USES OF GLYCERINE

COMPILED BY

THE GLYCERINE PRODUCERS' ASSOCIATION

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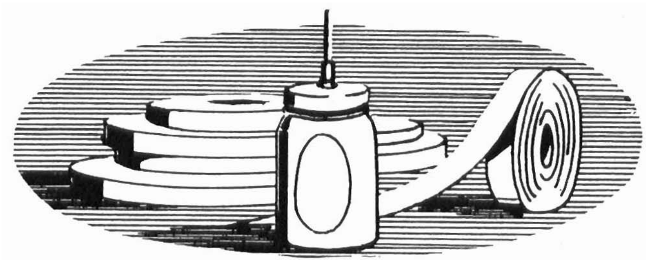
THE unusual combination of properties of glycerine has resulted in its use in a great variety of products and processes. Some of these uses depend on its physical properties such as hygroscopicity, viscosity or high boiling point — while others depend on its chemical properties. In many cases it may be a combination of several of its properties, both physical and chemical, which make it applicable.

Another factor which makes glycerine widely useful is its non-toxicity. As a food it is easily digested; its metabolism places it with the carbohydrates, though it is present in combined form in all vegetable and animal fats. It is non-irritating to the skin and mucosa except in high concentration where it has a dehydrating effect.

Historically, glycerine was produced commercially as a by-product in the manufacture of soap. But for roughly the past 15 years, it has been produced synthetically from propylene and more recently by hydrogenolysis of carbohydrates as well as fermentation. Production from combined sources in 1963 totalled approximately 295 million pounds. Of this, more than one-half went into three major uses; alkyds, tobacco and cellophane. The remainder goes into literally thousands of products and processes.



ADHESIVES AND PASTES

Glycerine is a very good solvent for organic and inorganic substances—e.g. phenols, borates, etc. Its strong hydrogen-bonding properties have been suggested as an explanation for its very good solvent activity. This, in turn, explains the excellent plasticizing action on proteins, particularly gelatin, which can tolerate a large amount of glycerine and still remain a firm gel, which is not the case with glycols or glycol ethers.

Flexible glues are basically combinations of animal glue, glycerol and water, characterized by the deposition of a glue film which "sets" rapidly and remains more or less flexible for an appreciable period of time. These glue or gelatin compositions can be cast in molds to provide a tough, resilient, rubber-like or rigid solid, or may be utilized in other ways for a variety of products.

The horn-like hardness of glue and gelatin can be modified to almost any extent by the addition of glycerine and water. Flexibility is first attained, then as more glycerine is used, the mixture can be made rubbery and finally a permanently soft and tacky product is obtained. As the glycerine content is increased, the amount of water permanently held is increased and the melting point of the composition is decreased.

Many kinds of modifying agents may be added to such compositions, so as to alter them physically or chemically, to satisfy the multitude of different ideas on how the basic properties can best be used.

Flexible glue compositions combine the simplicity of easy preparation with the complex structure of a protein that nature has built but man has not yet duplicated. Animal glue or gelatin contains more than 14 different amino acids. Derived from collagen by hydrolysis, animal glues belong to the group of simple proteins, with molecular weights ranging from 40,000 upward. Animal glue solutions set quickly to a jelly-like state; the jelling may be reversed by the application of heat, or made irreversible by appropriate chemical treatment.

Glycerine's chief role in a glue composition is that it acts as a plasticizer. When glue or gelatin is mixed with or dissolved in glycerine, the mass is rendered permanently plastic, and remains so even when the water content of the mix is low. Glycerine changes the glue composition so it does not dry, on loss of water, to a hard and often brittle material, but remains flexible and strong.

This modifying effect of glycerine is due in large degree to its hygroscopic or moisture-retaining action which minimizes the effects of fluctuation in water content of the composition. Other so-called softeners usually behave in much the same way though the sulfonated oils first used with glues exert more of an internal lubricating effect, than hygroscopic effect.

The behavior of glycerol-plasticized glue and gelatin compositions depend on the properties of the components and the way in which they are combined with water and with one another in the final composition.

Flexibility depends not only on the glue to glycerine ratio but also on the jelly strength and viscosity of the glue itself. Technical gelatins and hide glues are inherently stronger and will permit the use of larger amounts of plasticizers and other modifiers without losing strength as rapidly as lower strength, lower viscosity glues.

The ratio of glue to glycerine is important not only in governing flexibility of the resulting composition but also in changing the speed of setting, the amount of water that needs to be added, etc. Any increase in the percentage of glycerine will, in general, decrease speed of setting but improve flexibility. Decreasing the percentage of glycerine causes these effects to be reversed.

In the preparation of flexible glues the dry glue is soaked in cold water for an hour or two, until soft and is then melted in a jacketed kettle at 140° F. The amount of water required will vary with the grade of glue used and the final fluidity desired. The desired weight of glycerine is added and dispersed. The amount of glycerine can vary from 2% to over 100% depending on the use of the finished product.

Glycerine-plasticized glues have proved useful as laminating agents. Adhesives of this sort, containing about 35% glycerine have been developed for uniting plies of wood, cloth, paper and other materials. Adhesives based on gelatin or sodium carboxymethyl cellulose, plasticized with glycerine, have also been advocated for laminating cellophane and other non-fibrous materials.

Glycerine is used too in vegetable adhesives for labeling or as office pastes. In starch pastes, it is added as a plasticizer to give a more flexible bond, and should be incorporated as glycerite of starch. The advantage of using the glycerite is that although the film is plasticized, no adhesive power is lost; if pure glycerine is used there is a loss of initial tack.

Glycerine is widely used in dextrin adhesives which are employed for bottle labeling, gumming envelope flaps and labels, book-binding and carton sealing. The advantage of dextrin over starch is that a higher content of solids is possible, giving higher initial tack; also by blending the various types of dextrin according to their degree of hydrolysis, a variety of properties can be obtained. These adhesives are more liable to "set back," however, and give a more brittle film. Glycerine helps to alleviate these tendencies and to slow down skinning and dry out on storage.

Remoistening adhesives for use on envelope flaps and labels should have the following properties:

a) light color and transparency
b) high solids content
c) ability to flow
d) form a thin film that does not curl or crack.

These conditions are achieved by using a well-hydrolysed potato dextrin and a larger proportion of glyceryl borate.

Adhesives based on natural gum incorporate glycerine as a modifier. Gum arabic mucilage usually contains a small amount — one percent or less.

Resins

Of the natural resins the most important is rosin, which is used, combined with glycerine, as ester gum. Rosin itself has a very high acid value and is not water resistant. Ester gum, however, is more resistant to water and alkalies and has an acid value 6-8 and a melting point of about 10° C. higher than the parent rosin.

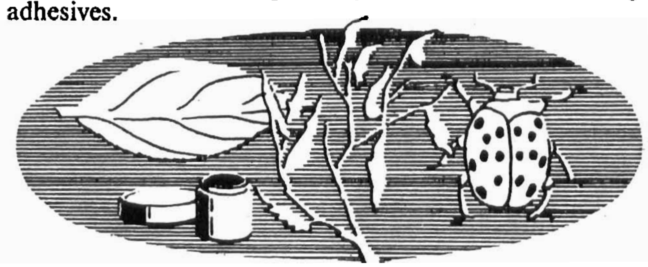
It is prepared by reacting rosin with 12-15% glycerine at 250° C. By itself, it is not a very good adhesive but is a valuable addition to formulations based on cellulose nitrate and acetate, vinyl resins and natural and synthetic rubber.

In the field of synthetic adhesives, polyester resins, prepared by the action of phthalic or maleic anhydride on glycerine or other polyhydric alcohols play a major role, and are useful in making adhesives.

Alkyds can be blended with a great many resins and cellulose esters, and have very good specific adhesion to metals. They are excellent for bonding cellulosic films, textiles, rubber, wood and cork to metal, and are useful for laminating safety glass and plastic.

Alkyd resins themselves are used for heat sealing adhesives. These are long oil length resins based on non-drying oils. They can be emulsified, and the emulsions used to prepare very good adhesives for laminating or sticking metal foil to wood.

Alkyd resins based on maleic anhydride are much harder than those based on phthalic anhydride, and can be used with other synthetic resins in solvent compositions or combined with polyvinyl acetate for heat sealing adhesives.



AGRICULTURE

In considering the use of glycerine in agriculture, one encompasses many fields of application such as care of plants, trees, and animals, flowers, fresh and preserved, insecticides and veterinary products.

Some uses for glycerine in this field stem from the fact that it is a good solvent. Also because of its viscosity or body it is a good suspending agent. Other applications may derive from the softening action, penetrating ability or even its familiar antifreeze action. But perhaps its most important virtue is its superior hygroscopic or humectant action; by which it attracts and retains moisture under temperature and climatic conditions that render other substances ineffective.

