



Government of the Union of Myanmar
Ministry of Forestry
Forest Department
Forest Research Institute



Study on the Betterment of Fast Drying Quality of Myanmar Lacquer Through The Chemical Modification

Daw Khine Khine Tun, M.Sc. (Chemistry),
Research Assistant ,
and
Daw Khin May Lwin , B.Sc. (I.C), Dip. Pulp & Paper Technology (India),
Assistant Research Officer ,
Forest Research Institute.
May 2001

မြန်မာ့သစ်စေးကို ပိုမိုအခြောက်မြန်စေရန် အသုံးပြုမည့် ဓါတုနည်းစဉ်များကို ဖော်ထုတ်လေ့လာခြင်း

ဒေါ်ခိုင်ခိုင်ထွန်း၊ B.Sc (Hons;), M.Sc. (Chemistry) (Mawlamyine)၊ သုတေသနလက်ထောက်၊
သစ်တောသုတေသနဌာန၊ ရေဆင်း

ဒေါ်ခင်မေလွင်၊ B.Sc (I.C) (Rgn.), Dip. Pulp & Paper Technology (India)
လက်ထောက်သုတေသနအရာရှိ၊ သစ်တောသုတေသနဌာန၊ ရေဆင်း။

စာတမ်းအကျဉ်းချုပ်

ယခုအခါတွင် ယွန်းပစ္စည်းများပြုလုပ်ရာတွင် အပင်မှရသော သစ်စေးအတိုင်း အသုံးပြုလျက် ရှိပါသည်။ မြန်မာယွန်းပြုလုပ်ရာတွင် အရောင်တောက်ပြောင်ရန်နှင့် အခြောက်မြန်ရန်အတွက် ဂျပန်ယွန်း ပညာကဲ့သို့ နည်းလမ်းကောင်းများကို အသုံးပြုခြင်း မရှိသေးပါ။ မြန်မာ့သစ်စေးသည် အခြောက်ခံရန် အလွန်ကြာသဖြင့် မြန်မာယွန်းပြုလုပ်ရာတွင် ခြောက်ရန်အချိန် (၃) လခန့်ကြာပါသည်။ ယခုစာတမ်းတွင် သစ်စေးကို အခြောက်မြန်စေသောနည်းလမ်းများကို သုတေသနပြု စမ်းသပ်လေ့လာ ထားပါသည်။ လေ့လာတွေ့ရှိချက်အရ Oven တွင် ၁၀၀ ဒီဂရီစင်တီဂရိတ်အထိထားပြီး အခြောက်ခံခြင်းသည်စီးပွားဖြစ် ထုတ်လုပ်သူများအတွက် အခြောက်မြန်သည့် နည်းလမ်းကောင်း တစ်ခုဖြစ်ကြောင်း တွေ့ရပါသည်။

Study on the Betterment of Fast Drying Quality of Myanmar Lacquer Through The Chemical Modification

Daw Khine Khine Tun, B.Sc. (Hons:), M.Sc. (Chemistry), (Mawlamyine
Research Assistant,
Daw Khin May Lwin , B.Sc. (I.C)(Ygn.), Dip. Pulp & Paper Technology (India),
Assistant Research Officer,

Abstract

Nowadays, only crude resins are used for the lacquerware arts. Myanmar lacquer arts did not use the modification method for the brightness and drying to improve the quality as the Japanese lacquerware. Myanmar lacquerware products take about 3 months to season. The main factor is being the slow process of drying of thitsi (Myanmar lacquer). This paper is attempted to find ways for fast drying process. It was found that drying in oven at 100°C is the suitable method for the commercial scale production.

Contents

	Page
စာတမ်းအကျဉ်းချုပ်	i
Abstract	ii
1. Introduction	1
2. Literature Review	1
3. Materials and Methods	5
3.1 Materials	5
3.2 Methods	5
3.2.1 Determination of Purified Thitsi (Thitsiol) from Thitsi (<i>Melanorrhoea usitata</i> Wall.)	5
3.2.2 Infrared Spectroscopy Studies of Thitsiol	5
3.2.3 Determination of Drying Time	6
4. Results and Discussions	7
5. Conclusions	8
6. References	

