, conditioning the recording discs by exposure to an atmosphere of saturated humidity immediately before recording has been found to be convenient. Ammoniacal dewaxed lac varnishes plasticized with 20 per cent. castor oil fatty acids have been found to be satisfactory under these conditions. The ageing qualities of such discs are being examined.

10. "Ad Hoc" Investigations

(i) Among the samples of water-proof varnish sent to the Inspectorate of Military Explosives, Kirkee, two have been approved. At the request of the C.I.M.E., bulk samples of one gallon each of the approved variety have been sent for large-scale trials.

(ii) Lac-CNSL combinations developed earlier have been further improved to increase the water-resistance and adhesion on metal and wood. These compositions have been found suitable for preparing artificial writing slates, blackboards, etc.

(iii) An adhesive composition sent to a radio firm in Madras has been found satisfactory by the firm as regards both colour and drying properties.

Meteorological Report

The average meteorological data for each month during 1946-47 are given in the following table :

Table

Month		Dry bulb °F	Max. temp. °F	Min. temp. °F	Relative humidity	Sunshine (hours per day)	Wind speed (mls.p.hr.)	Rainfall (inches)	Remarks
April	1946	81·6	93·5	62·7	56·0	9·3	2·4	3·67	
May	1946	83·4	99·3	72·9	55·0	8·7	3·0	5·60	
June	1946	83·6	93·6	74·9	72·0	5·6	3·5	10·80	
July	1946	79·1	86·2	74·0	86·0	3·3	3·0	9·92	
Aug.	1946	79·4	86·8	73·5	86·0	4·6	2·4	10·61	
Sept.	1946	79·9	88·0	71·2	78·0	6·6	2·7	4·80	
Oct.	1946	76·7	86·1	65·9	76·0	7·2	1·6	4·42	
Nov.	1946	71·0	81·7	57·5	63·5	8·6	1·9	1·82	
Dec.	1946	66·9	79·0	51·8	60·8	9·8	1·2	—	
Jan.	1947	62·4	75·6	49·2	57·1	8·4	0·93	0·68	
Feb.	1947	67·0	81·7	52·0	48·0	9·8	1·5	0·83	
March	1947	76·7	89·0	61·7	43·0	9·5	3·4	2·85	

The total rainfall during the period as well as the monsoon rain as compared with those of the previous three years are as follows :

	1943-44	1944-45	1945-46	1946-47
Total rainfall (April-March) ...	71·69	66·47	52·23	56·00
Monsoon rainfall (June-Sept.)	59·13	54·01	40·91	36·13

The total rainfall during 1946-47 was also below normal, but this figure was higher than that of the previous year although the monsoon rain was less, as the above table shows.

The highest maximum temperature during the period was 107°F and was recorded on the 5th June 1946, the lowest minimum temperature during the same period being 40°F on the 15th January 1947.

DEMONSTRATION & PUBLICITY

(LAC INFORMATION)

The Lac Information Officer, in addition to answering all enquiries regarding the lac industry and research developments at the Institute, maintained contact with the present and prospective consumers of lac and shellac in India through correspondence, interviews, personal visits to factories and demonstration of industrial processes.

1. Consumption of Lac in India

Although no striking increase in the use of lac in any one industry has taken place, small quantities are being utilized by several consumers for various purposes, e.g., bleached lac varnish, electrical insulating materials, plastic moulded goods, quick-drying paints, adhesives, rubber goods manufacture, etc. It is difficult to estimate the actual quantities used without a detailed survey.

2. Marketing Conditions in India

During the year under report, the crop production and exports were above normal and manufacturers of seedlac and shellac had a large business. The position with regard to the availability and cost of charcoal and cloth registered a definite improvement, but labour charges are still comparatively high. There is still a dearth of suitable cloth in sufficient quantities in several manufacturing centres partly on account of an increased demand caused by the larger quantities of shellac manufactured.

3. Enquiries

About 300 enquiries were handled during the year, covering the manufacture and uses of lac for various applications.

Garnet lac. — Although a few firms are still evincing interest in the process of recovering lac from *kiri* by the solvent process, there has been no development owing to lack of suitable plant and the high cost of methylated spirit.

Bleached lac. — Samples and technical data were supplied to firms in S. America, Canada and India.

Lac-wax. — There is a good demand for shellac-wax from boot-polish, crayon and carbon-paper manufacturers ; literature was supplied and sources of availability indicated to several enquirers. A shellac manufacturing firm in Jhalda is experimenting on the isolation of wax by extraction with kerosene oil.

Shellac plastics. — Shellac moulded articles for electrical appliances and general utility goods are being manufactured successfully by a firm in South India.

