INTERNATIONAL JOURNAL OF APPLIED SCIENCE RESEARCH
FEDERAL POLYTECHNIC OKO, ANAMBRA STATE

ANALYSIS OF DRYING OIL AND LOCAL OIL BLENDS FOR PRODUCTION OF WOOD VARNISH

Benjamin Onyebuchi Udoye.

Department of Chemical Engineering, Federal Polytechnic, Oko, Anambra State, Nigeria; Email:[1]benudoye@yahoo.com, Tel: +2348065991888

And

Obele Chikwendu Nwabuonu

Department of Chemical Engineering, Federal Polytechnic, Oko, Anambra State, Nigeria; Email:[2]chikwenduobele@gmail.com, Tel: +2347030534697

Abstract

Drying oils have very wide industrial applications. Drying oils (Linseed, poppy, safflower, etc.) are vegetable oils used to modify the consistency, gloss and drying time of colour. They harden to a tough, solid film after a period of exposure to air. This work involved the harnessing of locally sourced oil blends to substitute for the imported linseed oil that will reposition our economy for self-reliance in Post Covid-19 Era. Here, five oil blends (linseed/castor, linseed/ soybean, melon/soybean, melon/castor and linseed/melon) were used in the ratio of 80:20, 60:40, 40:60 and 20:80. The solvent extraction method was used to extract oil from the locally available oil seeds (castor oil, melon and soybean). The various oil blends were each mixed with Alkyd modified resin, Pb-Co Naphthenate (Drier), and Acetone and N-butanol (solvents) to produce varnish of a homogenous nature. It was observed that melon and soybean, each blended with linseed oil, are good quality oil for varnish production. Therefore melon and soybean, each blended with 20% linseed oil are recommended for use in production of wood varnish in industries as their application will reduce the cost of using imported linseed oil, reduce health risks associated with the pandemic and also reposition the economy for self-reliance in Post Covid-19 Era.

KEYWORDS: Extraction, Distillation, Reflux, Substitution, Homogenous, etc.

Introduction

All vegetable oils contain as their main ingredient, the mixed triglycerides with mixed unsaturated fatty acyl chains. Vegetable oils also contain non-glyceride components which are generally considered undesirable for edible and chemical products. They are phosphalides, sterols, tocopherols, and fatty alcohol, hydrocarbon and colouring matters (Ikiensikimama, 1991).

Vegetable oils are divided into three classes i.e. the drying, the semi-drying and the non-drying oils which are graded according to their "iodine value". Kirk,2007, defined them as follows: Drying oils (Iodine value>140),Semi-drying oil(Iodine value 125-140) and Non-drying oils (Iodine value <125).

Drying oils are liquid oils (triglycerides) that are converted by the action of the oxygen of the air to dry, hard, insoluble resinous material or film. Actually, any spreadable liquid that reacts with oxygen of the air to form comparatively dry film would be classified as a drying oil (Kirk, 2007). These include oils found in a variety of fish, poppy, safflower, linseed etc. The saturated oils are poor drying while the unsaturated ones are better drying. The removal of poorer drying components and non-glyceride impurities improve film forming property. Semi-drying oils dry slowly and their drying ability are enhanced by driers. They are paler in colour than Linseed oil. Poppy and Safflower are in this category. Non-drying oils may never dry to form a thick film and they are completely saturated oils. The linseed oil, safflower, soybean and some other plant oils have 18-carbon chains with unsaturation at the following positions: oleic at 9, linoleic at 9 and 12, linolenic at 9, 12 and 15. Oils of the linoleic-linolenic acid type contain oleic, linolenic and linoleic acids and members of the group are generally derived from seeds of annual plants such as soybean, safflower and linseed which grow in temperate climate.

When a solid resin is dissolved in a drying oil, the resultant solution is known as "varnish" Varnish is therefore a clear liquid that solidifies as a thin film on oxidation with atmospheric oxygen. Usage of turpentine as a volatile solvent in its production was practiced in the recent centuries. Thus varnish became a combination of various proportions of resins, drying oil, volatile solvent and minor additives such as metals containing drier catalysts and antioxidants (Himadri, 2017).

Reliability and quality of a varnish can be checked using its drying time. The drying time is the time required of the varnish on application, to dry to a hard resistant film. The drying time is influenced by the environment, mostly temperature, relative humidity, circulation of air and light (Himadri, 2017). There are Set-to-touch, Talc free and Dry hard time. The set-to-touch time is the time in which the film that is formed gradually becomes more rigid that is unbroken by a slight pressure of the finger. The talc free time is that which involves the formation of a film to which dust or talcum particles do not adhere. The dry hard time is the time the film becomes relatively hard, capable of meeting with good resistance to the impact and abrasion it is likely to receive when in use. A good varnish requires about 20 minutes for a set-to-touch dry, 150 minutes for a talc free dry and 24 hours for a dry hard time dry(Osuagwu,1992).

