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Study on Effective Treatment for Production of "Teak Oil" (Teak Varnish) from Tung Oil

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တန်းဆီမှ ကျွန်းဆီအဖြစ်စမ်းသပ်ထုတ်လုပ်ရန်အတွက် အကျိုးသက်ရောက်သောစမ်းသပ်မှုဖြင့် လေ့လာခြင်း

သီတာချို၊ သုတေသနလက်ထောက်-၂
ခင်မေလွင် ၊ သုတေသနအရာရှိ
စုမြင့်သန်း၊ သုတေသနလက်ထောက်-၂
သစ်တောသုတေသနဌာန၊ ရေဆင်း။

စာတမ်းအကျဉ်း

တန်းဆီပင်များသည် စီးပွားရေးအရအရေးပါသော စက်မှုကုန်ကြမ်းပင်များဖြစ်ပါသည်။ တန်းဆီပင်၏ အဆံမှ ဈေးကွက်ဝင် အဖိုးတန် သဘာဝအခြောက်မြန်ဆီတစ်မျိုး ထွက်ရှိပါသည်။ အခြောက်မြန်ရခြင်းမှာ မပြည်ဝသော ဆီမော်လီကျူးတွင် ပါဝင်သည့် နှစ်ထပ်စည်းများကြောင့်ဖြစ်ပါသည်။ အဆိုပါ နှစ်ထပ်စည်းများသည် လေထဲရှိ အောက်ဆီဂျင်အားဖြင့်ပြုကွဲ၍ ပါအောက်ဆိုဒ်များ အဖြစ် ပြောင်းနိုင်ပါသည်။ ဆီတွင်ပါဝင်သောနှစ်ထပ်စည်း အရေအတွက် (ဆီ၏မပြည့်ဝမှု) ကိုအိုင်အိုဒင်းထည့်၍ စမ်းသပ်ခြင်းဖြင့် သိနိုင်ပါသည်။ ဆီ(၁၀၀) မီလီလီတာ စုပ်ယူသော အိုင်အိုဒင်းဂရမ် အရေအတွက်သည် အိုင်အိုဒင်း တန်းဖိုး(အိုင်အိုဒင်းအရေအတွက်) ဖြစ်ပါသည်။ နှစ်ထပ်စည်း ပါဝင်မှုများသော ဆီများသည် မပြည့်ဝဆီဖြစ်မှုပိုကာ အခြောက်မြန်၍ အိုင်အိုဒင်းတန်ဖိုးမြင့်ပါသည်။ ယေဘူယျအားဖြင့် အိုင်အိုဒင်းတန်ဖိုးမြင့်သော အခြောက်မြန်ဆီများသည် သုတ်ဆေးနှင့် အခြားသောအရောင်တင်သစ်ကြာရှည်ခံဆေးများအဖြစ် သုံးစွဲရန် သင့်လျော်၍ အိုင်အိုဒင်း တန်ဖိုးနိမ့်သောဆီများသည် ဇီဝဒီဇယ် ပြုလုပ်ရန် သင့်လျော်ပါသည်။ယခုစာတမ်းတွင် *A.moluccana* နှင့် *A.montana* တန်းဆီ(၂)မျိုး၏ အိုင်အိုဒင်း တန်ဖိုးများနှင့် ၄င်းဆီများနှင့် ကြက်ဆူဆီတာပင်တိုင် ရောသောအခါ ရရှိသော အိုင်အိုဒင်း တန်ဖိုးများကို သုတေသနပြု စမ်းသပ်လေ့လာထားပါသည်။ ရရှိသော အိုင်အိုဒင်းတန်ဖိုးများကို နှိုင်းယှဉ်သောအခါ *A. moluccana* တန်းဆီမှ တန်ဖိုးမြင့်သစ်အရောင်တင်ဆေး (ကျွန်းဆီအဖြစ်) ထုတ်ယူရန် အကောင်းဆုံးဖြစ်ကြောင်းတွေ့ရှိရပါသည်။

Study on Effective Treatment for Production of "Teak oil" (Teak varnish) from Tung oil

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Abstract

Tung oil trees are economically important industrial raw plants. Its nuts yield marketable, valuable drying natural oils. Drying results from the double bonds in the unsaturated oil molecules being broken by atmospheric oxygen and being converted to peroxide. How many double bonds it has (how unsaturated it is) iodine is introduced to the oil. The amount of iodine in grams absorbed per 100ml of oil is then the iodine value. The greater the number of double bonds in the oil, the higher the iodine value, the more unsaturated and the higher is the potential for the oil to dry (polymerize). Generally, high iodine value oils are suitable as the base of paints and other wood preservative coating and low iodine value oils are suitable as the bio-diesel.