Oil-cloth. — Five new firms were contacted and arrangements are in progress for their starting this industry. Non-availability of suitable cloth is still a handicap.

Varnishes. — Baking insulating varnish has been successfully adopted by a large firm of electric fan manufacturers in Calcutta.

The use of insulating varnishes for the manufacture of varnished fabric has been taken to the pilot plant stage successfully and commercial production is expected to start shortly.

An air-drying shellac varnish for impregnating paper-pulp in the manufacture of radio loudspeaker cones has been found satisfactory and semi-large-scale trials are in progress.

Pigmented varnishes for coating writing pencils were suggested to a firm in Quilon and adopted successfully.

Shellac nitrocellulose lacquers are being developed by a firm in Western India.

Adhesives and cements. — A shellac adhesive for the manufacture of flexible micanite has been found satisfactory and is in regular production by a firm in Calcutta.

An adhesive for use in the manufacture of waterproof emery paper is being used by a firm in Saharanpur, and another in Madras is carrying out pilot-plant trials.

Depolymerization of insoluble lac. — A simple method of making old insoluble lac fit for use again for spirit varnishes was worked out, but it is found that, although the treated material is soluble to the extent of 97 per cent., it does not retain its solubility for long, becoming insoluble on further storage for a few weeks.

Lac-dye. — There would appear to be still a market for fresh lac-dye for silk fabrics, provided the resulting seedlac can be marketed profitably in the same locality. Lac-dye cakes have been found to be unsuitable and only fresh dye-liquor is useful. Further work is in progress to encourage this industry.

4. Foreign Markets

The American market has displayed the earliest post-war recovery and continental ports have received appreciable quantities of lac since December 1946. Informations about the reaction in the American markets to high prices, the development of synthetic resins that threaten to replace shellac in the gramophone record industry in the U.S.A. and on allied matters were regularly received from and through the India Govt. Trade Commissioner in New York, and were brought home to the members of the Indian Lac Cess Committee and the general public through circulars and publicity notes.

5. Exhibitions

Exhibits representing various uses of lac, many of them developed at the Institute, were sent to the Rural Uplift Exhibition in Delhi, the U.S.A., British Empire Exhibition in Sydney, Science Congress Exhibition, and the exhibition held in connection with the Asian Relations Conference, and were widely appreciated.

6. General

A close touch was maintained with current developments in lac and synthetic resin research in India and abroad through reference to reports, journals, etc.

Information and data were supplied to various Govt. departments on the work of the Institute, marketing conditions, industrial statistics, standardization of grades, etc.

7th June 1947

P. K. Bose
Director,
Indian Lac Research Institute

APPENDIX A

(ENTOMOLOGICAL SECTION)

A Statement of Lac Produced and its Disposal

Locality	SCRAPED LAC PRODUCED AND ITS DISPOSAL				
	Produced	Under use in Deptt.	Driage	Supplied to lac factory or chemical deptt.	Sold
	Md. sr. ch.	Md. sr. ch.	Md. sr. ch.	Md. sr. ch.	Md. sr. ch.
Baisakhi 1945-46 Crop					
Namkum ...	1 37 7		0 6 4	1 14 4	0 16 15
Jethwi 1946 crop					
Namkum ...	0 15 8		0 0 12	0 14 12	
Hesal ...	9 38 6		3 11 12	1 15 2	5 11 8
Katki 1946 crop					
Namkum ...	1 8 12	0 19 12	0 5 12	0 10 12	
				0 12 8 for Madras	
Aghani 1946-47 Crop					
Namkum ...	0 21 14	0 19 12	0 2 2		
Hesal ...	5 24 4	0 27 14	0 20 4	4 16 2	...
TOTAL ...	19 26 3	1 27 6	4 6 14	8 3 8	5 28 7

	Md. sr. ch.	Rate per md. Rs. As.	Rs. As. P.
(1) Receipts by supply to lac factory of scraped lac from Institute plantation	1 14 4	85 0	125 0 0
do do	1 29 14	95 0	165 15 3
do do	0 23 4	56 8	32 13 6
do do	4 16 2	85 0	374 4 3
		TOTAL	698 1 0
(2) Receipts by sale of scraped lac from Institute plantation	0 16 15	36 0	15 3 11
do do	5 11 8	40 0	211 8 0
		TOTAL	226 11 11
(3) Receipts by sale of scraped lac from purchased lac	2 5 0	36 0	76 8 0
(4) Receipts by supply of scraped lac to lac factory from purchased lac	0 7 12	95 0	24 8 9
do do	4 10 0	85 0	409 1 3
do do	2 11 0	56 8	128 8 6
do do	0 28 4	85 0	60 0 6
			622 3 0

