Epoxy Esters. In order to provide highly resistant coatings systems necessary to meet the demands of premium applications, an epoxy resin "backbone" is frequently the answer. By incorporating tall oil fatty acids into the formulation of esters, significant cost reduction can be achieved. Our laboratory has prepared a terpene-phenol glycaldyl ether derivative (5) which in its esters has shown unusual chemical resistance, solvent miscibility and resin compatibilities as compared with the common bisphenol types.

Tall oil fatty acids have been used in two ways in this segment of work: a) as partial replacement of the more costly dehydrated castor fatty acids, and b) as the sole fatty acid component. Table IV describes the formulations, resins and properties obtained.

The procedure used in the case of the split fatty acid cook was as follows: To a similar system used in the preparation of the alkyd resins were charged 66.7 parts of flux as the azeotrope-former. The mixture was heated to 260°C in two hr and held until the acid number reached 10. The remainder of fatty acid (16.7 parts castor fatty acids, four parts of xylol to maintain resin miscibility and resin compatibilities as compared with the common bisphenol types.

It appears from the data presented in Table IV that tall oil fatty acid based epoxy esters may be made with high performance features. Resin B described in the above table has the unique balance of properties for use as a dip coating vehicle requiring stability of the resin at application temp of 125°F with rapid conversion at 400°F baking temp. A vehicle of these qualities may find use in washing machine primers and topcoats, electrical equipment finishes, etc.

Conclusions

Tall oil fatty acids have been used in the preparation of new types of alkyd, urethane alkyls and epoxy esters. Fast drying durable resins are provided for use in trade sales, metal decoration, primer and topcoat applications.

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Mechanically Aided Thin-Film Evaporation as a Tool for the Tall Oil Industry


Abstract

This article describes the thin-film evaporation process and emphasizes its values in applications where heat sensitivity, high viscosity and low thermal conductivity are important processing factors.

Processing Tall Oil

Many products in the tall oil industry can be processed efficiently by thin-film evaporators since there are literally hundreds of tall oil products which are viscous, or heat sensitive, or both.

But tall oil products vary a great deal in composition. Thus, it becomes difficult to generalize on the applicability of the thin-film evaporator to these products. A number of tests which have been performed illustrate, however, the applicability of thin-film evaporation in tall oil processing.

One series of tests showed that valuable materials such as tall oil fatty acids could be recovered from waste tall oil pitch by thin-film evaporation. Since the residue becomes very viscous as products are separated, distillate rates are low in this operation, averaging 5-10 lb/hr/sq ft.

Tests have also been run on tall oil products whose yield rates and maximum Gardner colors were specified. Distillation rates here varied from 15-35 lb/hr/sq ft due mainly to the less viscous nature of the material. Similarly, work has been done on a tall oil fatty acid where the object was to remove color bodies to improve Gardner color from a No. 7 to a No. 3 or No. 4. Distillation rates ranged up to 38 lb/hr/sq ft.

TABLE IV

<table>
<thead>
<tr>
<th>Composition</th>
<th>Constants</th>
<th>Air dry properties 0.04% Co 3% mil wet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epoxy type</td>
<td>Epoxy wt</td>
<td>DCOFA wt</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A) Terpene-epoxy.....</td>
<td>66.7</td>
<td>16.6</td>
</tr>
<tr>
<td>B) Terpene-epoxy.....</td>
<td>65.3</td>
<td>16.7</td>
</tr>
</tbody>
</table>

DCOFA = dehydrated castor fatty acids (Baker 9-11 type).
TOFA = low rosin tall oil fatty acids (Acedar—Newport Industries).
IPA = lophophoric acid.
An excellent application is the separation of monomer from dimers and trimers in a dimerized tall oil fatty acid. Distillation rates ran up to 50 lb/hr/sq ft.

The other component in crude tall oil—rosin—has also been tested and distilled by thin film units with good results. Distillation rates average 20–22 lb/hr/sq ft. Operating pressure in these tests varied from 1–5 mm Hg absolute.

Such test results are hardly conclusive, but they are indicative of potential benefits to be derived from thin-film processing in the tall oil industry.

**Thin-Film Evaporators**

Let us take a closer view of this processing method to find out how and why it works. Thin-film evaporation theory is based on the fact that if you evaporate products that are heat sensitive or viscous you need (1) a large surface to vaporize and separate effectively, and (2) a thin layer to provide quick and efficient heat transfer. The problem has been how to provide both in a practical design.