Certain of these characteristics have been utilized in methods for stimulating plants and in maintaining the viability of plant materials during shipment and storage. In a study done some years ago, glycerine solutions were substituted for the water ordinarily used to moisten peat moss which is placed around roots before shipment. The plants were stored for various lengths of time to simulate shipping conditions and were than planted, some before and some after exposure of the roots to sun for a few hours. In each case there was a substantial decrease in mortality and an increase in yield when the plants were treated with glycerine concentrations ranging from 0.1 to 10%. The use of glycerine was found to reduce the incidence of stem canker to less than half that found with plants treated with water alone. In addition, the treated plants seemed to begin to grow sooner after transplantation. Later it was found the beneficial effects could be obtained by applying the glycerine directly to the roots instead of the peat moss.

Other studies indicate that narcissus bulbs, forced indoors in gravel and diluted glycerine solutions, gave greater and quicker growth and flowering than control bulbs grown in water alone. When the bulbs were soaked in a glycerine solution just before planting they gave appreciably higher yields. The reason for this stimulating action is not clear, but since it occurs with glycerine solutions as dilute as 0.1 percent, the effects propably do not result primarily from the humectancy of the fluid.

In other studies of the prevention of freezing of branches, leaves, buds and blossoms, a spray was developed consisting of an emulsion containing petroleum oil, water, glycerine, a spreader and alcohol. The protective coating which forms on the plant surfaces helps to insulate them from the effects of freezing temperatures and eliminates the need for smudge pots and similar devices. Such a solution sprayed on the growth would be water soluble and easily removed when the need for it no longer existed.

The introduction of so-called plant hormones or growth regulators also extended the use of glycerine to this field. One European investigator suggested that before a plant is brought into contact with these growth stimulating agents, the contact areas should be coated with glycerine because its penetrating qualities would insure the action of the hormone. Other workers in this field have recommended glycerine not only as a penetrant, but also as a vehicle for the growth substances. It can be used in this way for example with colchicine, a substance which has contributed materially to the field of plant breeding. It is said to produce bigger, brighter flowers on ornamental plants, with new shapes and denser, greener leaves. In treating buds or young shoots of woody or semi-woody plants, 0.5 to 1 percent colchicine in a 10% solution of glycerine applied once or twice is recommended.

Glycerine may serve as a vehicle for other plant substances. In one case it has been used as a vehicle through which indole-beta-acetic acid might enter the plant, resulting in real acceleration in the rooting and in a greater number of rootings.

The value of glycerine extends beyond the growing stage. After the greens are cut or picked, glycerine will help retain the bright appearance of decorative leaves or foliage. This can be done by dipping the leaves and branches of freshly cut foliage into a five percent solution of glycerine in water and allowing the excess liquid to drain. The same treatment given to bright, colorful autumn leaves makes them less crumbly and brittle, and much easier to handle.

One method recommended for extending the life of autumn leaves and branches consists of slitting the stems of freshly picked branches and immediately immersing them in a solution of glycerine and water. The proportion of glycerine may range from one to three parts of glycerine to two to three parts of water. The stems are kept in the glycerine solution about two weeks. After this treatment, they can be kept without water and the leaves retain their color and acquire a tough lasting texture instead of crumbling.

A similar method is used for preservation of twigs and buds in their natural form and color. The specimens are treated with a 60% solution of glycerine. For preserving the green chlorophyll pigment, the addition of acetic acid and a mixture of pulverized copper salt and zinc is also required.

Glycerine-gelatin combinations have long been used to give flowers a waxy appearance and help maintain their shape and color. A process, long used, calls for eleven ounces of gelatin softened by soaking in cold water, dissolved in nine ounces of heated glycerine. The flowers are dipped in this preparation which, on cooling, resembles colorless wax. The glycerine in the coating keeps it pliable, and allows the flowers to be handled quite freely.

Glycerine's plasticizing action finds use too in one of the most modern methods of preserving flowers and foliage. As described in a patent, the procedure varies with the type of plant material being treated, and its water content. In all the procedures, however, the final step consists of applying a coating by immersion in an emulsion made from glycerine, acetone and a viscous, paste-like, pyroxylin cement. It is claimed flowers and foliage preserved this way can be kept a long time without deterioration.

Beyond the field of plant stimulation and preservation, glycerine plays an important role in maintaining the health of growing trees and plants. It is an essential part of many potent insecticides and weed killer preparations for fighting tree diseases. As pointed out before, glycerine has a plasticizing and softening action, and is an excellent solvent. But besides this, the viscosity or "body" of glycerine makes it useful as a suspending medium for substances that are not soluble.

Some years ago a series of investigations were made which proved the value of glycerine in preparations for treating tree wounds. Bordeaux paste, creosote, linseed oil paint, coal tar, grafting wax, heavy petroleum jelly, bitumen emulsion, and a glycerine-mercury salt mixture were tested as coatings for tree wounds to overcome infection by Polystictus versicolor, a fungus causing white rot. The last two treatments were found to give the best results. However, when the bitumen was used on terminal wounds, of healthy limbs, there was a tendency for the wounds to exude sap, which collected under the coatings. Preference was therefore given to the glycerine-mercury salt solution. Two applications of this at three week intervals controlled even the worst cases of infection.

An identical mixture has been recommended as a disinfectant for use in combating tree canker. Tree cankers cause severe damage and experts recommend frequent painting of active cankers with the glycerine-mercuric solution and disinfecting of all tools used on the tree with the same solution.

An additional element which makes cankers dangerous is the fact that, during the winter months, these growths harbor the bacteria responsible for "fire blight." Glycerine is an essential component of many preparations for controlling fire blight. Its penetrating solvent and hygroscopic properties are used, for example, in chemical paints for treating blight-caused cankers. Two solutions have been recommended for controlling this, one a cadmium sulfate solution, the other a cobalt nitrate solution. Both of these treatments call for glycerine which acts as a penetrant.

In 1962, prune and apricot trees in California were found to be attacked by a new disease, ceratocytis canker, apparently as a result of bark injuries from shakers and other machinery. This is well known to almond growers as mallet wound canker and the fungus is now attacking prune and apricot trees. To stop the spread of this disease, the diseased bark is cut away and the area painted with phenylmercuric nitrate mixed with glycerine and a small amount of lanolin.

Glycerine-containing preparations have proved valuable in the treatment of crowngall disease, an important cause of tree damage in many parts of the country. Work done at the University of California reported that a mixture of methyl alcohol, acetic acid, glycerine and iodine was satisfactory for the eradication of crown galls.

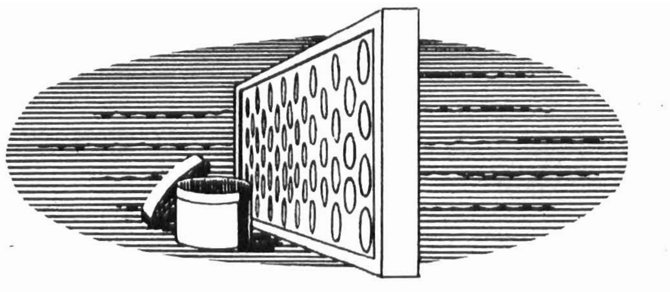
Fire blight or "blight," another major factor in tree damage, is caused by bacteria that is spread by rain and insects. The organisms winter over and attack the young shoots in the spring. Along with pruning and cutting, the disease may in large measure be controlled by treating the diseased spots with a cobalt nitrate in a glycerine-alcohol solution.

For insecticides, glycerine is an efficient solvent or vehicle and its presence often heightens the efficacy of such products. For example, as a vehicle for tartar emetic spray in treating red spider mite, it is much more efficient than the old brown sugar syrup vehicle.

Glycerine is likewise a frequent ingredient of other types of products to thwart insects. Tree banding mixtures, such as the one developed to control the action of giant mealy bugs, calls upon both the solvent and hygroscopic action of glycerine, while patented glycerine-containing preparations have been prepared to preserve wood against the action of termites. Old fashioned poison pastes to be spread around places frequented by ants consisted of equal parts of tartar emetic sugar and glycerine made into a paste. The glycerine here acts to prevent the paste from drying out.

Glycerine finds use in making fly-catching preparations. Methods utilizing fly repelling solutions such as formaldehyde, sodium salicylate or the like, exposed in shallow vessels, also employ glycerine to help provide more sustained action. Sticky fly paper compounds likewise frequently include glycerine. The glycerine can be incorporated with sodium silicate or tincture of pyrethrin.

Glycerine derivatives also play a role in the field of agriculture. Parital esters of glycerol or glycerol polymers of a low degree of polymerization and babassu or castor oil are effective emulsifiers for DDT. An adaptation of this is a compound adapted for dispersion in water to form a spray for fruit trees and other crops in which DDT, rotenone or other insecticide is dissolved in a fatty acid monoester of glycerine. These spray compositions adhere well to the surface of the plants, are not substantially washed off by rain water, but are easily washed off the harvested fruit by aqueous solutions of emulsifying agents.