This paper is analyzed by testing Iodine Values (IVs) of *A.moluccana* and *A.montana* tung oils and the mixture of these two oils, castor oil and turpentine treated under the same conditions. When compared to (IVs) of each other, *A.moluccana* tung oil gave the best result to extract value-added wood finish product as 'Teak oil".

Keywords: Tung oil**,** Iodine Value, treatment, *A.moluccana, A.montana,* Teak oil

Contents

1. Introduction

Tung oil trees belong to the *Euphorbiaceae family, Genus Aleurities and* it has (9) species. In Myanmar, four kinds of Genus Aleurites (*A.moluccana, A.montana, A.fordii, A.cordata*) can be found naturally in Shan state. Generally, it can grow from the forest of (tropical very dry to dry forest) to (subtropical dry to moist forest). Tung tree survives the absolute maximum shades temperature ranging from (18.7) to (26.2) °C and the normal rainfall from 750 to 2000mm. It occurs from 2500 to 3500ft above sea level and a soil pH ranging from 5.4 to 7.1. It can easily grown in a loamy soil but the plant are unable to withstand must frost.

In Myanmar, five companies started plantations on a commercial scale and, by 1939, the estimated acreage under Aleurites was 10,000 acres at northern Shan state. But, being destructive of the World War Π, the little plantations are leaving now in Myanmar. Under the guidance of the state, tung trees (15555) acres have been cultivated everywhere in Myanmar from 2000 to2006. As the market-oriented economic become well, many plantations should be established and also its economically important natural oil should be produced not only use enough inside the country but also export to abroad.

Tung oil is produced from the seed kernels of the tung oil tree for a variety of purpose including usage in paints, varnishes and wood finishes. Tung oil has been used for centuries to preserve and beautify teak wood. In local market, tung oil and polymers are well known as "Teak oil' because it not only seal and protect but also remove dirt and stains from teak and other fine woods. "Teak oil" is a unique formulation based on tung oil and polymers to provide long lasting protection for teak surface. It penetrates deep into the pores of wood to strengthen the wood fibers. It gives teak a natural warm golden color as well. Tung oil also finds use in the manufacture of lacquers, varnishes, paints, linoleum, oilcloths, resins, artificial leather, felt-base floor, coverings greases, brake-linings and in clearing and polishing compounds. It is applied to coat containers for food beverages, and medicines; for insulating wires and other metallic surface, as in radio, telephone and telegraph instruments.

But, tung oil has not yet utilized widely in Myanmar. In modern times, it received wide application as an ingredient in paint, varnish, and caulk; as a wood finish for furniture and other wooden objects in other country. In Myanmar, finishing materials are imported from abroad until now. If the import materials are replaced by the value added tung oil finish, the economic development of the country will also of great help from the non wood forest product sector.

Thus, with the objective of the production of the better quality value added finishing material from *A.moluccana* or *A.montana* tung oil species as "Teak oil" for wood based products by comparing iodine value of each oil are intended to be investigated.

2. Literature Review

Tung oil is a wood finishing product that protects wood from accidental spills and water marks. Tung oil's ability to dry quickly and polymerize into a tough, glossy, water-proof coating has made it is especially valuable in paints, varnish, linoleum, oil cloth and printing inks. The largest application for oil is paint and varnish, and also wide utilized by soap, ink, electrical insulators, furniture, ship-buildings, etc(James A.Duke.1983). It is manufactured by pressing the tung nut, no petroleum distillates or other additives. It will

offer superior color, faster drying term elastic finish. Elasticity is an important factor as the oil must continue the expansion and contraction of the substrate on which it is applied (Donald Newell-vol-1-4th edition). Tung oil is easy to work with and protects by penetrating deeply the wood surface, leaving no streaking or brush marks. It gives a protective barrier against water, stains, abrasions and wear. Tung oil will not darken with age as other finish, and tung oil finish dries clear to allow the wood natural beauty to come through. The look is natural, hand-rubbed classic; perfect for fine furniture (W. Gordon Rose, A.F. Freeman, and R.S. Mckinney).