Materials and Method

Chemicals and reagents used are;

•Alkyd resin, a binder which exposes particles of oil to oxidation.

•Pb-Naphthenate and Co-Naphthenate as driers.

•Acetone and N-Butanol for dispersion of gloss or spreadability.

•The extracted oils for gloss of varnish.

•Hexane (solvent).

These materials were used for the grinding and extraction processes, an electric blender, a manual grinder, a soxhlet extractor, a mantle heater, sheets of Whitman filter papers(18cm in D), a funnel, sample bottles, conical flasks, a round bottom flask, a continuously running pump system for cooling, a condenser, a stop watch for viscosity measurement, sample bottles to contain various sample blends, raw od melon, soybean and castor-oil seeds, a graduated cylinder and electronic balance for density measurement.

Extraction of Oil

The solvent extraction method was used for extraction of the oils. This method includes grinding, and distillation which separates the oil from the solvent. Except for the imported linseed oil bought from the market, soybean, castor and melon seeds were locally acquired.

The decorticated seeds were each ground using the electric blender for castor oil and the melon seeds while the manual grinder was used for soybean seeds because of its hard nature. The well ground samples were wrapped in the filter sheets to avoid contamination of the extracted oil during reflux operation of the apparatus. Sample of a particular variety were packed in the extractor such that a good contact with solvent was made to obtain a maximum extraction. A continuous running pump system was connected to the condenser fixed to the extractor through the top which was held with a clamp. The round bottomed flask (half filled with the solvent), on top of the mantle heater was also connected to the extractor to make a complete process. The process began with the evaporation of the solvent in the flask and its condensation on top of the extractor to form a solution of solvent and oil. The process was repeated for about four times through reflux operation, which ensured that an optimum amount of oil was collected before the equipment was dismantled. The oil-lean cake was then discharged. And for the separation of the oil from the solvent, the flask was connected to the emptied extractor. On heating the extract or solution of oil and solvent in the round-bottom flask, the solvent evaporated from oil utilizing the difference in their boiling points. The solvent recovered was reused in another batch of extraction. The oil recovered in round-bottom flask was filtered using the conical flask, filter sheet and funnel. The filtered oil was then put in the sample bottle for the varnish production. The above procedure was repeated for each of the sample seeds.

Production of Wood-Varnish

The wood-varnish was produced using the blends of the oil in the ratio 80:20, 60:40, 40:60 and 20:80. Linseed and melon were base oils while castor-oil and soybean oil, were supplementary oils. The first sample was produced using the linseed/castor-oil blend in the ratio 4:1. Production, first started by introducing 22.0ml of Alkyd resin to a beaker. While the beaker was being stirred, 2.0ml of the 4:1 blend of oil was added to it. About 0.102ml of Pb-Naphthenate and 0.01ml of Co-Naphthenate were also added to the beaker and the entire content was vigorously stirred. Lastly, 12.0ml of Acetone and 4.0ml of N-Butanol were added to the content of the beaker and stirred vigorously for 5 minutes to obtain a homogenous mixture called Wood-varnish. Subsequent samples were prepared using the same process and different ratios of all blends.

Density Measurement

The density of various blends were calculated by measuring the weight of 5.0ml of every sample with the graduated cylinder and electronic balance.

I.e, density(g/ml) = mass(g)/volume of sample(ml).

And, for the first sample(80%linseed,20%castor) in table 1 for blend 1, density(g/ml) = 5.49/5.00 = 1.098

Viscosity Measurement

The viscosity measurement was made with Ostwald viscometer shown in fig 1. This apparatus utilizes the principle that mobility of a liquid is directly dependent on its dynamic viscosity(Ikiensikimama,1991).

In this experiment, water was first introduced through the opening A, to reach the mark D by closing the opening B. On unclosing the opening B, the time it took the water to run from D to E was quickly recorded with a stopwatch. This experiment was repeated twice for each varnish blend and the average calculated and recorded.

The viscosity results in the tables were calculated with the formula below;

$z_2/z_1 = t_2d_2/t_1d_1$,

where t_1= time for water flow between D and E (1.15 second, as recorded)

t_2= time for varnish flow between D and E

d_1= density of water @ room temperature (1.12g/ml)

d_2 = density of varnish blend

z_1 = viscosity of water @ room temperature (1.0centipoise)

z_2= viscosity of varnish blend (calculated).

And, for the first sample(80%linseed,20%castor) in table 1for blend 1, the viscosity was calculated as follows;

$z_2 = z_1t_2d_2/t_1d_1$= 1.0 x 31.5 x 1.098 / (1.15 x 1.2) = 25.06centipoise.