1. Introduction

The thitsi tree (*Melanorrhoea usitata* Wall.) belongs to the family Anacardiaceae and is closely related to the well known lacquer tree of Japan, *Rhus vernicifera* (Japanese urushi noki), which is a member of same family. It is a large deciduous tree with a straight clean cylindrical bole and a spreading crown of dark green leaves. Most of the thitsi are grown in Indaing Forest and mixed with In (*Dipterocarpus tuberculatus* Roxb), Thitya (*Shorea oblongifolia* Thw.syn), Ingyin (*Pentacme saimensis* (Miq).Kurz), Mondaing (*Cycas rumphii* Miq),Hmanni (*Gardenia erythroclada* Ham), and Lunbo (*Buchanania lanzan* Spreng). It is very common in the forest of Southern Shan State and it is also found in the forest of upper Chindwin, Mu, Katha, Northern Taungoo and Pyinmana. In its natural habitat the absolute maximum shaden temperature varies from 100 °F to 110 °F and the normal rainfall from 35 to100 inches or more. It is distributed between 25° N and 11°S. It occurs below 3800 ft sea level. Soil type is characteristic of gravel and sand formations through poorer class of this type predominates on all laterite soils.

A natural vanish, known as Myanmar lacquer or thitsi is obtained by tapping the thitsi tree through V-shape incisions in the bark. The collection of thitsi is from June to January but the best season for tapping is July to October. Thitsi is widely used as a water-proofing paint for boats, cloth and paper (umbrella), as glue for gilding, as a non-fouling and preservative paint for wood, metal ware and leather. In Myanmar, 71.6% of the total production of thitsi is used in the Lacquerware Industry.

Nowadays, only crude resins are used for the lacquerware arts. Myanmar lacquer arts did not use the modification method for the brightness and drying to improve quality as the Japan lacquerware. The Myanmar thitsi in its pure natural state is very similar in appearance to pure Japanese lacquer. But in Japan, the lacquer are used after improvement of quality.

The essential conditions for the drying of Myanmar Lacquer are identical with those of Urushic or Japanese lacquer. Myanmar lacquer takes longer time to dry than Japanese lacquer. The quality of thitsi depends on its content of urushic acid (urushiol). Best quality lacquer contains highest percentage of urushiol.

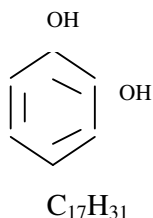
A lacquerware product takes about 3 months to finish processing. The main factor is the slow process of a thitsi coating to dry and become hardened. Research is underway for a better technique of drying thitsi coating more quality without bringing any adverse effect on its salient properties. Modern methods of preservation of bamboo and wood, the basic for the lacquerware products are also imperative for the enhancement.

2. Literature Review

In Myanmar thitsi can be divided into three classes. They are black color (first class), brown color (second class), red color (third class). The quality of thitsi is also depend on the concentration of Urushic acid. The first class thitsi can get in summer times. The second class and third class can collect in raining and winter seasons.

Pure thitsi is a viscous, greenish fluid of glutinous consistency, which turns brown and then jet-black color on exposure to the air. A crude black thitsi is of better quality than the brown or red one. It has a peculiar sweetish odor and it is slightly heavier than water. The specific gravity at 23°C of pure fresh Myanmar thitsi obtained from *Melanorrhoea usitata* is 1.0016 and the specific gravity at 23°C of Japanese lacquer, *Rhus vernicifera* is 1.0020.

The molecular formula of thitsiol from thitsi (*Melanorrhoea usitata* Wall.) is $C_{23}H_{36}O_2$. The structural formula of thitsiol is



The chemical composition of three different classes of thitsi resin are shown in Table 1.

Table. 1. Chemical composition of three different classes of thitsi resin.

Composition	Black Thitsi (%)	Brown Thitsi (%)	Red Thitsi (%)
Ash	0.045	0.108	0.089
	0.033	0.125	0.087
Matter insoluble in benzene	2.65	2.77	2.76
	2.58	2.77	2.75
Matter insoluble in water	8.00	17.00	29.27
	7.83	16.47	30.04
Urushic Acid	90.06	78.80	67.73
	87.87	81.87	68.51

Source: Myint Myint Sein, Study on the chemical constituents of Thitsi, 1983.

The Myanmar's varnish or thitsi under powerful microscope consists of two kinds of particles. Some are very numerous, small globules dark brown in color and some are light color globules, which are scattered more sparsely than the former. (Sir David Brewster, 1908)

The Japanese lacquer under the microscope appears as a brown emulsion consisting of minute globules of two kind. They are numerous, small dark colored globules more sparsely scattered and large globules of lighter color. Therefore, it may be concluded that the Myanmar's varnish or thitsi exhibits under the microscope is similar composition as the Japanese lacquer. (H. Yoshida, 1983) .