The thin, transparent oil penetrates deep into wood pores, forming an almost permanent seal against moisture because it never loses its elasticity and it is very resistant to weathering. For centuries tung oil has been used for paints and waterproof coatings. It is the world's oldest and best wood preservative and woodworkers consider it to be one of the best natural finishes for wood.

Tung oil undergoes oxidation and polymerization on exposure to air in thin films and forms a continuous coating free from tackiness. Drying oils of vegetable or animal origin are extensively used in paint formulation synthesis and partially synthesis drying oils. Steven D.Russell defined drying oils as liquid vegetable oils that will dry in the air to form a solid film. This drying is a result of polymerization by the action of atmospheric oxygen. The resultant film formed is typically hard, non-melting and usually insoluble in organic solvents. The fatty non-conjugated oils, such as linseed oil, contain polyunsaturated fatty acids, whose double bonds are separated by at least two single bonds. Conjugated oils, such as tung oil, are polyunsaturated fatty acids, whose double bonds are partly or fully conjugated.

He also reported that the place of cultivation and climate can alter the fatty acid spectrum of a drying oil. Conjugated tung oil is more reactive than non-conjugated linseed oil. Also conjugated double bonds favor polymerization and oxidation. These conjugated double bonds dry more rapidly than non-conjugated oils. The resultant film gives a high resistance to yellowing and increased resistance to water and alkalis.

The drying of the film typically progress in three overlapping steps:

1. Induction – through a process, the oxygen uptake steadily increases. Factors such as temperature, light and heavy metals/inhibitors in the oil, affect the overall uptake rate.
2. Initiation – as the film continues to take up oxygen, its mass increases. The double bonds in the film begin to rearrange and polar groups develop in the film. This leads to the association of molecules through forces.
3. Cross-Linking – as the number of double bonds in the film begin to diminish, larger molecules form and volatile and non-volatile compounds are generated.

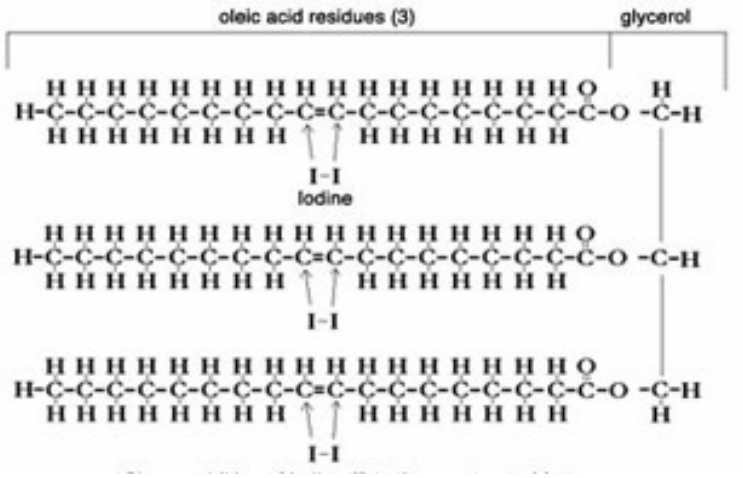
The principal drying component in tung oil is eleostearic acid (75-80%) with smaller amount of oleic (15%), linoleic acid (8.5%), palmitic (4%) and stearic acid (1%). Tannins, phytosterols, and poisonous saponin are also reported. Eleostearic acid is a crystalline unsaturated fatty acid that exists in 2 stereoisomeric forms: An alpha acid occurring as the glycerol ester especially in tung oil, and a beta acid obtained from the alpha acid by irradiation (W. Gordon rose, A.F. Freeman, and R.S. Mckinney).