APPENDIX I

Tabulated Statement of the Progress of Investigations

ITEM	COMD. IN	PROGRESS	FUTURE WORK PROPOSED
1	2	3	4
		ENTOMOLOGICAL SECTION	
1. Improving crop production on *palas* by artificial partial pruning.	1940	Successful results as in previous years. Large-scale demonstration in Kundri gave good results.	Investigation closed. Large-scale cultivation under Bihar Forest Dept. to be guided and supervised for 3 years.
2. Determination of most suitable pruning methods and seasons for *kusum* and *palas*.	*Kusum* 1941	Investigation restarted at Hesal; results fair. Natural growth in *kusum* takes place in spring each year.	To be continued for at least another 5 years.
	Palas 1942	Pruning at Kundri forest area according to our methods indicates pruning in February suitable to grow *Katki* crop.	To be continued.
3. Investigating the economics of utilizing *palas* for the *Baisakhi* crop only and *ber* for the *Katki* crop only.	1942	The *Baisakhi* crop from brood point of view was almost 100 per cent. better on *palas* than on *ber*.	To be continued.
4. Investigating the possibilities of *F. bengalensis*, *O. dalbergioides* and *A. lucida* as *Baisakhi* hosts.	1945-46	These hosts continued to give fair results. Alternation of *barh* or *ber* with *khair* satisfactory.	To be continued and such alternations with *palas*, *ber* and *khair* to be studied.
5. (a) Proper harvesting, storage and disposal of sticklac to avoid enemies.	1945-46	Results confirm the previous years' data that by *ari* crop cutting followed by immediate sale of the *ari* lac a cultivator actually loses.	To be continued.
(b) Infecting brood lac in wire-gauze baskets with a view to the control of enemy insects.	1945	Suitable type of brood baskets of 60-mesh brass-woven-wire under investigation.	To be continued.
6. To control enemies by :			
(a) Cold water immersion.	1930	Seedlac and shellac made from cold-water treated lac is not inferior to that from control. Treated lac better refraction. Cost of scraping is reduced by about 50 per cent.	Investigation closed, effect of storage to be studied.
(b) Hot water immersion.	1945-46	Not a practicable method.	Stopped.
(c) Heat-treatment.	1941	Results incomplete.	To be continued.
(d) Gammexene	1946	Immersing sticklac in emulsion more effective than dusting. Results incomplete.	To be continued.
7. Biological control.			
(i) To discover suitable alternative hosts to breed *B. (M.) greeni* in the laboratory.	1942	Pink boll-worm of cotton gave highest rate of parasitization, next was the *amaltus* pod borer.	To be continued.
(a) Breeding of suitable alternative hosts.	1945-46	Attempts to breed pink boll-worm proved fairly successful.	To be continued. To get quick results insectary required.
(b) Rendering host larvae suitable for parasitization by *B. (M.) greeni*.	1944-45	Amputation and coddling in hot water gave satisfactory results.	To be continued.

Item	Comd. in	Progress	Future work proposed
1	2	3	4
(c) Presentation of alternative hosts for parasitization	1944-45	Results confirm previous data that domes of tissue-paper covered with *Eublemma* excreta and powdered sticklac give good results.	Completed. General investigation to be continued.
(ii) Breeding of *B.* (*M.*) *greeni*:			
(a) Prevention of interference by mites.	1945-46	As previously reported heating cages and domes to 50°C for 6 hours proved effective.	Infestation of mites carried by host larvae to be studied.
(b) Breeding on unnatural hosts on a mass scale. Breeding on *E. amabilis*.		6,373 *B.* (*M.*) *greeni* were bred on alternative hosts, average of adults bred per parasitized host was 0·9, maximum of 1·4 was on pea pod borer (*E. zinkenella*); 25,670 *B.* (*M.*) *greeni* were bred on *E. amabilis*; breeding rate was 0·84.	To be continued.
8. Demonstration			
(i) Demonstration of improved methods of cultivation and advice to cultivators.	1940	Brood-lac and pruning instruments were distributed. Provincial and Indian State candidates trained. Advice given to cultivators. Partial pruning of *ber* and defoliation of *palas* preserved brood-lac.	To be continued.
(ii) Improved cultivation in forest area.	1942	Scheme is progressing satisfactorily but thefts are affecting revenue.	To be continued.
9. Namkum Plantation		Mortalities in *khair*, *ber* and *kusum* replaced. *Kusum*, *pandan* and *A. lucida* being extended.	Resting the existing main hosts and replanting when necessary. The proper upkeep of plantation requires increased labour.
		CHEMICAL SECTION	
Moulding Powders			
(a) Lac-urea-formaldehyde powders.	1938-39	(i) Results of incorporating inorganic extenders studied. (ii) Standardization of lac moulding powders: Effect of heat-cure and moisture-content studied.	To be continued.
(b) Lac-formaldehyde-phenol combinations.	1946	Moulding compositions with a rather long curing time result.	To be further studied.
(c) Lac-dimethylol-urea compositions.		Direct combination of dimethylol-urea and lac studied.	To be continued.
Fillers	1941-42	Fillers from *Cryptomeria japonica*, jute-sticks, etc., studied. Compressed powder from jute-sticks has a specific volume nearly equal to that of foreign wood-flour.	To be continued.
Varnishes & Lacquers			
(a) Lac-CNSL varnishes	1943-44	Lac-CNSL varnishes further studied.	Electrical insulating properties to be further studied. Experiments to be continued.
(b) Lac-formaldehyde-urea varnishes	1941-42	The varnishes specially when modified with phthalic anhydride and *n*-butyl alcohol appear to have good weathering properties.	
(c) Lac-linseed oil-glycerine air-drying varnish.	1944-45	Modifications have been tried with a view to improving electrical properties, but so far without success. Appears to be suitable for coating fabrics.	To be continued.