Thitsi causes violent crysipelatous swelling when it comes in contact with the skin, followed by pain and fever. An oily non-volatile substance present in the lacquer was liable to cause dermatitis. The poisonous substance is not volatile and that it is present only in the petroleum ether or alcoholic extract. The substance may be precipitated by lead acetate. The poisonous substance is identical with urushiol which is the main component Japanese lacquer. Old lacquer products are non toxic. (Toyama, 1964)

Puran Sing (1908) carried out the experiments on the rate of drying with the original juice and also with various mixture of its several constituents under different conditions for the drying of the varnish. For the purpose of shortening the drying period, he used a very thin layer of the experimental material coated on the glass plate, which was exposed to the action of air. He kept the glass plate which was coated with original thitsi. He indicated the results as follows:

- (1) at 25°C under a bell jar along with a dish full of water and found that it dried after 22 hours.
- (2) in a wooden chest at 22-25°C with pieces of wet cloth, hanging inside and also pinned on to the sides of the chest. The cloth pieces were soaked a new from time to time with cold water and found that it dried after 5½ hours.
- (3) in a dessicator over sulphuric acid and found that it had not dried even after 2 days. Accordingly, he reported that keeping the atmosphere of the drying chamber in as moist as condition as possible hastened the drying process.

He also reported that the urushic acid, the main constituent of thitsi, could not dry by itself when exposed to the action of moist air. He determined the rate of drying by coating a glass plate with a mixture of gum, water and urushic acid and allowed to stand for 48 hours exposed to moist air at the temperature of 22°C to 25°C. He reported that the mixture did not dry and the consistency of the mixture does not change. Thus he stated that the gum, though useful in increasing the adhering power of the varnish, took no direct part in the drying process. When the rate of drying was determined by using the mixture of urushic acid, water and nitrogenous constituents, he found that the mixture dried almost at the same time as the original thitsi. Thus he concluded that the presence of nitrogenous constituent is essential for the drying of the varnish.

He report that the composition of Burmese varnish does not vary to any great consequently possess about equal drying power. He stated that sesamum oil, the common adulterant of thitsi, greatly impairs the drying power of the varnish. The Japanese adulterate their varnish with linseed oil, which, if excess is avoided, does not greatly impare the drying power of varnish. Thus he stated that the presence of an oily substance in natural varnishes inhibits to a more or less extend the catalytic action of the nitrogenous constituents in helping the drying process.(Puran Sing,1908) Burmese lacquering and drying process is done in cool, chimp underground cellars because thitsi cannot be dried by heat, light and dry air. (Rosenthal, 1906)

A.W Hixson and Zai-Ziang Zee(1983) studied the drying of the sap of the lacquer tree or *Rhus vernicefera* alone and also mixed with China wood oil and driers. They reported that the drying process differs from that of the usual drying oils and also varies with drying conditions. In the presence of moisture drying is accomplished by initial volatilization, formation of intermediate transition compounds and final oxidation. These steps are accelerated by the action of moisture and the oxidase enzyme laccase which is present in the lacquer. The temperature, as well as humidity, plays an important part in the drying process 25°C being more favorable than 0°C or 40°C for the drying of the most lacquer oil varnishes. Lead, cobalt and manganese accelerate the drying to about the same extent, the manganese being slightly the best. The optimum amount of manganese is about 0.2%. The most favorable condition for drying lacquer is at 25°C with 80% relative humidity and the most satisfactory varnish is that containing 80% Chinese lacquer and 20% China wood oils. (A.W Hixson and Zai-Ziang Zee, 1926)

According to the reports of R.Norris Shreve (1945), the rate of drying of paints is hastened by the addition of driers which are oxygen carriers usually soluble in oil. The driers are lead, manganese and cobalt resinate, linoleates, oleates, or acetate or oxide. These driers are needed to be employed in only small amounts of the order of one part of metal to a thousand parts of the paint.

Drying oils of vegetable or animal origin are extensively used in paint formulation synthesis and partially synthesis dryings oils. They undergo oxidation and polymerization on exposure to air in thin films and form a continuous coating free from tackiness. Oils containing conjugated double bonds can dry more quickly than those which contain non-

conjugated bonds and yield hard water resistance film. Drying oils may be subdivided into yellowing and non-yellowing oils according to the tint which they take on exposure to atmospheric or elevated temperature.

Important non-conjugated yellowing oils are linseed, perilla and fish oils. They are composed of mixed glycerides of linoleic and linolenic acid. Linseed oil is extensively employed in the paint and varnish industry.