The chemical structure of tung oil eleosteric acid is

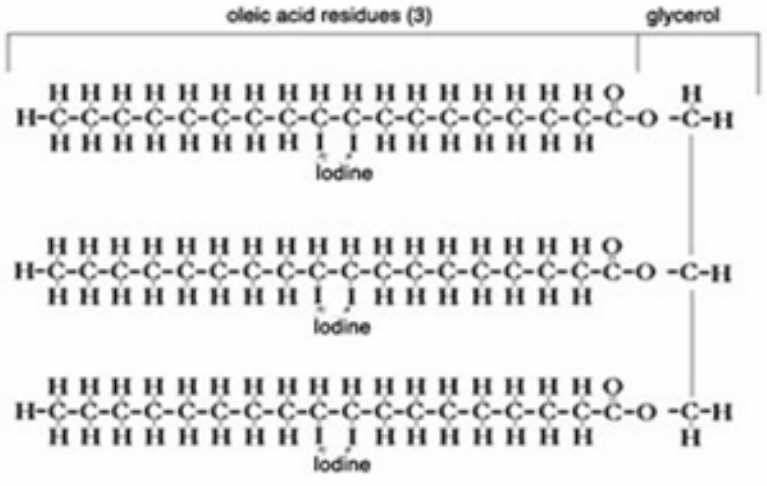
$$CH_2 – (CH_2)_3 –CH = CH – CH = CH – CH = CH – (CH_2)_7 – COOH.$$

Tung oil dries exceptionally well, not only due to the high percentage of a triple unsaturated acid, but also due to the fact that these bonds happen to be arranged in a conjugated position. The drying of it results from the double bonds in the unsaturated oil molecules being broken by atmospheric oxygen. Then, these oil molecules converted to peroxide and cross-linking occur at this site. Chemically, vegetable oils and fats contain a glycerol molecule bonded to three fatty acid chains. This structure can also be called a triester or triglyceride. The degree of saturation (How many doubles have in the oil) is indicated by the Iodine Value (IV) of the oil. (IV) Can be determined by adding the iodine to the oil (Phillip Calais, www.shoetcircuit.com).

Before iodine is added, the fatty acid chains of the oil molecule have been unsaturated with the double bond as shown in the structure.



After the addition of iodine, it has been saturated with iodine as shown in the structure and there are no more double bonds between carbons.



The amount of iodine in grams absorbed per 100ml of the oil is then the iodine value. The higher the iodine value, the greater the number of double bonds in the oil and

the higher is the potential for the oil to polymerize (dry). High iodine value oils are more unsaturated with more double bonds.

More recently, tung oil has gained favor over other vegetable oils for furniture finishing because it is faster drying and does not darken as much with age and also resists abrasion, acids and alkalis (Donald Newell-vol-1-4th edition).

Advantages of Tung oil finish (Teak oil)

- Naturally polymerizing finish
- Cures by oxidation not evaporation
- Does not form a glossy finish no matter the number of coats
- Form a flexible water proof finish
- Resist abrasion and acids
- Does not blister and peel (properly applied)
- Does not mold like linseed oil
- Long shelf life
- Does not darken with time like linseed oil
- Concentrated (thin one to one, doubles the coverage)
- Zero VOC's
- Combined with "Citrus Solvent" makes an all natural finish
- FDA approved for food contact (Donald Newell-vol-1-4th edition).

Properties and Characteristic of Tung Oil finish

-Tung oil finish will not darken with other finish will.
-It resists marring, penetrates well, and remains elastic and unlikely to check.
-Tung oil builds quickly, consolidates the wood surface and builds a transparent malte finish .
-Tung oil will not mildew or bleed like linseed oil when dry which makes it an excellent candidate for outdoor finishes.
-It should be kept in an airtight container with minimum air space (Donald Newell-vol-1-4th edition).

3. Material and Methods

3.1 Materials

A.moluccana and *A.montana* seeds were collected from Lashio and Heho townships of Shan state. The following materials were used for testing.

1. Soxhlet apparatus
2. Oven
3. Tung Oil
4. Castor oil
5. Terpentine
6. Iodine trichloride
7. Potassium chloride
8. Sodium thiosulphate

9. Mercuric iodide
10. Starch
11. Buret

The following methods were used for determination of purified tung oil from the tung kernels.

