Vegetable Drying Oils in the Floor Covering Industry*

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THE floor covering industry manufactures a wide range of products among which are "soft goods" such as carpets, etc., and the "smooth surface" floorings such as linoleum, printed felt base, and mastic, asphalt, rubber, ceramic, and plastic tiles. Since the only floorings among these which use vegetable drying oils to any extent are linoleum and printed felt base, this paper will be limited to these materials.

The term "linoleum" is very loosely used by many people. It is often used in reference to printed felt base or other types of floor covering. For this reason it will be well to point out the difference between linoleum and printed felt base and then consider them separately in our discussion of vegetable drying oils since the problems involved in the manufacture of each are quite different. Linoleum in its simplest form is a plastic composition made from oxidized linseed oil, natural gums and resins, pigments, and organic fillers such as ground cork or wood flour. This composition has a base of woven or felted fabric and is usually made in thicknesses up to about 0.25 inch.

The name "linoleum" was derived from the Latin words for flax, "linum," and oil, "oleum." The first piece of linoleum was made in England in 1863 by Frederick Walton. It consisted of a mixture of an oxidized linseed oil-kauri gum-rosin cement, ground cork, and pigments. Walton had previously obtained patents covering the manufacture of oxidized linseed oil (1860) and the manufacture of a floor covering from oxidized oils (1862). This should be distinguished from floor oilcloth which was first mentioned in 1578 and later patented in 1627 and was a fabric coated with multiple layers of paint. The first plant for the manufacture of linoleum was built by Walton in 1864, and in 1865 the total sales amounted to 50,000 square yards. The first plant in the United States began operation on Staten Island, New York, in 1874.

Modern linoleum is somewhat similar in composition to that described in the original Walton Patent. However, many important changes and improvements have been made in equipment and methods since that time. Many of the ingredients now used are the same, but the products obtained are far superior to those made years ago. Many improvements have been made in the production of the linoleum "cement." The original method was to allow thin layers of linseed oil to air oxidize and polymerize to a hard, tough "skin." This was accomplished by allowing boiled linseed oil to flow down over cotton scrim cloth which was hung from the ceiling of large oxidizing "sheds." In this way a layer of oxidized oil was formed on the cloth and by successive floodings multiple layers of oxidized oil were built up. This process was carried out at a temperature of about 125°F. and took several months before a skin of sufficient thickness could be obtained. This skin was then fluxed with natural gums at elevated temperatures and on cooling a tough, rubbery gel resulted which was known as a "cement." Many advances have been made in oil oxidation, and the modern mechanical methods give cements in hours rather than weeks as in the old method. In making most cements conventional driers are used. The cement is used as the binder for the linoleum sheet. It is mixed with pigments (color and filler) and organic fillers (ground cork or wood flour), and then calendered on a woven or felted fabric base. The marble or striated type of pattern is formed and controlled by the method of mixing, sheeting, and calendering.

THE modern "Automatic Rotary Inlaying Machine" for making geometric inlaid linoleum is one of the most ingenious and interesting pieces of equipment in American industry. This machine handles four separate sheets of linoleum composition, cuts figures, then inlays and calenders these figures on a woven or felted fabric base, and rejects the unused composition. This is all done automatically and at a comparatively high speed. This machine represents a tremendous capital investment, and there are only three in existence in this country. Two of these are located in the Congoleum-Nairn plant at Kearny, New Jersey. These machines have revolutionized the manufacture of inlaid linoleum by their increased efficiency, improved quality, and greater volume of production.

The final step in the manufacture of linoleum is the seasoning. This is carried out by festooning the linoleum in huge ovens and allowing it to cure at temperatures of 150°-200°F. for a matter of from one to 10 weeks, depending on the type and thickness of the goods. The time and temperature of seasoning are critical factors and must be controlled closely to obtain a resilient, flexible, serviceable, and attractive floor covering.

In order fully to understand the role which drying oils play in the linoleum industry, one must first examine the qualities which are necessary for economical and successful processing. In the production of cement it is essential that the oil be readily oxidizable since the cement must be in a highly oxidized state to attain the desired binding qualities. This is also necessary since the seasoning of the linoleum sheet is essentially a polymerization of the oxidized binder. The time and nature of the seasoning, then, will be greatly dependent on the nature of this binder. This cement must lend itself readily to efficient mixing with the pigments and fillers; for this reason it must have good wetting properties.

The mix formed from the cement, pigments, and fillers is a soft plastic mass. The sheet formed from this mix must be able to support its own weight during processing, therefore it must have good tensile strength. The surface, decoration, and texture of the final calendered sheet are controlled by manipulation of calender pressures and temperatures and by the thermoplasticity of the mix. The tensile strength and thermoplasticity of the mix are primarily dependent on the cement used.