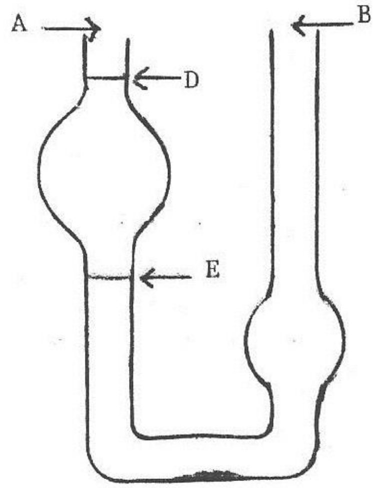

Fig 1: Ostwald Viscometer

Drying Time Measurement of Varnish

The drying time of varnish was obtained by merely observing the time it took for a sample of the varnish blend applied on a wooden material to achieve a set-to-touch, a talc free and a dry hard time dry, using a time piece. Result obtained and recorded for the first sample (80%linseed, 20% castor) in table1for blend 1 is 31minutes, 155mins, 36hours for set-to-touch, talc free and dry hard time respectively.

Results and Discussion

Results obtained are as recorded below in tables 1-5. It is observed from table 1(linseed/castor) and table 3(melon/castor) that viscosity of the blends decrease with increasing ratio of castor, which yield varnish of inappreciably lighter film. This trend is also noticed in table 4(melon/soybean) but at a slower rate, as ratios of soybean blend increase. It is also observed from table 2(linseed/soybean) that viscosity of the blends increase with increasing ratio of soybean. This is a very good property of soybean(a non base oil) because varnish of reasonably higher viscosity will yield a thicker film that will offer better protection and high gloss of a product. The trend is also noticed in table 5(linseed/melon) but with a slower rate.

It is again observed from tables 1- 5, that the drying time of various blends increase with increase in their viscosity, for their set-to-touch and talc free dry time. This is true for the experiment as higher viscosity can be likened to a thicker wet cloth which will take a longer time to dry. It is worthy of note that very high viscosity and a fast drying rate affect the flexibility of the varnish. However, the very slow effect of varnish is ameliorated and controlled by the use of calculated quantity of driers additive during production of varnish. This result would have been the same for the dry hard time if the samples of varnish applied on wood were monitored on hourly basis, which can only be possible in the day time.

Table 1: Wood varnish measured properties of linseed/castor oil blend ratios.

BLEND 1		**WOOD VARNISH PROPERTIES**						
Linseed (%)	Castor (%)	Weight (g)	Density (g/ml)	t_2 avg (s)	Viscosity (centipoise)	Set-to-touch time(min.)	Talc free time (min.)	Dry hard time (hrs.)
80	20	5.49	1.098	31.5	25.06	31	155	36
60	40	5.48	1.096	17.9	14.22	25	142	36
40	60	5.48	1.096	13.0	10.32	22	140	36
20	80	5.48	1.096	12.6	10.01	21	140	36

Table 2: Wood varnish measured properties of linseed/soybean oil blend ratios

BLEND 2		**WOOD VARNISH PROPERTIES**						
Linseed (%)	Soybean (%)	Weight (g)	Density (g/ml)	t_2 avg (s)	Viscosity (centipoise)	Set-to-touch time (min.)	Talc free time(min.)	Dry hard time (hrs)
80	20	5.47	1.094	14.0	11.2	25	130	36

60	40	5.48	1.096	17.45	13.86	28	135	36
40	60	5.48	1.096	23.29	18.50	29	150	36
20	80	5.48	1.096	35.75	28.39	33	157	36

Table 3: Wood varnish measured properties of melon/ castor oil blend ratios

BLEND 3		**WOOD VARNISH PROPERTIES**						
Melon (%)	Castor (%)	Weight (g)	Density (g/ml)	t_2 avg (s)	Viscosity (centipoise)	Set-to- touch time (min.)	Talc free time (min.)	Dry hard time (hrs.)
80	20	5.48	1.096	16.00	13.02	28	133	36
60	40	5.48	1.096	9.76	7.74	25	120	36
40	60	5.47	1.094	8.55	6.78	25	119	36
20	80	5.48	1.096	7.50	5.39	24	119	36

Table 4: Wood varnish measured properties of melon/soybean oil blend ratios

BLEND 4		**WOOD VARNISH PROPERTIES**						
Melon (%)	Soybean (%)	Weight (g)	Density (g/ml)	t_2 avg (s)	Viscosity (centipoise)	Set-to-touch time (min.)	Talc free time (min.)	Dry hard time (hrs.)
80	20	5.48	1.096	7.30	5.80	21	121	36
60	40	5.47	1.094	7.15	5.67	18	118	36
40	60	5.47	1.094	6.90	5.87	23	123	36
20	80	5.48	1.096	7.60	6.04	25	125	36