Non-yellowing natural oils include soyabean, tobacco seed and sunflower oils. They are virtually free from linolenic acid but rich in linoleic acid. They are more slowing drying than linseed oil and are generally used in combination with tung, linseed or perilla oils.

Castor oil, basically a non-drying oil is used in the paints, varnish and lacquer industry after dehydration at 350°-400°F.

Drying oils are processed to enhance their drying rate, water resistance, color retentivity, etc. Raw oils are refined after treatment with alkali or acid to prevent them from breaking up (depositing sediment) at high temperature and at the same time to improve color retention properties.

The bulk of drying oils used in the form of 'bodies' (thickened by heat polymerization at 250°-325°F in an inert atmosphere with or without catalyst), or blown (oxidized by blowing air). The blown is made by dissolving the drier in oils with little or no heating. They possess satisfactory drying, wetting and color retention properties.

High polymer resins are used along with drying oils in the formulation of coating compositions. They react with drying oils when heated and form copolymers which enhance the drying rate and improve hardness, gloss and durability of films.

Metallic soap, the driers, are incorporated in compositions to serve as oxidation and polymerization catalysts and speed up solidification and drying. The driers in common use are salts of lead, cobalt, manganese, zinc, calcium, and iron with polythenoid fatty acid, rosin acids, naphthenic acid, and octoic acid. (Anon,1965)

The usual driers are salts of metal with a valence of two or greater and unsaturated organic acids. The approximate order of effectiveness of the more common metals is cobalt, manganese, lead, Chromium, iron, nickel, uranium and zinc. They are usually prepared as the linoleates, naphthenates and resinates of the metals. Paste driers are commonly the metal salts as acetate, borates or oxalate dispersed in a dry oil. (Gessner G.Hawely, 1981)

Driers of naphthenates and octoates are more stable than linoleates, and resinate. Thinner is employed for adjusting the consistency of coating formulations. Turpentine was formerly used as thinner for resin and oil coatings.

Surface active agents are used for improving the dispersion of pigments and for promoting emulsifying, levelling, and spreading properties of coating composition. Organic chemicals commonly employed for this purpose may be classified into cationic, non-ionic, and anionic agents. They improve moisture resistance, adhesion, and anti-corrosive properties of paints. The cationic agents include salts of amines. The non-ionic surface active agents are esters of fatty acids containing 12-18 carbon atoms, such as lauric, oleic or steric acid. The anionic surface active agents include metallic soaps. (Anon, 1965)

3. Materials and Methods

3.1 Materials

Thitsi samples were collected from Moenai (Shan State), Kawlin and Pyinmana during the period of April to June, Year 2000.

The following materials were used for testing.

1. Soxhlet apparatus
2. Bamboo sheets
3. IR spectrometer
4. Oven
5. Thitsi (resin from *Melanorrhoea usitata* Wall.)
6. Castor oil
7. Lead acetate
8. 70% linoleic acid
9. Naphthenic acid

The following methods were used for determination of purified Thitsi (Thitsiol) from Thitsi.

3.2 Methods

3.2.1 Determination of Purified Thitsi (Thitsiol) from Thitsi (*Melanorrhoea usitata* Wall.)

Method I

The percentage of thitsiol in thitsi was determined by distillation method. About 10 g of thitsi was accurately weighted in a porous thimble and placed in the soxhlet apparatus. The extraction carried out on with 100 cm³ ethanol until the mixture was clear. After the extraction the alcoholic extract was distilled, dried at 105°C and weighted. Brownish paste-like thitsiol was obtained.

Method II

The percentage of thitsiol in thitsi was determined by distillation method. About 10 g of thitsi was accurately weighted in a porous thimble and placed in the soxhlet apparatus. The extraction carried out on with 100 cm³ pet ether until the mixture was clear. After the extraction the extract was distilled, dried at 105°C and weighted. Brownish paste-like thitsiol was obtained.

3.2.2 Infrared Spectroscopy Studies on Thitsiol

For the infrared spectroscopy, the sample of thitsil obtained from thitsi (Moenai, Kawlin, Pyinmana) were sent to Myanmar Scientific and Technological Research Department, Yangon. The samples were determined by Fourier Transform Infrared Spectrometer in September, Year 2000.

3.2.3 Determination of Drying Time

After the purification, thitsiol and thitsi samples were mixed with drying agents such as dehydrated castor oil, lead naphthenate and lead linoleate. The samples were tested as follows:

Method I

About 0.5 g of thitsiol (Moenai, Kawlin, Pyinmana) was mixed with 0.1 g of dehydrated castor oil and 1drop of terpentine. The mixture was heated at 100°C.