* Presented at American Oil Chemists Society Meeting, Chicago, Ill., October 21, 1947.

To summarize, any oil used to make linoleum must be readily oxidizable with and without resins to a tough, rubbery gel with good wetting properties and tensile strength; it must have, in combination with resins, a certain required degree of thermoplasticity; and it must be readily polymerizable below 200°F. The oil which has fitted these requirements best is linseed, which has always been the major binder ingredient in linoleum.

THE other requirements for oils used to manufacture linoleum are that they impart certain desirable qualities to the finished product. A good piece of linoleum must be flexible, resilient, bright and clean colored, resistant to fading, abrasion, soiling, denting, and resoftening, and should withstand mild alkalies and soaps. It must not continue to cure after removal from the stove since this would give hard and brittle goods, which would mean poor handling and installation qualities. The surface must be smooth and lend itself to easy maintenance. The oil used in the cement is a major factor in the flexibility, color, and resistance of the linoleum. The thermoplasticity and wetting power of the cement will determine to a large extent the surface qualities of the goods. Again it has been found that linseed oil gives the best combination of these qualities.

Many oils other than linseed have been used to produce linoleum. By a partial replacement of linseed with other oils a good combination of qualities may be imparted to linoleum, and actually many replacements have been made during the development of the linoleum industry. The comments which follow are for complete replacement of the linseed oil.

Soybean oil gives a more flexible, softer end product with excellent color. The serious objection to soybean oil is the slow time of cement making and seasoning. The partial replacement of linseed by soybean oil, however, has given linoleum of excellent quality. Preliminary work using chemically treated or segregated soybean oils has indicated that these oils give improved processing and seasoning times. If no other adverse effects are noted with these oils they could become an important factor in the linoleum industry.

Hard oils of the Chinawood or oiticica type have not given good results as a binder in linoleum. These oils are of the "polymerizing" type and do not yield the necessary oxidized type of cement. The gel has low tensile strength and poor binding properties. The sheet made from the gel is dry and weak.

Dehydrated castor oil gives results similar to Chinawood or oiticica oils. The deficiencies in the processing of these oils are far too great to give much consideration to the good qualities that they might impart to the finished linoleum.

Perilla oil has been used as a linoleum raw material to a limited extent. Cement-making time is good, but the finished linoleum is harder, more brittle, and shows more discoloration than the linseed product. The cost and limited availability of perilla oil has been an important factor against its use in linoleum.

The problem of availability is most critical when any oil is considered for possible use in linoleum because of the tremendous quantities of oils used by the industry. For this reason many oils such as safflower, sunflower, and milkweed seed, which are available in only limited quantities, have not been fully investigated as floor covering raw materials.

PRINTED felt base differs radically from linoleum. It consists of an asphalt saturated felt on which is a decorative enamel surface coating. This type of floor covering was first made in Erie, Pennsylvania, in 1911 as yard goods, and shortly thereafter the Congoleum rug was produced at Marcus Hook, Pennsylvania, under a basic patent issued to the Congoleum Company.

In order to seal the asphalt and to provide a smooth surface for the enamel top coat, "facing" or "coating" paints must first be applied to the saturated felt. Drying oils have been used in both the coating and enamel surface paints. The problems involved in each type of paints are different and must be considered separately.

Coating paints are generally of two types: oleoresinous solvent-cut or emulsion. The emulsion can have either a protein or oleo-resinous base. For good performance and results using an oleo-resinous emulsion, the oil must be readily emulsifiable into a stable paint. It must have sufficient film forming properties to give good sealing and flexibility. This factor of flexibility is especially important because the overall flexibility of the goods will be dependent to a large extent on the coatings used. Since all felt base products are sold in rolls, serious cracking difficulties are encountered if brittle coating paints are used.

The enamel surface coating, called "print paint" in the industry, is the actual visible and wearing surface of the goods. The method of applying this paint is radically different from other application methods found in the protective coating industry. The paint is applied on a flat-bed print machine which is unique with the industry. The paint is applied by a series of blocks which are fed by inking rolls and carriages. The coated felt is carried only intermittently under the blocks, and each block prints its own particular color and design. Most patterns require up to 14 different colors, but as many as 24 different colors may be used, each requiring its own printing block and paint carriage. The printed felt is then carried up into large baking ovens, which necessitates travel through a vertical position as it is fed into the top of the oven. The goods are then placed in flat racks or festooned during the drying period.