AIR CONDITIONING AND REFRIGERATION

In the field of air conditioning and refrigeration, several properties of glycerine account for its use. Its smooth feel and viscosity make it a natural lubricant, and its hygroscopic effect is one of the factors contributing to its status as a plasticizing agent. Its humectant quality, which attracts and retains moisture, makes it useful in these fields while its ability to remain fluid at low temperatures, plus its high boiling point and low vapor pressure add to its useful properties.

Certain of these attributes find use in the preparation of the viscous dust trapping fluids used in filters. Air filters for the removal of dust, soot and pollens are usually moistened with a rather viscous liquid to which the unwanted particles adhere. Unless it is the throw-away type of filter, it must be washed and a suitable quantity of the adhesive liquid reapplied. If a glycerine solution (50% is recommended) is used, it can be washed off with water and a fresh solution applied. In making such a solution, a small amount, about 0.2%, of glue or other viscosity increasing material is added.

Because, in some installations, filters may be placed close to hot furnace pipes, glycerine has an added safety factor. The flash and fire points of glycerine, even in a 50% concentration, are in the neighborhood of 400° F.

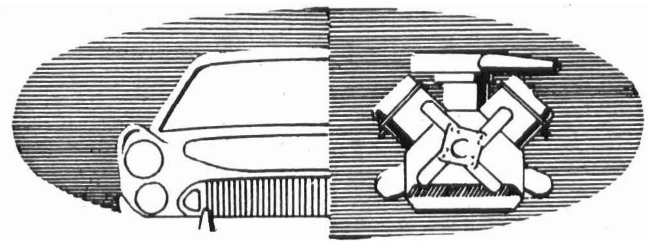
Glycerine has also been used in the production of more elaborate dust trapping fluids for air filters. In one case, a glycerine reaction product is employed to make a non-volatile, non-flammable, odorless and chemically stable, dust collection fluid for impregnating the porous structure of air filters in air conditioning units. One patent in this field calls for glycerine esterified with sulfamic acid, and a fungicide added to the ester. In another case, glycerine or certain of its water-soluble derivatives may serve as the vehicle for filter screen compounds. Such fluids are used in special equipment for humidifying and cleaning the air.

Because of its hygroscopic action, glycerine can absorb moisture from the air. For this reason it is used for drying gases. Changes in temperature have very little effect on the equilibrium relative humidity.

Because of its ability to remain fluid and efficient at low temperatures, it can be used as a low temperature lubricant. Glycerine has been recommended as a major component of lubricating and sealing liquids for use in refrigeration systems. The use of glycerine as a lubricant for the sulfur dioxide compressors in refrigeration systems is well established.

Glycerine litharge cements made by mixing glycerine and litharge, with or without water and inert filters have an excellent reputation for their ability to set rapidly and form bonds or seals of notable hardness, resistance and durability.

In the maintenance of air conditioning units, most refrigeration piping is done with screwed fittings, and glycerine litharge cements may be used to seal these joints. When this sets, the joint is every bit as tight as a welded connection insofar as refrigerant leaks are concerned.



AUTOMOTIVE

At one time glycerine found a large outlet in the automotive field as the first "permanent" antifreeze. When used this way, it is combined with small amounts of other ingredients including a corrosion inhibitor. Glycerine, of itself, is not corrosive, but under conditions of use in a car, it may become so due to oxidation and the resulting formation of organic acids. However, over the years glycerine for this use has been replaced by cheaper materials.

But in other aspects of automotive manufacture and maintenance, glycerine finds wide fields of application. Its physical properties have been put to extensive use in the formulation of many types of surface cleaners and polishes. For example, in the preparation of emulsion type cleaners and polishes, glycerine helps to cut down on the tendency of some polishes to streak or leave rubbing marks. It thereby makes possible a brilliant shine on varnished surfaces such as automobile bodies, metals and glass. When abrasives are included in the formula, glycerine prevents the abrasive particles from absorbing oil from the mixture and thus makes them work more efficiently.

In glass cleaners that combine the attribute of anti-fog action, glycerine is also incorporated, as it is in chromium polishes and cleaners and tire cleaners. In the latter the glycerine acts to keep the rubber from "drying out." Not only the cleaning but the processing of rubber used in tires may use glycerine in the vulcanizing medium.

Glycerine is an important component of many modern greases made with hydrocarbon oils and soaps. The glycerine which may be present as a by-product of the saponification during the manufacture of the grease, or as an additive, serves a number of useful purposes in the lubricant. It aids in stabilizing the structure of the grease, reduces the change in consistency, increases the lubricating power and prevents increase in the coefficient of static friction on heating.

Glycerine plays a number of other roles in the automotive field which will be covered more extensively under specific sections such as rubber treatment and manufacture, glass laminants, valve grinding compositions, tire preserving paints, leather treatment finishes and cleaners and waterproofing fabric for hoods, etc.

BEVERAGES

In the field of beverages, glycerine plays an important role. Not only is it used in the preparation of soft drinks and such things as tea and coffee extracts, but it is a natural ingredient in wine and beers. Louis Pasteur, when making his famous studies on fermentation in 1885, found that 3.5% of the sugars in alcoholic fermentation are converted to glycerine.

In processes where alcohol is distilled off to make whiskeys of various types, gin and other high alcoholic content liquors, glycerine, because of its high boiling point, is left behind in the mash. In the production of wines, glycerine remains in the beverage as an important flavor contributing constituent. Thus, wine contains a certain amount of glycerine in its natural state, since the fermentation process yields glycerine as well as alcohol; the final content of glycerine being approximately 10% of the total alcohol content of the wine, though this figure varies with the types of wine and with factors such as fermentation and alcoholic evaporation during storage.

The alcohol-glycerine ratio is often employed as a means of determining adulteration in wine, the ratio being much more important than either constituent alone. In some wine producing countries, the limits of alcohol-glycerine have been fixed by law.

The low freezing point of glycerine solutions has been utilized in processing certain wines. In the manufacture of champagne and other sparkling wines, glycerine may be used in the "disgorging" process. In this procedure, the sediment and a portion of the liquid in the bottle neck are frozen solid by placing the neck in a liquid, often glycerine, cooled to below 12° Fahrenheit. This permits the removal of the agrafe and the plug is forced out by gas pressure in the bottle with little loss of liquid.

The formulation of base flavors for use in the production of various types of liquors and liqueurs frequently utilizes the advantageous qualities inherent in glycerine. It is used not only in making these fruit flavors for liqueurs but is likewise used as a vehicle in making flavors for stronger drinks such as gin, essence of cognac, essence of rock and rye whiskey and artificial Scotch flavors.

As glycerine is normally present in wines, it is a normal ingredient of beer, again as a product of fermentation.

Glycerine is used quite extensively in the preparation in the base extract of soft drinks, from which the bottled beverage is prepared. In the dilute solution, it adds smoothness to the drink. In the same way, it may be used for preparing fountain syrups.

Glycerine has been used in vanilla and citrus flavors as a vehicle and in coffee, fruit and spice extracts of many kinds, and it has been used in chocolate syrups to improve the body and smoothness. Flavor pastes and powders often contain glycerine, and it is solvent for many food colors such as carmine and cochineal.

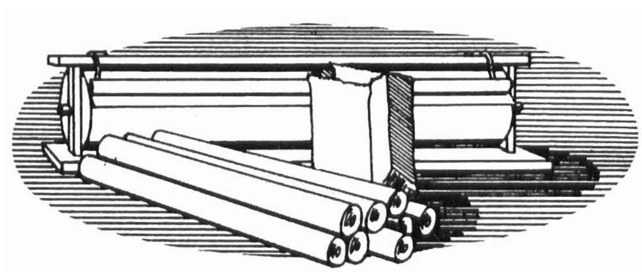
Not only is glycerine an excellent solvent for flavor and taste materials present in natural products, like coffee beans, but it serves to blend the several components into a harmonious whole. For many years it was used in coffee-chocolate vehicles for disguising the taste of medicines like quinine.

In the preparation of coffee extracts a glycerine menstruum is considered preferable to dilute alcohol, giving a smoother product. In making liquid coffee products, glycerine may be used as an extractant or vehicle or both.

In the preparation of liquid tea concentrates, glycerine acts to keep the solution clear. The addition of glycerine and dextrose to a tea concentrate, the pH of which has been adjusted to 7.7 to 8.0, results in a product that retains its clear, attractive appearance, natural flavor and aroma during extended periods of storage.

The function of the glycerine dextrose combination is to solubilize the precipitate that normally forms in cooled liquid tea concentrate. Many agents, sucrose among them, have the same effect, but in the concentration needed for clarity, impart too sweet a taste to the finished drink. A concentrate with an optimum clarity and minimal sweetness is achieved by using 5% glycerine and 15% dextrose. In beverage uses as in foods, glycerine is normally an acceptable food additive, but attention must be given to food standards and labelling regulations which apply.

The packaging of beverages calls for glycerine also in the corks and cork liners used in bottle caps. Here it acts to maintain the flexibility of the cork and thus insure a high seal which does not dry out and retract.