Method II

About 0.5 g of thitsiol (Moenai, Kawlin, Pyinmana) was mixed with 0.1 g of lead naphthenates and 1drop of terpentine. The mixture was heated at 100°C.

Method III

About 0.5 g of thitsiol (Moenai, Kawlin, Pyinmana) was mixed with 0.1 g of lead linoleate and 1drop of terpentine. The mixture was heated at 100°C.

Method IV

About 0.5 g of thitsi (Moenai, Kawlin, Pyinmana) was mixed with 0.1 g of dehydrated castor oil and 1drop of terpentine. The mixture was heated at 100°C.

Method V

About 0.5 g of thitsi (Moenai, Kawlin, Pyinmana) was mixed with 0.1 g of lead naphthenates and 1drop of terpentine. The mixture was heated at 100°C.

Method VI

About 0.5 g of thitsi (Moenai, Kawlin, Pyinmana) was mixed with 0.1 g of lead linoleate and 1drop of terpentine. The mixture was heated at 100°C.

Method VII

About 0.5 g of thitsi (Moenai, Kawlin, Pyinmana) was mixed with 1drop of terpentine. The mixture was heated at 100°C.

The lacquering process

The above mixtures (from Method I, II, III, IV, V, VI, VII) were painted on clean bamboo sheet with a brush to form a thin layer of uniform coating, the weight of which must have 0.06 g/in². The sheet was tested for different condition of (1)underglound cellar of relative humidity 80% and (2) in oven at 100°C. The specium was said to be dried if no tackness was left by a finger when press on the lacquered surface.

4. Results and Discussions

The percentage of thitsiol from different location are summarized in Table 2.

Table 2. The percentage of thitsiol in thitsi (*Melanorrhoea usisita* Wall.)

Sr.No	Provenances	Thitsiol %	
		extract with ethanol	extract with pet ether
1	Moenai	91.36	95.90
2	Kawlin	89.50	91.43
3	Pyinmana	69.14	72.03

It was found that the highest thitsiol content are from Moenai and the lowest are from Pyinmana. The quality of thitsi are depended on the concentration of thitsiol. The data of thitsiol content showed that, the first class thitsi are from Moenai, the second class thitsi are from Kawin and the third class are from Pyinmana. When the thitsiol was extracted, extractive with pet ether was more effective than extractive with ethanol.

The result of drying time are shown in table 3 and 4.

Table 3. Drying time of thitsiol in different conditions.

Sr.No	Method	underground cellar			Oven at 100°C (hour)		
		Moenai (weeks)	Kawlin (weeks)	Pyinmana (weeks)	Moenai (hour)	Kawlin (hour)	Pyinmana (hour)
1	I	*	*	*	8:20	8:20	
2	II	2	2	2	3:05	3:30	
3	III	2	2	2	3:00	3:05	

* not dried

Table 4. Drying time of natural thitsi in different conditions.

Sr.No	Method	underground cellar			Oven at 100°C		
		Moenai	Kawlin	Pyinmana	Moenai (hour)	Kawlin (hour)	Pyinmana (hour)
1	IV	*	*	*	8:30	8:30	9:00
2	V	2week	2week	2week	3:05	3:35	5:20
3	VI	2week	2week	2week	3:05	3:05	5:20
4	VII	4 day	4 day	4 day	*	*	*

* not dried.

In table 3 and 4, drying time of thitsiol in 3 different condition and drying time of natural thitsi in 4 different condition are summarized. It showed that drying in oven at 100°C was better than drying in underground cellar.

The result of oven dry condition for thitsi and thitsiol are very similar in Table 3 and 4. Method I, II, III, IV, V, VI and VII showed that drying in underground cellar for thitsiol was not effected.

The infrared spectrum obtained were shown in Figure 1, 2 and 3.

The band at $3500\text{--}3300\text{ cm}^{-1}$ corresponds the stretching frequency of the phenolic – OH group. (νOH)

The band at $3100\text{--}3000\text{ cm}^{-1}$ represents the stretching frequency of the phenolic – CH group. (νCH)

The band at 1495 cm^{-1} , 1463 cm^{-1} , are the typical stretching frequency of the C=C groups of the aromatic system and the sidechain of thitsiol. ($\nu\text{C}=\text{C}$)

The band at 1328 cm^{-1} , 1279 cm^{-1} , and 1188 cm^{-1} are the stretching frequency of the C-OH groups. ($\nu\text{C-O}$)

The band at 732 cm^{-1} and 698 cm^{-1} are the typical out of plane bending frequency of the CH groups of aromatic system and the unsaturated side chain of thitsiol. (δCH)

5. Conclusions

The quality of the product largely depends upon the quality of raw materials used for its production. The black thitsi, the best quality thitsi of *Melanorrhoea usitata* from Moenai contains a high percentage of thitsiol which could be extracted with pet ether.