3.2 Methods

3.2.1 Method I

Extraction of purified tung oils (*A.moluccana* or *A.montana*) by using hot water.

Tung seeds were washed with water, air-dried and some of low quality seeds were removed. Then, the nut shells were hulled by using a hammer and the kernels were ground by motor and pestle.

After the grinding, hot water was introduced into the ground kernels and stirred homogenously. This mixture was filtered with strainer until it became low viscosity. Then, the filtrate was cooked on the stove to get crude oil. After cooking, crude oil was placed in the oven at 75ć for fives days.When the color of the oil become clear, pure tung oil was obtained.

3.2.2 Method II

Extraction of purified tung oils (*A.moluccana* or *A.montana*) by using petroleum ether.

Tung seeds were washed with water, air-dried and some of low quality seeds were removed. Then, the nut shells were hulled and the kernels were ground by motor and pistol.

After the grinding, the ground kernels were put into the porous thimble and placed in the soxhlet apparatus. The extraction carried out on with 500ml petroleum ether until the mixture was clear. After the extraction the extract was distilled and dried at 75c·. When the color of the oil became clear pure tung oil was obtained.

3.2.3 Beta Tung oil test

For the precipitated condition of the oils, owing to the conversion of the alpha-eleosteric acid into higher melting beta form, the sample of the oils obtained from the above two methods of extractions' were preliminarily analyzed by Beta Tung oil test.

3.2.4 Determination of oil contents

For the oil contents, *A.moluccana* and *A.montana* tung oil samples extracted by hot water were selected. Then, oil yields% of each was compared.

3.2.5 Determination of chemical and physical characteristics

The chemical and physical characteristics such as Specific gravity, Refractive index, Iodine Value, Saponification Value, Free fatty acid (%), Moisture (%) and Color of *A.moluccana* and *A.montana* tung oil samples extracted by hot water were tested. After the testing, the chemical and physical characteristics of each were compared with the standard properties of oil.

3.2.6 Determination of Iodine value (IV)

After the purification, purified tung oil samples' iodine values were tested. 0.1gms of *A.moluccana* oil was added into the mixture of 15ml of carbon tetrachloride and 25ml of Wijj's solution. The mixture was allowed to stand for 30minutes in the dark at room temperature. Now, 100ml of potassium iodide solution was introduced in this mixture and titrated with 0.1N sodium thiosulphate solution using starch solution as indicator. After titration, (IV) of oil was calculated Then, these oil samples were mixed with dehydrated castor oil and turpentine by the following ratio (table). The iodine value of each samples were also tested for each treatments.

Table 1. Different treatment for making finish from A.moluccana tung oil

Sr. No.	Methods	Treatment
1	I	*A. moluccana* oil (0.1g)
2	II	*A. moluccana* oil (0.1g) + turpentine (1 drop)
3	III	*A. moluccana* oil (0.1g) + caster oil (0.1g)
4	IV	*A. moluccana* oil (0.1g) + caster oil (0.1g) + turpentine (1drop)

Table 2. Different treatment for making finish from A.montana tung oil

Sr. No.	Methods	Treatment
1	V	*A.montana* oil (0.1g)
2	VI	*A.montana* oil (0.1g) + turpentine (1 drop)
3	VII	*A.montana* oil (0.1g) + caster oil (0.1g)
4	VIII	*A.montana* oil (0.1g) + caster oil (0.1g) + turpentine (1 drop)

4. Results and Discussions

The results of Beta tung oil tests are shown in table-3.

Table 3. Beta tung oil tests of *A.moluccana and A.montana*.

Sr. No	Name	Extraction	Beta Tung oil test
1.	*A.moluccana*	By hot water	No crystalline precipitate
2.	*A.moluccana*	By petroleum ether	Crystalline precipitate
3.	*A.montana*	By hot water	No crystalline precipitate
4.	*A.montana*	By petroleum ether	Crystalline precipitate

According to Beta Tung oil test's results, the method of extraction of oils by using petroleum ether gave crystalline precipitate. Oils extracted by petroleum ether also take a little longer time for jelation in the heat test. Otherwise, as this method of extraction necessary to use chemicals, its cost higher than by the hot water extraction.