Table 5: Wood varnish measured properties of linseed/ melon oil blend ratios

BLEND 5		**WOOD VARNISH PROPERTIES**						
Linseed (%)	Melon (%)	Weight (g)	Density (g/ml)	t_2 avg (s)	Viscosity (centipoise)	Set-to-touch time (min.)	Talc free time (min.)	Dry hard time (hrs.)
80	20	5.47	1.094	7.00	5.55	19	115	36
60	40	5.48	1.096	8.25	6.55	18	121	36
40	60	5.48	1.096	7.55	6.00	24	123	36
20	80	5.48	1.096	11.50	9.13	26	127	36

Conclusion

From the analysis of the various blends of drying oils, table1, blend 1 of 80%linseed/20%castor ratio and table2, blend 2 of 20%linseed/80%soybean ratio with viscosities, 25.06 and 28.39 centipoise respectively, yield good results for a wood varnish of high gloss. But blend 2 is preferred because soybean which takes a greater part (80%) of the blend, can be sourced locally. They can also pose a problem of slow drying which can be improved with addition of more driers.

More so, tables 1 and 3 confirmed castor- oil (non-base oil) as a non-drying oil as its viscosity was observed to decrease rapidly with increase in its oil blend ratio. This justifies viscosity to be a good property for deciding a particular oil or its blends for varnish making. Tables 2 and 5 confirm that soybean and melon with linseed blends are comparatively good quality oils for wood-varnish production as their viscosity kept increasing with increasing ratio of their blends. Finally, increase in drying time of various blends was observed to be due to a high humid condition in which the drying time tests were performed.

Recommendations

In view of the above analysis, it is recommended that viscosity be used as a good property for deciding a particular oil or its blends for varnish production.

It is also recommended that melon and soybean, each blended with 20% linseed oil be used in production of wood varnish in industries, as their application will reduce the high cost of using imported linseed oil, reduce health risks associated with the pandemic and also reposition the economy for self-reliance in Post Covid-19 Era.

Reference

Angela, O. M., Enobong, A. C., Francis E., Olayemi, O. and Damiloli, A. (2019). International journal of mechanical engineering and technology (IJMET) pp 506-516. Available at http://www.ijeme.com/ijmet/issues. 25p.

Arminger, B., Jaxel, J., Bachelor, M., Ginde, W., Altmutter and Hansmann, C. (2020). On the drying behavior of natural oils used for solid wood finishing: ELSEVIER Journal. Pp 5 and 6 https://doi-org/10.1016/j.porgcoat. 2020. 105831.

Daniela, L., Maria, F., Guillrmo, C. and Susan, N. (2014). Effect of Drying Operating conditions on canola oil Tocopherol Content: Antiodioxants Journal pp190-199, www.mdpi.com/journal/antioxidants.

Gardner, A. and Sward, G.G. (1972). Physical and Chemical Examination of Paints, Varnishes, Lacquers and Colours, 13th edition; A.S.T.M. Publishers.

Harold, A., Wittcoff, B. G., Reuben, J. and Plotkin, S. (2012). Industrial Inorganic Chemicals, 3rd edition; Wiley Publishers.

Himadri, P. (2017). Complete handbook on paints, varnish, resins, copolymers and cooctings with manufacturing process, formulations and technology: Bio-green books publishers New York pp 106-111, 125

Ikeiensikimama, S.S. (1991). Analysis of Drying Oil Blends for Industrial Application: A BENG Thesis of University of Port Harcourt pp. 3, 4 & 36.

John, Geddes M'intosh, (2015). The Manufacture of Vanishes and Kindred, vol.2 "varnish materials and oil, varnish making; Book on Demand Ltd Publishers.

John, S. (1971). A Treatise of Japanning and Varnishing; Tiranti Publishers.

Journal of the Oil and Colour Chemist Association (July and September, 1990)

Kirk, O. (2007). Encyclopedia of chemical technology, Vol.4,5th edition; Wiley Blackwell Publishers.

Osuagwu, A.E. (1992). Production of Red Oxide Primer and Textured Sand finish; An MEng Thesis, Nnamdi Azikiwe University, Awka.

Oyman, Z.O., Ming, W. and Vander R. L. (2005). Oxidation of drying oils containing Non-conjugated and conjugated double bonds catalyzed by a cobalt catalyst: ELSEVIER Journal, pp 198-204, www.elsevier.com/ locate/porgcoat

Seader, J.D. (2015). Separation Process Principles with Applications, 4th edition; Wiley Publishers.

Stephen, S. O. and Ajai, A. I. (2011). Effect of presence of free fatty acids on the drying of the oil/drying catalysts mixturs; African journal of pure and applied chemistry vol5 (7) pp 196-203. Available at http://www.academicjournals.org/AJPAC

Udoye, B.O. (1995). Analysis of Drying Oil Blends for Industrial Applications; A BEng thesis, University of Port-Harcourt, Rivers State.