Thitsi serves as a natural form of lacquer because of its excellent spreadibility in painting. Thitsi film, when coated on an article, has elegant charm and indoor weather ability. However, one of the salient features of thitsi shows that when dried in the presence of moisture, it attains maximum hardness. The dried films of thitsi, despite the well-knit and highly cross linked structure, is both flexible and rigid, having high frictional resistance. But the lacquerware product takes about 3 months to season. The main factor is being the slow process of a thitsi coating to dry and become hardened.

Comparison of drying time in oven at 100°C for natural thitsi and thitsiol are almost the same. Thitsiol was no effective in underground cellar. It should be suggested that thitsi and thitsiol should be dried in oven at 100°C for the commercial scale production.

Peak Report

File: C:\FIRST\TMP\POL2.RAS

Title: sample for Thitsay 1 J.806

Filter: Three Point Center of Gravity

cm-1	%T	cm-1	%T	cm-1	%T
413.03	0.12	425.29	0.07	444.74	0.07
468.89	0.10	2853.32	16.50	2924.52	14.04
3390.90	19.31	3399.23	19.33	3410.35	19.33
3416.57	19.32	3427.68	19.37	3453.63	19.56

WinFIRST Report

Name of owner: Daw Khin May Lwin

Sample: Thitsay 1 J.806

Comments : Film

Operator: Daw Khin Aye Than&Myint Myint Khine

Figure 1. Infrared spectrum of thitsol from Moenai



Peak Report

File: c:\first\lmp\pol3.ras

Title: sample for Thitsay2

Filter: Three Point Center of Gravity

cm-1	%T	cm-1	%T	cm-1	%T
408.28	0.06	417.08	0.05	436.79	0.05
452.20	0.06	465.09	0.06	698.43	4.88
731.99	5.94	1188.90	2.73	1279.57	0.88
1328.67	4.51	1351.16	4.23	1454.71	1.74
1463.84	1.59	1495.23	6.37	1598.19	9.10
2855.24	0.83	2925.96	0.29	3008.71	8.61
3000.72	2.73	3412.50	2.73	3435.55	2.68
3629.90	2.83				