CELLOPHANE, PAPER AND WRAPPING MATERIALS

Glycerine is widely used as a plasticizer for cellophane. After the regenerated cellulose film is cast, desulfured, bleached and washed, it is passed through a glycerine solution of high purity, then dried. The cellophane retains between 10 and 25 percent of its weight of glycerine, which imparts flexibility and durability to the finished product and prevents excessive shrinkage.

Recent work has lead to a new interpretation of the cellulose-softener interaction in terms of hydrogen-bond energies. The basic action of the softener (a term probably erroneously applied to the action of glycerine in cellophane) on the properties of cellophane seems to be its disruption or breaking of hydrogen-bonds. Water has this effect, though being fugitive it is not a commonly acceptable plasticizer. The factor weighting each softener with respect to water shows that a mole of glycerine is twice as effective in breaking hydrogen-bonds as a mole of water.

Measurements were made of the elastic modulus, of viscous flow and delayed elasticity. The inelastic deformity was found to be a linear function of the heat of vaporization of the softener, which is related to hydrogen-bonding energy.

Additional work was based on the development of a special apparatus for determining the elastic modulus — along with measurements of the softener content and moisture content at various levels of relative humidity. It was shown that the softening action of glycerine is *not* caused by a simple increase in moisture content from the presence of the glycerine, but largely by the direct effect of the glycerine molecules on the cellulose structure. At each level of relative humidity (15 to 81%) the modulus of the films decreases with increasing glycerine content, yet only at 81% relative humidity did moisture content increase with increasing glycerine content. Thus, glycerine will maintain its softening action even at low levels of relative humidity to which the sheet is exposed. From these data, the amount of glycerine needed for a particular elastic modulus at a given relative humidity can be calculated.

Glycerine-plasticized plain cellophane may be modified and improved in many ways. For example, the degree of plasticization may be varied to meet the needs of the product or a particular packaging machine. Antisticking agents may be incorporated in the glycerine plasticizing bath to minimize the tendency of superimposed cellulose sheets to stick to each other. Many other treatments for cellophane, such as increasing tear strength or imparting moisture resistance, incorporate glycerine in their processes. In one process, the cellulosic films or sheets are treated with aqueous alkaline solutions containing glycerine and an ammonia or amine salt of styrene maleic resin.

Flameproofing of cellophane can be accomplished with a solution containing glycerine, ammonium sulfamate and formaldehyde while adhesives for cellophane may be plasticized with glycerine.

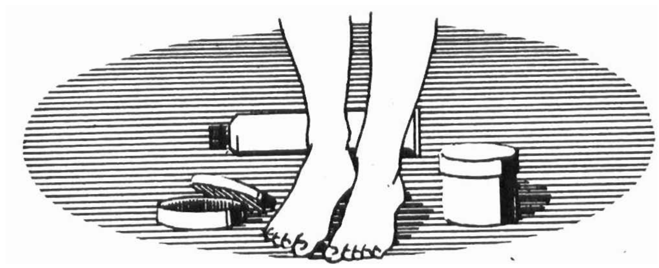
Various films and sheet materials other than those based on regenerated cellulose may be softened with glycerine; i.e. carboxymethyl cellulose, sodium alginate, and protein materials like casein and gliadin.

Much cellophane produced is used in food wrapping, and any material in contact with foodstuffs must be nontoxic under all conditions of storage and use. It has been shown that plasticizers can be absorbed from cellophane by food. Glycerine being edible and completely nontoxic is a preferred plasticizer for food wrappings.

Aside from cellophane, glycerine fluids are used in a wide variety of paper products. Chief among these is as a plasticizer and softener for glassine and parchment papers. In the making of such papers, it has been pointed out that the extremely high degree of the beating of the stock, coupled with severe super-calendering under high pressure, would yield a very brittle sheet unless additional processing were employed. So, to obtain the flexibility, the paper is treated with plasticizers before it reaches the super-calender. The plasticizers most commonly used are glycerine and sugar in the form of invert sugar or dextrose. In some cases, as in a process for making a moisture-vapor-proof wrapping material, the glassine paper is plasticized with a mixture of glycerine and dextrose.

Vegetable parchment paper which provides protection where high strength, insolubility, greaseproofing and resistance to disintegration are required, is similarly improved with glycerine. It can be plasticized with glycerine so that it is "soft as a rag."

Various other paper treatments depend on glycerine as a plasticizer. It is used to combat brittleness in silicate films on paper and chipboard. Adding glycerine to sizing compounds helps to equalize the shrinkage coefficients of the paper and size and thus aids in the prevention of wrinkling. It is used as a softening agent for paper towels, tissues, and napkins and in sealing compositions for cardboards and metal containers.



CHIROPODY AND PODIATRY

There are several ways in which glycerine serves the podiatrist. Among its functions in chiropody are its use as a humectant or hygroscopic agent, as a solvent for many active drugs, as a vehicle or suspending agent for insoluble substances, as a lubricant, a penetrant and as a softening agent. Applied to the skin it provides a soothing effect, acts to make the skin soft and supple, and affords a protective action.

These physiological, topical effects are extensively used in the treatment and prevention of foot disorders. In cases where there is hardness, drying and scaling, rubbing on glycerine serves to soften the skin and prevents further drying. Rubbed on calluses and covered overnight, glycerine has a definite softening effect on the horny formations.

Glycerine is useful also in the treatment of both soft and hard corns. It may serve as a solvent or vehicle for various caustics used in the treatment of corns, such as sodium hydroxide or zinc sulfate.

Chiropodists use many types of collodions as medicated paints or protective coatings and glycerine is a useful plasticizing agent for such products. Preparations of this type made with glycerine provide more elastic and flexible films which, in contrast to ordinary collodion, are less likely to dry out and peel off.

The emollient and lubricating properties of glycerine make it useful too for improving circulation in the feet. For this reason it is often used in massage preparations and in products used to combat chillblains. In general, glycerine is a most useful component of balms and creams for tired or aching feet, and a frequent ingredient of antiperspirants and deodorants.

Excessive sweating of the feet is frequently associated with mycotic infections, particularly "athlete's foot". Many creams and lotions designed to combat this disease call for glycerine in their preparation. The care and treatment of the toenails also find important use for glycerine in preparations for treating hard nails which are frequently based on glycerine combined with a liquid neutral soap and a surface active agent.

Conversely, when a nail hardening preparation is indicated, the inclusion of glycerine with the alum or potassium sulfate is called for.

When a nail bleach is required the bleaching agent, such as hydrogen peroxide or borax, is combined in a glycerine solution. Here again, the glycerine prevents too drastic an action by the bleaching agent.

Cuticle softeners, or so-called removers are often prepared from a small amount of alkali combined with a glycerine solution.

Aside from preparations used on the feet or nails, glycerine may be used in the various cold solutions used to disinfect a chiropodist's instruments. When added to the formaldehyde type of solution it is said to raise the disinfecting power.

COSMETICS AND TOILET PREPARATIONS

U.S.P. Glycerine is one of the basic raw materials of the cosmetic industry. It is also one of the oldest and most valuable ingredients. This time tested use is the result of its properties of humectancy, emollient action, its stability and above all its non-toxicity. Two authors, writing on the cosmetic industry stated "glycerine is pre-eminent among the humectants used in cosmetics and it is doubtful if its position can be seriously challenged by other materials in this field. It possesses greater power of water absorption than most of the other products which have been suggested for use and under normal conditions is readily available in the requisite quantity."

With the obvious exception of dry powders and hair sprays, there is hardly a type of toilet goods product in which one or more of glycerine's properties could not be used to advantage. The characteristics which make it adaptable to this wide range of materials are:

1) It serves as an efficient humectant or hygroscopic agent.
2) In addition to the plasticizing effect of the moisture it holds, glycerine itself is an effective plasticizer.
3) An outstanding solvent and a good vehicle for many substances, its viscosity provides body and the ability to suspend many insoluble materials in liquid preparations.
4) It has excellent lubricating properties and imparts a desirable smoothness to many products.
5) Its antifreeze properties are important to winter shelf life.

Proportions of glycerine used range all the way from a fraction of one per cent up to seventy-five per cent. Without considering them as absolute values, some idea of the range of U.S.P. Glycerine concentrations used in cosmetics and toilet goods may be obtained from the following list given in "Cosmetic Dermatology." (New York, McGraw-Hill, pp. 51, 278.)