Item	Comd. in	Progress	Future work proposed
1	2	3	4
(d) Lac-linseed oil-lime varnishes.	1946-47	Film properties have been studied.	To be continued.
(e) Lac-linseed oil-lead oxide-lime varnishes	1946-47	A satisfactory composition which has been developed is being further studied.	To be continued.
Lac-linseed oil-red lead insulating varnish	1945-46	Developed for preparation of " Empire-cloth " B.D.V. at saturated humidity is unsatisfactory.	To be further studied.
Medicinal use of lac-dye	1945	The pure dye is recommended for making *Tr. lacca*, which is a substitute for *Tr. cochineal*.	Completed.
Fundamental Researches			
(1) Constitution of hard lac resin	1947	Several degradation products obtained and being studied.	To be continued.
(2) Constitution of soft lac resin	1943		
(3) Effect of infra-red and direct heat on lac and lac films.	1947	Preliminary studies made.	To be continued.
(4) Accelerators in the heat-curing of shellac	1946	The influence of many new inorganic and organic chemicals recorded.	To be continued.
(5) Nature of shellac in solution.	1946	Osmotic pressure of shellac solutions studied.	
(6) Melt viscosity of shellac.	1946	Several studies have been made.	To be continued.
(7) Depolarization measurements on shellac-solutions.	1946	Preliminary studies have been completed.	To be continued.
(8) Dielectric properties	1940-41	Dielectric properties of some lac varnishes and lac-glycerine-linseed oil resin and hydrolysed lac studied. Comparative studies of several allied resins made. Suitability of lac laminated boards investigated.	To be continued.
Improvements in the manufacture of seed-lac, shellac, etc.			
(a) Preparation of garnet lac from *kiri*.	1943	Net loss of spirit per maund of garnet lac prepared amounts to 6 gallons.	To be continued.
Home-recording Discs	1941	Simple plasticised lac varnishes in aqueous ammoniacal solution suitable for single coat application have been studied.	To be continued.
'Ad hoc' Investigations.	—	(1) Water-proof varnishes. (2) Lac-CNSL emulsions improved as regards water-resistance and adhesion on metal and wood. Found suitable for making artificial writing slates. (3) An adhesive for fixing metal to paper, etc.	

APPENDIX II

List of Publications during 1946-47

Bulletin 64: Dielectric Properties of Manila copal, by G. N. BHATTACHARYA.

Biological Control of Eublemma amabilis Moore: A predator of lac insects by one of its indigenous parasites *Microbracon greeni*, Cam., by P. S. NEGI, S. N. GUPTA, M. P. MISRA, T. V. VENKATRAMAN and R. K. DE.

IN THE PRESS

1. *Bulletin No. 65* — Lac-Linseed Oil Varnishes. Part I. Lac-linseed oil-red lead, by Y. SANKARANARAYANAN.
2. *Research Note No. 35* — A Study of the Dielectric Strength of some Lac Varnishes, by G. N. BHATTACHARYA.
3. *Practical Applications of Recent Lac Research*, revised and enlarged edition.
4. *Bulletin No. 67* — Molecular State of Dissolved Shellac, by S. BASU.
5. *Bulletin No. 68* — Viscosity and Axial Ratio of Shellac and its Constituents, by S. BASU.
6. *Bulletin No. 66* — Melt Viscosity. Part I. Shellac and its Constituents, by S. BASU.
7. *Research Note No. 36* — On the Suitability of the Dielectric Constant Method for the Determination of Moisture in Lac, by G. N. BHATTACHARYA.

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