WinFIRST Report

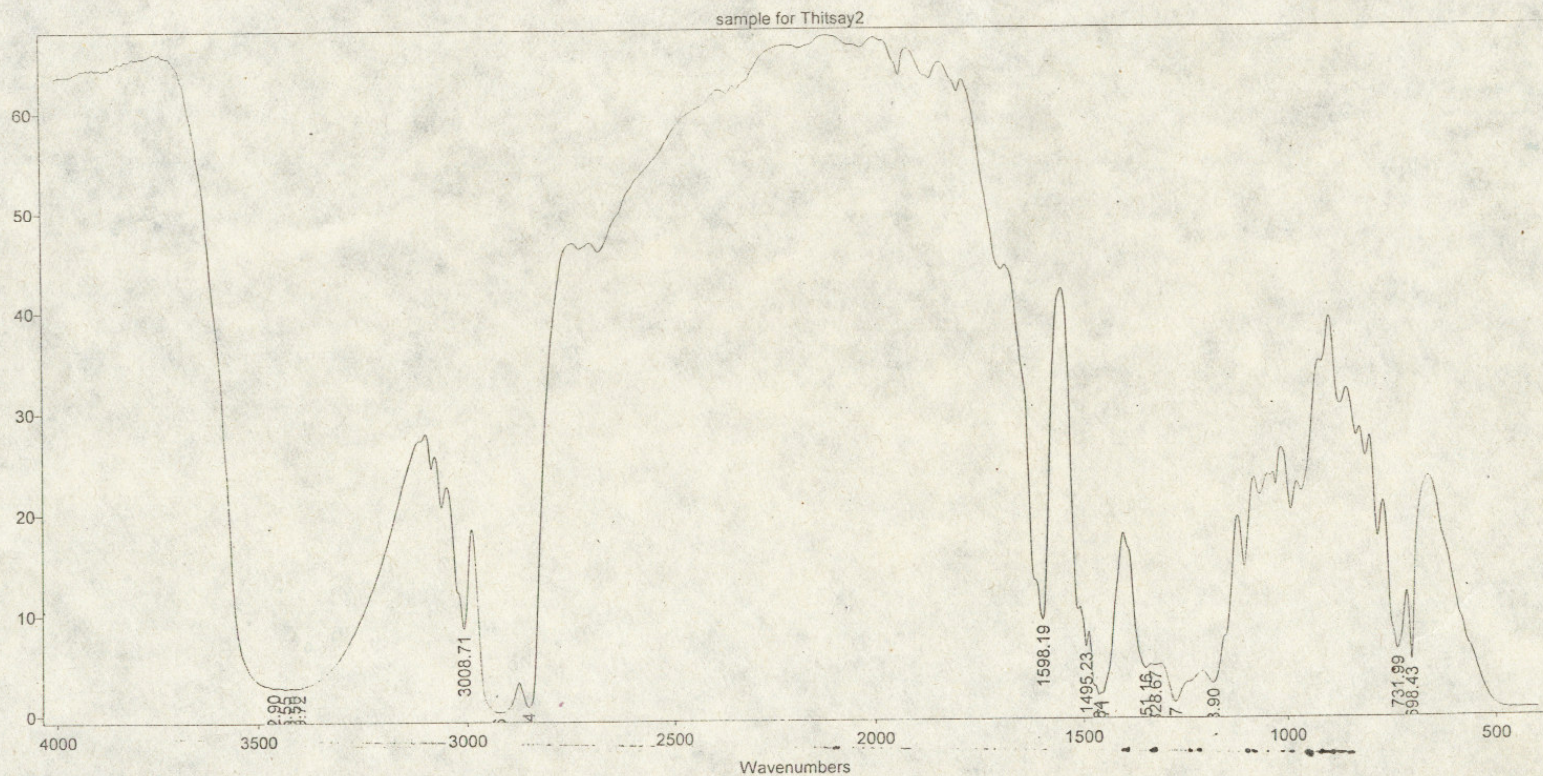
Name of owner: Daw Khin May Lwin

Sample: Thit say2 J.807

Comments : Film

Operator: Daw Khin Aye Than&Myint Myint Khine

Figure 2 Infrared spectrum of thitsol from Kawlin



WinFIRST Report
 Name of owner: Daw Khin May Lwin
 Sample: Thitsay3 J.808
 Comments : Film
 Operator: Daw Khin Aye Than&Myint Myint Khine

Peak Report
 File: c:\first\mpool4.ras
 Title: sample for Thitsay3
 Filter: Three Point Center of Gravity

cm-1	%T	cm-1	%T	cm-1	%T
424.44	0.04	444.97	0.03	468.56	0.08
698.43	5.39	732.12	6.91	1189.55	3.24
1279.76	1.15	1328.76	5.04	1351.02	4.71
1454.83	1.97	1463.25	1.87	1495.32	7.08
2855.07	1.05	2923.70	0.41	3008.83	10.34
3399.64	3.37	3410.87	3.36	3433.86	3.28
3465.21	3.42				