Skin toning Lotions..	15%	Deodorant Pastes	20%
Dry Skin Lotions	10%	Depilating Pastes	10%
Shaving Soaps	2%	Eye Wash	3%
Brushless Shave	5%	Facial Clay	5-10%
Beard Softeners	5%	Liquid Powder	5-8%

Not mentioned in the above list, but perhaps most important of all, is the use of Glycerine in toothpastes, which require as much as 40% or more of U.S.P. Glycerine in their composition. It is the basic medium in which the toothpaste is formed and by which the paste is maintained at the desired smoothness and viscosity. Its value lies partly in the natural viscosity of glycerine and partly in its non-volatility as contrasted with water. By using glycerine instead of water or other fluids, the manufacturer protects his product against possible change from a smooth-flowing paste into a stiff or concrete-like mass. In addition, glycerine serves to sweeten the paste and dissolve or carry flavoring materials. "Fashions" in tooth pastes may change, as they have in the past fifteen years, but U.S.P. glycerine remains one of the major ingredients used. The additives that have of late years been used such as chlorophyll, ammonia compounds, fluorides and antibiotics have caused the therapeutic qualities of toothpastes rather than the cosmetic qualities to be stressed. But the basic formulation in the toothpastes has remained essentially unchanged. The standard components are still cleanser, binder, softening and plasticizing agent, sweetening compound, foam producer, aromatic, preservative and water. The softeners, predominantly glycerine, still constitute 10 to 40% of the formulation. This is needed to produce the desired consistency and glossiness, and must be used in correct proportion to the binder for perfect results.

U.S.P. Glycerine is virtually indispensable in making protective creams for the prevention of industrial dermatitis. It acts as an adjunct to the emulsifiers and as a major ingredient of the aqueous phase, used in combination with gums to make oil in water emulsions. The addition of two or three percent glycerine facilitates emulsification. When a careful balance of the water and oil phase is essential, glycerine is often used to prevent loss of essential moisture. Because of its low volatility, it helps prevent excessive evaporation and thus extends shelf life.

Glycerine serves too as an important constituent of the aqueous phase of such emulsions. Since it is completely miscible with water, it acts here both as a solvent and dispersing agent. Being oil repellent, it is an effective skin protector. Hence it is used not only in creams and lotions, but also in the preparation of protectors which deposit an elastic film on the skin during exposure, but are easily removed with water afterwards.

In the manufacture of oil-in-water emulsions, essential to the vanishing cream type of cream such as hand creams, face creams, and brushless shave creams, there are four basic ingredients; stearic acid, alkali, water and glycerine. The glycerine allows a smooth application of the cream and prevents "rolling" on the skin. Here, too, the glycerine acts to preserve the cream.

Aside from these basic forms of cosmetics and toilet goods, glycerine is widely used in what might be considered specialty types of preparations. For example, it can be used in make-up cakes, cream rouges, suntan lotions and creams, leg make-up and insect repellents.

Two types of modern preparation which may be adapted to various uses are stick cosmetics, such as solid colognes and hand creams, and the aerosol products so widely used. Aerosol shave creams and hand lotions are basically an adaptation of the more classic types of creams, and still call for glycerine in their compounding.

Glycerine's soothing and emollient effects, as well as the contribution of its physical properties, make it a valuable component of after-shave lotions and related products. With the increase in the use of electric razors, it has been necessary to provide specialized preparations to meet the requirements of the type of equipment. Here again, glycerine is frequently used to give body to the lotion.

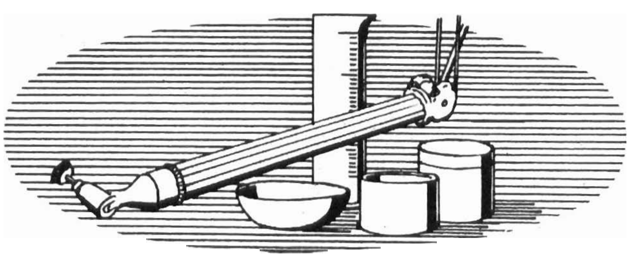
Glycerine enters quite extensively into preparations for the hair and scalp. In shampoos, glycerine helps retain moisture and delay evaporation. It tends to keep the hair softer and retains moisture. It can also act in manufacture as a clarifier or body agent.

In order to minimize the damage to hair by the heat and alkalinity of heatwaving lotions, glycerine is often included in the formula to overcome hair dryness.

The glycerine serves also to give a desirable lustre to the finish of the hair after it has been treated with a permanent waving solution. Hair reconditioning creams, dressings and hair dyeing preparations often include glycerine as do depilatory types of cream. The glycerine here gives softness and suppleness to the creams and tends to counteract the secondary effects of the depilatory chemicals.

In addition to the use of glycerine in cosmetic formulations, glycerine derivatives such as the monoglycerides of fatty acids, and both the acetylated and sulfated monoglycerides are finding wider use in the cosmetic field.

Sucroglycerides are obtained by the direct reaction of sucrose with natural fats and hence are actually mixtures of mixed sugar esters with monoglycerides. They are used as detergents and emulsifiers in cosmetics and toilet preparations. Studies on their use as compared with other wetting agents suggest that they remove less of the natural fat of normal skin and are less irritating to the eyes and mouth mucosa, but do have equally good cleansing properties.



DENTISTRY

Glycerine is used in the field of dentistry as a solvent or suspending medium for materials such as antiseptics, oral medications, root canal pastes, polishing compounds, disclosing solutions and mouth washes.

Tooth pastes may contain up to 40% of glycerine (see section on Cosmetics and Toilet Goods), but this type of use carries over into the dental laboratory where it serves as a suspending medium for abrasive and polishing materials. Office polishing agents used by the dentist for the mechanical removal of tartar often use glycerine for the suspending medium for the abrasive.

Disclosing solutions are of value to the dentist who uses these preparations to stain the mucinous and bacterial plaques on the teeth. These films take a deep brown stain, while the rest is readily washed away from the clean portion of the teeth. Most of these disclosing solutions are simple solutions of iodine, iodine salts, glycerine and water. The use of glycerine here is to reduce the irritating effects of the iodine.

Among the chief uses of glycerine in the dental field is its employment as a solvent for other medicinal agents. Foremost among these are the glycerites of boroglycerine, of iodine and potassium iodide, of iodine and zinc iodide, of tannic acid, phenol and of hydrogen peroxide. It is particularly useful as a vehicle for these drugs used locally in and around the mouth where it serves as a protective film for the skin and mucous membranes. The syrupy quality of glycerine makes it a useful vehicle to help keep in suspension many substances which would ordinarily settle out. It lends body, smoothness and palatability to many of the combinations of which it is an ingredient and contributes to the efficacy of other medicines. In the case of glycerite of hydrogen peroxide, the glycerine keeps the oxygen released from the peroxide in contact with the tissues, and serves several other functions.

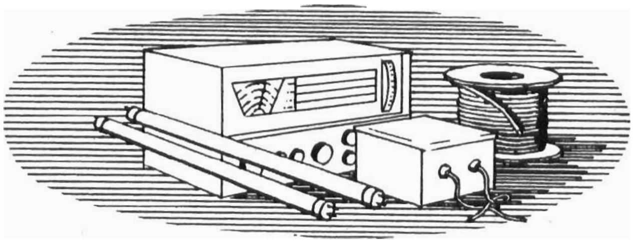
Its hygroscopic action draws plasma from the deeper parts of the wound, thereby washing out microorganisms and exposing them to antiseptic action, and its viscosity gives the solution the mechanical advantage of both liquid and ointment type preparations.

Zinc-iodide-iodine glycerites are used in the treatment of marginal gingivitis, pericementitis and lacerations where an antiseptic and astringent effect are required. Likewise, glycerine is used as the massing agent or pasting medium for making a chemical cautery employed in the treatment of peridontal pocket.

Various glycerine-containing preparations are used both in the office and home treatment of Vincents infection. Prominent among such products are local applications consisting of arsphenamine or neoarsphenamine in glycerine, while penicillin preparations used in the treatment of this disease may also be compounded with glycerine. Products used in pulp and root canal work, similarly make use of glycerine's properties. Iodized phenol solutions in glycerine have been used for treating root canals, and glycerite of iodine mixed with a special powder to make a paste can be used to seal permanently over the stumps of pulp tissue that remain in the root canal.

In addition to these, glycerine is used in treatments for hypersensitive dentin, liquid cavity seals and topical anesthetics.

Aside from its application in the prevention and treatment of oral conditions, glycerine is extensively used in the purely mechanical aspects of dentistry. It is employed, for example, in the production of such products as Moldin and Plasticine and various other molding compounds. Some dental impression waxes include glycerine in their formulation. It is a good lubricant, with the added advantage of being water soluble and hence easily washed away when employed as a parting agent in casting plaster or artificial stone. Being a good heat transmitting medium, it is sometimes used in casting plastic dentures and the like. Some of the casting materials for taking impressions include glycerine in their formulation, here the glycerine acts as the solvent for the dental impression material.



ELECTRICAL

In the production of many modern electrical appliances, glycerine is a vital material. Not only is it widely employed in the manufacture of electrolytic condensers such as are used in radios and in the production of neon lights and other forms of discharge tubes, but it also finds an important place in processes for electrodeposition and treatment of metals. Glycerine-containing resins are also used as electrical insulating agents, binders and the like.