When the tung oil was extracted, extractive with hot water was more effective than extractive with petroleum ether. Thus, only the oils which were extracted by hot water was applied for this research.

Oil contents from *A.moluccana* and *A.montana* tung kernels are described in table- 4

Table 4. The Oil contents from *A.moluccana* and *A.montana* tung kernels

Sr.No	Name	Methods of extraction	Oil contents
1.	*A moluccana*	hot water	43%
2.	*A.montana*	hot water	26%

It was found that the oil yield of *A.moluccana* is higher than *A.montana*. When the oil was extracted on a large commercial scale, *A.moluccana* was more effective than *A. montana*.

The chemical and physical characteristics of tung oils are shown in table- 5

Table 5. The chemical and physical characteristics of tung oils

Sr. No	Properties	Grade 1	Export grade	A.moluccana (extract by hot water)	A.montana (extract by hot water)
1.	Specific gravity	0.9360-0.9395	0.9360-0.9395	0.9079	0.9174
2.	Iodine Value	163	163-173	144	137
3.	Saponification Value	190-195	190-195	190	182
4.	Free fatty acid (%)	3	4	2.13	2.5
5.	Moisture (%)	0.1	0.5	0.1	0.2
6.	Color	Yellow35; Red 5	Transparent	Pale yellow	yellow

It was found that the chemical and physical characteristics of *A.moluccana* and *A.montana* tung oils are nearly similar to that of Grade 1 and Export grade. Depend upon the (IV), the oil of *A.moluccana* was of inferior quality than *A.montana* oil.

The Iodine Values (IVs) of oils from different treatments are summarized in Table 6 and 7.

Table 6. Iodine values of *A.moluccana* oil with different treatments.

Sr No.	Methods	Iodine Value of oils
1.	I	148
2.	II	157
3.	III	200
4.	IV	206

Table 7. Iodine values of *A.montana* oil with different treatments.

Sr No.	Methods	Iodine Value of oils
1.	V	146
2.	VI	150
3.	VII	196
4.	VIII	201

By comparing Table 6 and 7, it was found that, *A.moluccana* tung oils has a slightly higher (IV) than *A.montana* tung oils treated under the same conditions. High (IV) oils are more unsaturated with more double or triple bonds and the higher the potential for the oil to dry (polymerize). Caster oil and turpentine are incorporated in composition to serve as oxidation and polymerization catalysts and accelerate the drying process. Drying results from the double bonds in the unsaturated oil molecule. Thus, high (IV) oils suitable as the base of wood finish product, paint and other coatings. The highest IV was found in method IV of table6. Thus *A. moluccana* oil (0.1g) + caster oil (0.1g) + turpentine (1drop) ratio is the suitable treatment for the teak oil making.

5. Conclusion

The quality of the product largely depends upon the quality of raw material used for its production. The oil of *A.moluccana* is of inferior quality. Although both of the fatty tung oils arranged in a conjugated position, *A.montana* tung oil has a slightly lower (IV) than *A.moluccana*. These indicate a somewhat lower eleostearic acid content, which is not necessarily a disadvantage in the paint and other coating industries. *A.moluccana* oil also contains chiefly of the glycerides of linolinic,linolic and oleic acids. *A.moluccana* oil, with added castor oil and turpentine gave films which were harder, more brilliant, and more highly water resistant than those given by *A.montana* oil treated under the same conditions. Thus, superior quality value-added finishing product could be extracted from the *A.moluccana* tung oil.

6. Recommendation

According to the tested properties, it can be found that the quality and oil yield of *A.moluccana* is superior to that of *A.montana.* The marketable natural oil could be produce from the A.moluccana tung nuts. The excess tung oils from Myanmar could be exported to world market if the utilization of tung oils enough inside the country. For the commercial scale production of the oil not only enough for use inside the country but also export to world market, it is suggested that more of the *A.moluccana* tung oil plantations should be systematically established in Myanmar. Thus, the foreign exchange potentially can be generated from the industrial plants products.

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