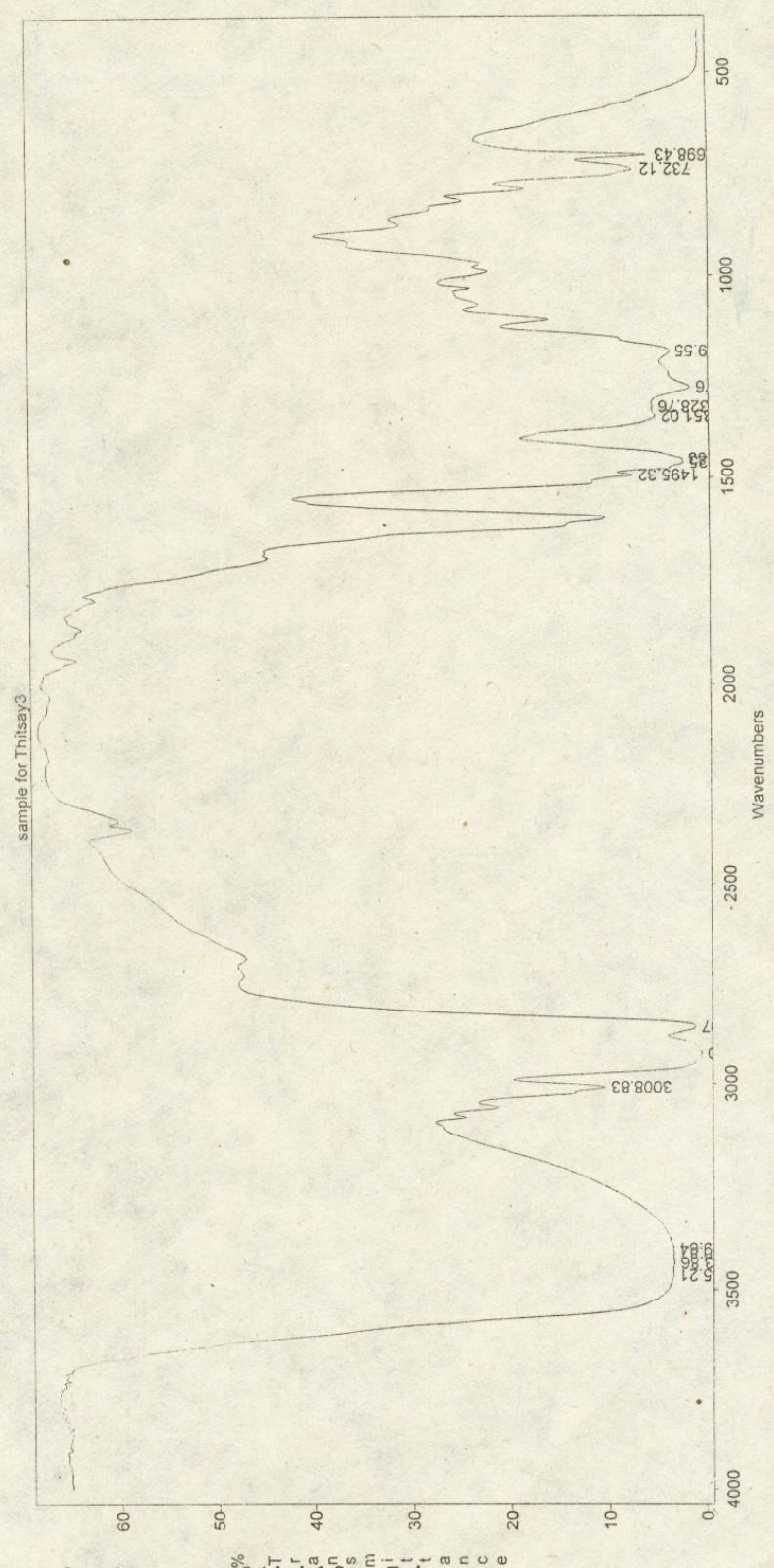


Figure. 3. Infrared spectrum of thitsiol from Pyinmana.

References

1. Anon, (1965), The Concil of Scientific&Industrial Research, The Wealth of India, "Industrial Products", Part VI, New Delhi.
2. Anon, (1996), "Forest Bulletin", Forest Department, Myanmar, November.
3. Albert Hill, F. (1976), "Economic Botany", Harvest University.
4. Albert Hill, F. (1981), "A text book of Useful Plants and Plants Products".
5. Aung Myint, Tin Hla, Tin Lay & Myint Thein, (1976), Burma Thitsi, Research and Training Circle, Paper No.2/66-67.
6. Gessner G.Hawely,(1981), "The Condensed Chemical Dictionary 10th edition.
7. Hannah R.W and Swinehart J.S., (1974), "Experiments in Techniques of Infrared Spectroscopy".
8. Hixon, A.W and Zai-Ziang Zee, (1962), "Chem. Abstr", Vol-20.
9. Hundlery, H.G. (1960), "The Burester Forester, Thitsi", Vol.10, No.2.
10. Kirt and Basu, (1960), "The Burmese Forester, Thitso", Vol 10, No.2.
11. Kyaw Tint and Tun Hla, (1991), "Forest Cover of Myanmar", Forest Department.
12. Myint Myint Sein,(1983), " Studies on the Chemical Constituents of Thitsi (Part I), Mandalay University.
13. Norris Shreve, R. (1906), "The Chemical Process Industry"
14. Puran Sing, (1908), "The Indian Forest Records", Vol 1, Part IV.
15. Rosenthal, (1962), "Chem. Abstr.", Vol 8.
16. Sir David Brewster, (1908), "The Indian Forest Records", Vol 1, Part IV.
17. Toyama, (1964), "Chem. Abstr", Vol 60.
18. Yoshida, H. (1883), "Journal of the Chemical Society" Vol XLIII.
19. Yu Thein, (1999), "Myanmar Lacquerware Techniques", International Congress of East Asian and European Lacquer Techniques"