Although glycerine is a major polyhydric alcohol, electro-chemical studies have shown that the addition of even large amounts of glycerine-water solutions to aqueous acetate or phosphate buffered solutions, or to dilute hydrochloric acid or sulfuric acid solutions, has an almost negligible effect on the hydrogen ion concentration. In contrast to ethyl alcohol, which does ionize, similar ions of glycerine are formed to such a slight degree that the electrode potential remains practically unchanged.

One of the more important uses for glycerine in this field is in the manufacture of electrolytes for electrolytic condensers. As a rule, these electrolytes are simple combinations of glycerine with boric acid or sodium borate, and are used for making semi-dry electrolytic condensers. However, modifications of this also use glycerine, as in electrolytes which on cooling set solid. These are prepared from boric acid, glycerine and urea or aniline. This material may be used for impregnating material or as a casing. A polarizing electrolyte mixture suitable for dry-type, high-voltage, electrochemical condensers can be prepared from glycerine and gum arabic and a powdered material such as aluminum oxide, to form a solid mass on setting. Also when the surface of an electrode becomes corroded, the corrosion can be removed by washing with boiling glycerine. The manufacture of gas-filled electric luminescent discharge tubes and the like offers another use for glycerine. Here glycerine is particularly valuable as a binder for coating the interiors of the tubes with luminescent material. Sometimes this binder is a combination of glycerine and boric acid and in other cases glycerine alone is used.

Another important use of glycerine is in the field of metal electrodeposition and treatment. Classically, glycerine has been used in plating baths for electroplating iron with chromium, nickel, tin, lead, gold, silver, copper, bronze or cobalt. In more recent years, it has found use in methods for electrodepositing molybdenum, indium and galium. It also is employed to increase the operating speed of plating baths.

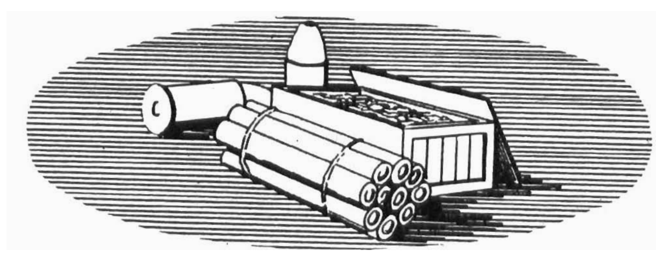
Glycerine enters too into the electrical treatment of aluminum and its alloys. In the electropolishing of aluminum and for coloring by electrochemical means, glycerine used as an inhibitor prevents excessive etching and helps produce a smooth, white surface. In studies to establish the optimum electrical conditions for formation of dense fine-grained, wear-resistant ferrous coatings, an electrolytic bath containing a combination of glycerine and sugar was found to give the best results.

A method for testing the electrical conductivity of insulated wires, developed by Western Electric Company, calls for dipping the inner end of a reel of exchange area cable (used to link telephone central offices) into a conductive solution which contains glycerine and does not evaporate. Testing apparatus can then be conveniently confined to the outer end of the cable. This is one step in testing the electrical conductivity of each pair of insulated wire conductors within the cable.

Glycerine enters too into the production of a large number of miscellaneous electrical items, and glycerine-containing synthetic resins, generally known as alkyd resins, are widely employed in electrical materials. Like glycerine itself the resins are used as binders for luminescent materials associated with electrical discharge devices, and are used for making molded heat proof caps for such equipment. Protective covers for electrical heating units may be made from glycerine-phthalic acid, succinic acid condensation products, and in making resistance elements it is combined with conductive materials.

Alkyd resins are used in rendering insulators permanently flexible, and starting with materials such as glycerine, phthalic anhydride, shellac and oleic acid resinous compositions can be prepared which are especially suitable for electric insulation. Fibrous insulating materials such as cotton, silk, asbestos, glass or paper is bonded or united to a base or enameled conductor by means of a thin film of alkyd resin. Still other electrical insulating materials may combine other synthetic resins.

Electrodeposition of tiny pellets of metal or alloys on the end of fine wires for use in transistors is made possible by using glycerine as the plating bath in which metal salts are deposited. Glycerine has been found to be the most applicable solvent which must be heated to 270° C.



EXPLOSIVES

The use of glycerine as a component of explosives is probably its most generally recognized use. In this much publicized capacity, it is not as glycerine, but as the product of the reaction of glycerine and nitric acid, namely nitroglycerine (glyceryltrinitrate) that it plays so extensive a part.

Dynamite as it is manufactured today has many modifications. It has become largely an industrial explosive, and it is used in the United States for mining, quarrying, engineering, harbor improvement, agricultural and other purposes. The sensitive qualities of dynamite and its disruptive force make it unsuitable as a propellent in rifles or cannon, but it does have its place in military explosives.

Dynamites consist of an explosive compound, usually nitroglycerine, mixed with an absorbent composed of sodium nitrate and wood meal. The proportions are so chosen that the mixture will have an excess of available oxygen on explosion, and will, therefore, produce a minimum of poisonous gases. The use of the original absorbent, kieselguhr, has been completely abandoned, since it acted as an inert filler and thus reduced the strength of the dynamite. The materials which have replaced it, wood pulp or other fuel and the oxidizing salt, absorb the nitroglycerine and at the same time contribute to the heat and energy developed by the explosion.

Dynamites over the years have extended to diversified mixtures, all having nitroglycerine as the base. Today, a score or more of different dynamites are distinguished. They all, however, have the common property of not exploding by simple inflammation, shock or moderate friction. They explode only by the use of strong caps or detonators generally composed of mercury fulminate or some similar compound.

The straight nitroglycerine dynamites are made in strengths from 15-60% and have a high rate of detonation and are, therefore, used only where quick action or shattering effect are desired. They resist water fairly well, so that they may be used for underwater blasting, but are not as well adapted to this type of work as others which are designed specifically for this purpose. The best for this under-water work is gelatin dynamite which, instead of containing straight nitroglycerine, is a colloidal solution of nitroglycerine and nitrocotton. This is absorbed on a mixture of sodium nitrate and wood meal. The plastic consistency of the product allows it to be extruded through a mold of the required diameter into paraffin paper cartridges. The strength of these dynamites ranges from 20 to 90% and they produce the least amount of noxious gases of any type of explosive.

Another of the variations of dynamite is ammonia gelatin dynamite. This resembles the gelatin dynamite except that a portion of the nitroglycerine-nitrocotton colloid is replaced by ammonium nitrate. The explosive characteristics are similar to those of gelatin dynamite.

One of the most widely used dynamites is blasting gelatin. This contains nitroglycerine dissolved in nitrocotton to form a jelly, along with a small amount of antacid such as chalk. This explosive is tough and rubbery. Water has no effect upon it and it is used where the greatest possible concentration of energy is desired.

The production of poisonous gases from dynamites has been reduced by improving the oxygen balance of the ingredients, thus making a great step forward in the safety measures attached to the use of this material. The actual employment of these dynamites and other explosives in the United States is regulated by the U.S. Bureau of Mines. Explosives to be used under given conditions are tested, and if they meet the specifications demanded by the U. S. Bureau of Mines they are listed as "permissible explosives." However, the approval does not constitute final control, since the U. S. Bureau of Mines has no power to prevent local use of other materials. The regulations on this are made by individual states.

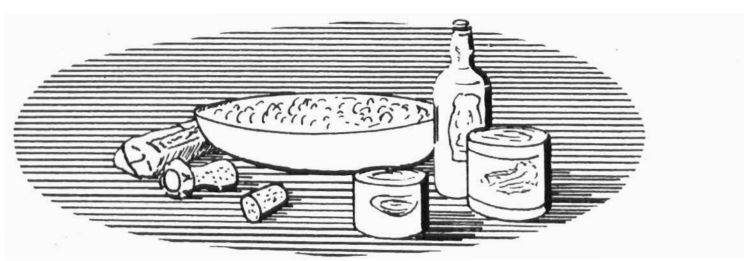
Whereas the few types of dynamites mentioned here find their widest application in the industrial field, glycerine derivative explosives also have an important part in the manufacture of the weapons of war. Whereas pyropowder is the commonest material used in military explosives, there are some types of weapons which require the use of propellents that have a greater potential than pyropowder, or, which for special reasons are commonly provided with powders having compositions different from pyropowder.

One of the most important of these propellents are the so-called double base powders. This term has been applied to the powders which contain nitrocellulose and nitroglycerine as the principal constituents. The powders which are used by various military services usually contain from 60-80% of nitrocellulose and 20-40% of nitroglycerine. Certain commercial powders used in sporting ammunition are of similar composition. However, they find the widest application in such things as trench mortars where especially rapid burning is desired. They are used in certain high velocity weapons where their high potential is valuable.