From this description of the printing technique the problems involved may readily be seen. The paint must not be sticky, or trouble from stringing will result as the blocks are raised. It must have good initial flow so that a smooth and well blended surface is obtained, and it must have good set after this initial flow to prevent sag as the goods are fed vertically into the ovens, or festooned during the drying. In short, the rheological properties of the paint must be under very close control during printing and stoving.

The flow properties of a print paint are generally dependent on the flow properties of the vehicles used to make the paint. Because of the flexibility required in felt base flooring, the print paint vehicles are generally of the long oil type. This means that the oils used and the methods of processing these oils will determine to a great extent the properties of the paint produced.

The oils used to make print paint vehicles are the conventional ones used by the protective coating industry. The methods of cooking these oils are also similar to those of the paint and varnish manufacturer. Chinawood, oiticica, and dehydrated castor oils are used as the "hard" or fast bodying and drying component while linseed and soybean oils are used as the soft oil component. The resins normally used are the conventional enamel resins such as pure or modified phenolics.

As mentioned previously, the attainment of the particular properties necessary in the print paint vehicle is greatly dependent on the processing of the oil in the kettle. One type of cook will be needed when Chinawood and linseed oils are used whereas dehydrated castor and soybean oils will require a different cook. It is a matter of adapting the cooking procedure to the oils which are being used to bring out best the desired qualities in the finished vehicles.

An examination of the qualities required in a piece of printed felt base floor covering will show why certain drying oils are preferred over others. The goods must be flexible, long wearing, and resistant to abrasion, denting, mild alkali, and soaps. The surface must be smooth, glossy, and attractive in appearance. The colors must be bright, attractive, and permanent. The print paint used must dry rapidly at baking temperatures of about 150°-175°F. to a hard, non-tacky film. As a basis of comparison with other surface coatings, the actual paint wear layer of printed felt base is equivalent in thickness to eight coats of a conventional brush-applied floor paint.

IN selecting oils, materials must be chosen which give the best combination of these desirable qualities. In the hard oil class Chinawood gives good dry, alkali resistance, abrasion resistance, and flexibility. Dehydrated castor oil gives excellent color and flexibility but only fair dry. Oiticica oil gives good dry, abrasion resistance, and alkali resistance but somewhat inferior flexibility. In combination with these oils, linseed gives good dry, alkali, and abrasion resistance but only fair flexibility and color. Soybean oil, on the other hand, gives excellent color and flexibility but less resistance and slower dry.

Many special oils, such as chemically treated, catalyzed, distilled, and segregated oils, have been investigated in printed felt base. Some of these have given good results and will probably be used as they become commercially available in large quantities. Perilla oil has also been investigated as a felt base raw material. This oil gives excellent dry, film hardness, and resistance, but the flexibility and color are only fair. It should be pointed out that many of the qualities such as color, gloss, flexibility, etc., of the finished felt base are affected by factors other than the oil. These, however, will not be discussed since only the vegetable drying oil phase of the industry is being considered.

In conclusion, it is interesting to consider a few facts and figures which illustrate the scope of the linoleum and felt base industries. The last available figures show that in 1941 a total of 205,000,000 square yards of felt base and 57,000,000 square yards of linoleum were produced. These figures indicate the relative amounts of each product produced. The amount of drying oils used in each will be about the same however since much more oil is used per square yard of linoleum.

The Bureau of Census figures on the use of drying oils for the past few years illustrate the amount of oil being used in the floor covering industry compared to the paint and varnish industry. This data is listed in Table I.

TABLE I
Bureau of Census—Oil Consumption
(Quantities in millions of pounds)

Year	Oil	Paint and Varnish	Floor Covering (and oilcloth*)
1938	Linseed	216	55
	Soybean	15	3.5
1941	Linseed	373	110
	Soybean	41	7
	Total Oil	570	137
1945	Linseed	322	67
	Soybean	21	4
1946	Linseed	362	66
	Soybean	25	6.5
1947 (1st half)	Linseed	187	38
	Soybean	37	12

*Oilcloth consumption is only a relatively small fraction of this figure.

One thing that is evident from these figures is the ever-increasing amount of soybean oil that is being used by both the paint and floor covering industries. In 1938 the ratio of linseed to soybean oil used in the floor covering industry was about 18 to 1. In 1946 this dropped to about 10 to 1, and the first half of 1947 showed the ratio to be only about 3 to 1.

Examination of these figures shows that the total volume of linseed and soybean oils used by the floor covering industry amounts to about 25% of the total of these oils used in the paint and varnish industry. Since there are only about 10 floor covering manufacturers in the country compared to the hundreds of paint manufacturers, it is readily seen that the individual floor covering manufacturers must be among the largest single users of drying oils in the country.