Modern thin-film evaporators have overcome many of their initial shortcomings, most of which related to fabrication limitations. Today, mechanical methods, based on centrifugal force generated by a rotor, distribute the product as a thin-film over the entire heat transfer surface. The thin-film increases heat transfer efficiency and makes it possible to take advantage of the benefits derived from low retention time in an evaporation system. One-pass operation is possible in most cases. Consequently average holding time is reduced. Higher temp can be used without danger of thermal degradation because time-temperature relationships are kept in balance.

Actually, the principle of operation for mechanically-aided thin-film evaporators is simple. A small amount of liquid is continuously fed into the top of a still, usually from a number of openings. The liquid flows down the evaporator wall by gravity, and, aided by mechanical wipers, forms a thin-film that covers the evaporating surface. Thus only a thin-film of liquid is heated at any given time.

Relative to cost, mechanically aided thin-film units are more expensive than conventional evaporators on a price/sq ft basis, but the cost is by no means prohibitive. The units become much more economical as the size increases. A 4-sq ft unit costs approx $2,000/sq ft, but a 100 sq ft unit costs only ca. $300/sq ft. It should be remembered that the price differential between standard evaporating equipment and thin-film units is not so significant when total installation costs are taken into consideration. Instruments, pumps, tankage, and other auxiliary equipment, plus the installation itself, represent a greater portion of the total cost of a system than the evaporator alone; and auxiliary equipment is apt to be the same with either installation.

Nevertheless, if an evaporation process can be accomplished satisfactorily in a calandria, natural or forced circulation evaporator, etc., thin-film units should not be considered unless superior qualities of the product are needed. An economic study in such a case should take into account the higher yields and superior color obtainable in thin-film units. Superior color, for instance, could possibly bring an increased price for the product—or less sales resistance.

In many applications, conventional approaches require so much sophistication that they are often more expensive than thin-film evaporators. Examples of this are the separation of fatty acids or fatty amines, and the removal of color from plasticizers. In the latter case, mechanically aided thin-film evaporation is almost mandatory; processors have found it the only suitable method for removing color to meet customers’ specifications. It is virtually impossible to remove color from plasticizers by standard evaporation because of heat damage and decomposition resulting from the relatively long time the product must remain at temp. With a mechanically aided thin-film evaporator, the plasticizers can be exposed to higher temp for a relatively short period with no thermal degradation of the product.

Furthermore, some users have found that the unit, although purchased for a specific difficult process, also can be applied to conventional evaporation processes economically. The same unit used for separation of di- from triethanolamines can also be used to recover spent ethylene glycol or to strip unreactive materials from alkyl phenol.

**Application Criteria**

Thin-film evaporation should always be given serious consideration whenever the processor is dealing with materials that are heat sensitive, or viscous, or have low thermal conductivity. Typical examples are tall oil, fatty acids, resin, amines, esters, rocket fuels, urea, and other fertilizers, radioactive wastes, and fruit juices. The range of separation processes is extremely broad and includes dehydrating, deodorizing, decolorizing, stripping and concentrating.

Mechanically aided thin-film evaporation is relatively new. Hence, compiling a complete formal set of criteria for application of thin-film evaporators is difficult. However, a good basic knowledge of the physical properties of the product may be all that is needed to decide whether or not thin-film evaporation should be used. Let us consider the effect of heat transfer, feed rate, viscosity and vacuum on thin-film evaporators.

**Heat Transfer Rate.** Extremely high heat transfer rates are characteristic of these units. In fact, overall heat transfer coefficients as high as 3750 BTU/hr/sq ft/°F have been reported. Such values are atypical and result from controlled conditions with special experimental apparatus which has an extremely thin heat transfer shell. More common values range from 350–450 BTU/hr/sq ft/°F for water-like products in production equipment with a heavier gauge wall that provides structural rigidity and strength to withstand high jacket pressure. With viscous products, the inside shell coefficient usually is the most important factor in determining the overall heat transfer coefficient. Reducing film thickness increases the film coefficient. A major consideration, therefore, in the mechanical design of thin-film evaporators is how to produce a thin, evenly spread film which moves rapidly across the surface.

Conductivity of the barrier wall is also a consideration. Most large size stainless steel units are clad with carbon steel to take advantage of its higher conductivity. Also, spirals in the jacket are often used when the heat transfer medium is either hot water, Aroclor, hot oil or liquid Dowtherm.

The high heat transfer efficiency of the mechanically aided thin-film evaporators makes them ideal for handling products that have low thermal conductivity. This is the type of product that might be more economically handled in a thin-film evaporator than in a standard type evaporator (even though the latter...