The other most widely used propellent which employs glycerine as a starting material is known as Cordite. About 1884, the French developed a propellent containing nitrocellulose, barium nitrate, potassium nitrate and sodium nitrate. Another popular propellent of the period was Ballistite, containing 40-50% of nitroglycerine. Whereas various propellents were used by other countries, none of these entirely met the requirements of the British Government. British research resulted in the development of Cordite. It was so named because it was produced in the form of cords and differed from Ballistite in that nitrocellulose was incorporated with the nitroglycerine by means of acetone, and mineral jelly was added for the purpose of lubricating the gun barrel. In the final tests, it was found that the mineral jelly was consumed in the explosion, and therefore, failed to perform its action as a lubricant. But the jelly was found to be an important constituent of the propellent because it lowered the temperature of the explosion, reducing the erosion of the barrel while increasing the volume of the gas given off, and thus maintaining the power.

The principal defects of this propellent were its tendency to erode the guns, particularly those of high caliber, and the fact that it had a limited life when stored at high temperatures. The composition of cordite was later modified to reduce the explosion temperature even more. This was accomplished by increasing the nitrocellulose.

Cordite is still used in large quantity as a propellent by the British although it has not maintained its favor with the other countries. However, all nations at the present time use as a propellent either gelatinized nitrocotton alone or else gelatinized nitrocotton mixed with varying quantities of nitroglycerine as the basis for their so-called smokeless powders.



FOODS

The solvent power of glycerine results in its use in many flavors and extracts, and such use frequently allows the elimination of part or all of the alcohol commonly used in such preparations. It has been used in vanilla flavors, and has been used in chocolate syrups to improve their body and smoothness. Flavor pastes and powders often contain glycerine. It is also a solvent for many food colors and the U.S.P. grade of glycerine, being completely non-toxic, is generally accepted by the Food and Drug Administration as a component of foods, except where specific food standards fail to list it as an optional ingredient.

Glycerine, as a by product of alcoholic fermentation is present in beer to the extent of 0.09 to 0.18 percent and in wine to the extent of about 10%. Also the addition of glycerine to distilled liquors improved their smoothness and body, and as such it has been suggested that a small amount of glycerine added to a cocktail would improve the flavor by making a smoother blend of the ingredients. With preparations of saponin and other foam-forming materials, glycerine has been used in heading liquids to produce foam on both carbonated and non-carbonated beverages.

The use of approximately 5% of glycerine in frozen eggs and frozen yolks prevents the formation of gummy lumps in the eggs, and cakes baked with glycerinated eggs have larger volume and better texture than cakes made with non-glycerinated eggs.

Glycerine enters into flavoring materials and curing salts and as a plasticizer in the many casings and coat--ings developed for the meat coating industry. It is used in both animal and artificial casings, the latter being composed essentially of regenerated cellulose. The glycerine increases the flexibility of the casings and their ease of handling and keeps them from drying out during shelf storage.

Jelly-like candies often use glycerine to prevent drying and graining, but it is also used in many other types of candies, particularly fudge, to maintain a soft texture and fine grain. Here the amount used is generally 9 to 10 percent of the weight of the sugar. In other candies the amount of glycerine may be from 5 to 15 percent of the weight of the sugar, depending on whether the candy should be firm or soft. In the same way it is used in cake icings. Here it acts to prevent the icing from graining but also from becoming hard and brittle, particularly in such things as wedding cakes where they are prepared ahead and must stand for some time before being cut.

Glycerine applied to dried fruits by dipping and spraying will reduce stickiness and inhibit surface crystallization of sugar. For the same reason, a small amount used in jams gives protection against crystallization. A recent development in this line is the preparation of citrus fruit peel for use in baking and other food preparation. In this process, the citrus peel is dehydrated by use of a high solid transfer medium made from dextrose, glycerine, corn syrup and starch. Here the transfer medium becomes the replacement agent, and results in a peel which is semi-translucent, has a natural peel color and retains the essential oils and "bite qualities" of the fresh form.

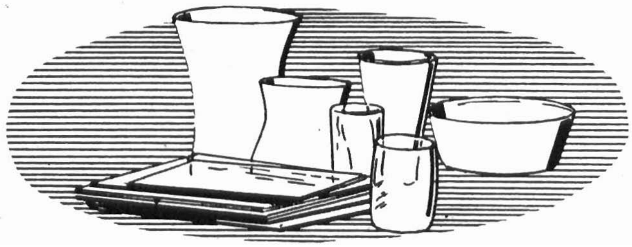
Glycerine, glycerine-salt and glycerine-invertsugar solutions have been found very satisfactory for direct contact quick freezing. The advantages of aqueous glycerine solutions for this type of freezing are: their suitable viscosities, good heat transfer ability, noncorrosive properties, in proper concentration, resistance to fermentation, their ability to retain natural color, and the fact that they have no objectionable odors or taste. They do not cause excessive rupture of the cells at cut surfaces and result in a natural looking product. Glycerine used for freezing fish has been tested and it has been found that freezing fish before rigor mortise sets in, glycerine at extremely low temperatures reduces the amount of ice formation and hence the tissue protein denaturation.

The addition of small amount of glycerine to peanut butter reduces oil separation and increases the stiffness of the butter. If added to the peanut butter after it is ground it has more effect and does not alter the taste. About 4% by weight of glycerine added to shredded coconut acts as a softener and humectant and keeps the coconut from drying out in the opened package. It is also used in cakes to preserve their moisture and retard staling. It gives an increased ratio of volume to weight when used in the proper amount. This will vary with the type of cake, but usually is in the neighborhood of ten percent of the weight of the sugar used.

An important but indirect use of glycerine in food processing is in the use of so called "mono-glycerides", which are emulsifiers and stabilizers for many products. They are the products of the reaction of glycerine with a wide variety of fats and fatty acids. The results are actually a mixture of mono-, di- and triglycerides, but they contain a high proportion of the monoglycerides and hence are called by that name. These monoglycerides impart surface activity, making the mixed ester both oil soluble and water dispersible. They are excellent emulsion stabilizers and hence are added to margarine to improve its stability and reduce spattering on heating; to shortenings to increase their plasticity; to dough mixture, to promote dispersion of the fat, help maintain moisture balance in the product and permit richer formulations with longer shelf life. In addition they are used in salad dressings, frozen desserts, candy and food coatings. One important use of these glycerides is as softening and anti-staling agents in the manufacture of white bread which is sliced and wrapped.

Another use of glycerine in the food field is in the manufacture of cork liners for bottle caps. Here the cork is treated with glycerine to maintain softness and pliability, thus preventing shrinkage of the cork, and insuring a tight seal. Whole corks are sometimes treated with glycerine by dipping the cork in the glycerine before inserting it in the wine bottle. The nontoxicity of glycerine as an ingredient of goods and beverages has been established through generations of safe use and clinical and scientific studies. It is recognized as safe by the U. S. Food and Drug Administration when it is of the synthetic product. Of course labeling laws as to ingredients must be followed.

The polyglycerol esters are a more recent commercial development and range from di-glycerol to deca-glycerol esters. These are prepared from polyglycerols combined with fats and fatty acids. The esters which offer a wide range of hydrophylic and lipophilic emulsifiers are utilized by the body and broken down into glycerine and fatty acids. Besides use in foods they have applications as emulsifiers in pharmaceutical, cosmetic, and other industrial applications.



GLASS AND CERAMICS

Glycerine has several properties which have made its use possible in almost all of the various ceramic industries, and many glass treatments and preparations. One of these properties is its humectancy, and because of this, small quantities when added to various ceramic mixtures and compositions, maintain in these formulations the small amount of water required to produce in them certain properties desirable to their forming and fabrication processes. Another desirable characteristic, so far as the ceramic industry is concerned, is that it will burn out of ceramic compositions during the firing process without leaving any carbon or carbonaceous material.

Glycerine is also an outstanding solvent and suspending agent, and along with its viscosity and good flow characteristics, provides an excellent medium for use in decorating various ceramic wares. It finds its largest use in the whiteware segment of the ceramic industry where it has a variety of applications. Probably the most extensive use to be found is in various methods of applying underglaze colors and decorations to raw clayware and to biscuit or fired ceramic ware.

Glycerine alone and mixed with water is also used in the application of underglaze ceramic colors where it has the advantage of providing excellent flow characteristics for good free brush designs, and it does not require hardening or firing operations when used with small amounts of water soluble gum binder. The more absorbent the ware, the more concentrated glycerine solution must be used.

The outstanding characteristic of the underglaze colors which are applied in a glycerine medium is that they will stay "open". In other words, they will not dry out rapidly, which means they are easy to handle on the color pallet and can readily be brought back to the proper consistency by addition of a few drops of the medium. This is in contrast to other media such as volatile oils which tend to lose their solvents by evaporation.

Glycerine also finds uses in the stamping of underglaze colors, both on biscuit and unfired or greenware. In this application, the stain along with the fluxes, other ingredients and adhesive is milled in a water medium. This mixture is then diluted with glycerine in sufficient quantity to get the working characteristics required for the rubber stamp and the particular ware surface being used.

Still further application is found in the decorating of whiteware products in certain silk screen underglaze decoration applications where glycerine is used in conjuction with other media in making up the underglaze colors. Other applications for glycerine in the whiteware field of ceramics are found in its use as a suspending agent for etchants such as hydrofluoric and nitric acid combinations used in the etching processes prior to the application of gold and color in the etched surfaces of fine china and dinnerware. It is used also in the preparation of certain whiteware casting slips where it has the ability to retard casting rates and drying. It is used too in certain whiteware applications in the formulation of plastic clay bodies where it serves to overcome certain plastic deficiencies.

The final use of glycerine in the decoration of ceramic whiteware is in the preparation of decalcomanias where it helps to insure perfect register in the multicolor decalcomania preparation process. It also finds use in the adhesives of decals as a solvent, plasticizer and blender.

Non-oily vitreous porcelain enamels for use on ceramic materials and metal may also employ glycerine. With these glycerine-containing combinations, a plurality of coatings may be fired at one time because of the adherent characteristics of the carrier, and these mixtures may be sprayed, brushed or screen applied.

In the abrasives manufacturing segment of the ceramic industry, glycerine-phthalate resins are being used extensively as bonding agents for the abrasive grains, and they are also used in the manufacture of special foundry cores.

In the manufacture of electronic and newer ceramic products, glycerine has a number of applications. Vacuum tube cathode insulators, ceramic capacitators and piezo-electric ceramic materials are often extruded in columns having thin wall sections and multihole structures. In aqueous systems, a small amount of glycerine (2-5%) will act as an excellent internal lubricant. Glycerine also provides the advantage that after the extruded column is cut off into suitable lengths, controlled humidity drying is not necessary to prevent differential shrinkage and warpage. The humectant ability of glycerine slows the drying process and thus reduces the tendency to differential shrinkage that causes warpage.

In the field of uniting ceramics to metals, glycerine is used in the special protective coatings that are employed in combination with the metallic solders. A number of the newer ceramic compositions are pressed isostatically and glycerine is the commonly used hydraulic fluid in this type of pressing.

An unusual application of glycerine is found in the manufacture of very thin walled titania and titanate dielectric capacitors. In this application, it improves the extruding characteristics and permits drying under controlled conditions. Prior to the addition of glycerine to these formulations, the cutting operation was causing very high losses due to chipping and cracking. However, the addition of glycerine with its humectant properties retained the small amount of moisture necessary to reduce, and in some instances, completely eliminate chips and cracks in this operation.

Another use of glycerine in conjunction with ceramics is in the manufacture of dental impression mold material, where it is blended with ground clay of low oil absorbing qualities.

In the manufacture of glass products, glycerine plays a wide role. In compositions for etching glass surfaces it is used, because it provides good solvent action for the active fluorine compounds, and it provides a certain amount of body or viscosity so the action will remain localized, and to some extent, because of its hygroscopic or moisture-retaining action. It is used in the composition of both glass etching inks and pastes. The properties of glycerine are called into play also in processes which depend on heat for the fixation of pigments or other materials onto glass, as so called "stamp pad" methods for marking glassware may also employ glycerine.

Where purely mechanical means, like sandblast etching are used, glycerine may help to achieve better results. In this process, sheets of glue made flexible with glycerine are used as stencils for designs on the glass surfaces.

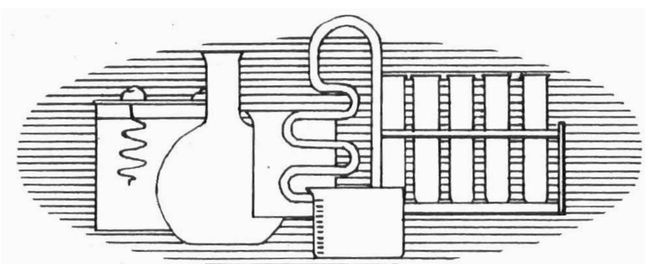
In the grinding and polishing of glassware glycerine may be used as a suspending medium for the abrasive. It has body enough and is sufficiently viscous to carry the abrasive well, and it is water soluble, thus making it easier to wash away the excess grinding agent when the job is done.

In removing scratches from glass surfaces, a paste of glycerine, water and jewelers rouge, when rubbed on the glass surface will cause the scratch to disappear, leaving the surface smooth and polished. Several properties make it useful in preparations for cleaning and polishing glass and to prevent misting, cloudiness or fogging of the glass surface. This applies not only to preparations dispersed in liquid, paste or pencil form but also in solutions for impregnating paper, cloth and chamois, such as antifogging cloths for use on car windows, eyeglasses and the like.

While glycerine is not much used in the production of the standard type of silvered mirrors, it is frequently used in the manufacture of decorative gold or copper mirrors, and has been used in compositions for making metallized designs on glass surfaces.

The use of glycerine in litharge cements is applicable to the glass and ceramic industries as it is in so many others. These glycerine-litharge cements have exceptional strength, and when hard set, are resistant to heat, moisture and most chemicals, and are gas tight, hence can be used for ceramic or glass joints.

The alkyd resins (glycerine-phthalic acid) are sometimes used for laminating glass with other compounds such as metals or decorative coatings applied to glass.



LABORATORY USES OF GLYCERINE

In discussing the laboratory uses of glycerine it must be approached from two points of view . . . 1) the clinical laboratory and 2) the industrial laboratory.

In the physics laboratory, glycerine finds use in studies of fluids, solid mechanics, thermodynamics, optics, acoustics and other areas. In studies of liquid-liquid flow phenomena, glycerine may serve varied functions. It has been used to study basic phenomena in viscosity, as for example in oil and water emulsions. In studying the influence of the internal phase viscosity on concentrated emulsions, glycerine was employed to show that neither the internal phase viscosity nor the ratio of viscosities of the phase, affects the emulsion viscosity. Resistance to wetting constitutes a major obstacle to material or product development. Glycerine-siloxane emulsions have been used for testing lubricating and waterproofing effects on hydrophobic compounds.

The high viscosity of glycerine is useful for studies on droplet generation and study, and since viscosity is a primary factor in the development of fluid foams, antifogging agents, and hydraulic fluids, glycerine is often used on studies in these areas. Aqueous solutions of glycerine are used as standards for the calibration of viscosimeters. In thermodynamic and heat transfer research, glycerine also serves many useful functions. For example, it has been used for basic studies of self-ignition temperatures of combustible liquids.

In the study of optics, glycerine has been used in methods for extending periods of color retention in fibres and the analysis of colored glass powders. In the latter, glycerine is used to generate the reflection spectra. In acoustics, experiments have been conducted to show that temperature rises may be produced when appropriate liquids are irradiated by ultrasonic sources. Glycerine is one of the few liquids to show a considerable rise; a rise attributable to its large viscosity coefficient.

In electricty and magnetism studies, glycerine has been used widely in experimental work. A glycerine solution is the basis for Method A, ASTM E104-51, for maintaining relative humidity by aqueous solutions, the method widely used to determine dielectric strength of electrical insulators. Besides the foregoing, glycerine has been used in a number of experimental studies in atomic and nuclear physics.

In the chemical laboratory, glycerine has been used primarily as a reagent material for its important esters, the alkyd resins and ester gums. It is used in an auxiliary role in such processes as paper chromatography, and titration, polarography and the study of the structure of high molecular substances, and has found application in fluid foam formations, especially in the field of dynamically stable foams.

In addition glycerine is employed in many analytical procedures by cyto- and histo- chemists. It is used in the Gersh modification of the Macalum method for histochemical detection of potassium, in the preparation of a special reagent in the Hand method for determining mercuric mercury, in the Gersh method for chloride and phosphate-carbonate detection and as an ingredient of a special reagent in the Post and Laudermilk iodine stain procedure for cellulose.

Other examples of glycerine applications in analytical procedures are the following:

(a) in the Kinsey and Robinson titrimetric method for determining urea,
(b) in the Linderstrom-Lang and Holter methods for proteolytic enzymes, the so-called "acidimetric acetone" and "alkalimetric alcohol" techniques,
(c) in the Glick acidimetric methods for esterase, lipase, and cholinesterase,
(d) in the Scholander and Roughton volumetric method for carbon dioxide, and
(e) in the dilatometric method of Linderstrom-Lang and Lanz for peptidase.

In addition to these, glycerine is used in a method for the determination of surface area of kaolinite. Here the surface area is calculated from the retention of glycerine and particle size. Another process where glycerine is used is in the colorimetric determination of dissolved oxygen in low concentrations in such things as boiler feed water. The determination is made by comparison with a color chart of liquids. The glycerine ingredient of the color reagent, of which it comprises 75%, is important in that it increases the speed of formation of the reduced indigo carmine indicator, and results in stability even in air. Without glycerine the reduced indigo carmine is not stable. The glycerine also results in a sharper, brighter color making for easier reading of the color comparisons.

Glycerine also plays an important role in the biological laboratory. It is widely used in bacteriological work, hematology and pathology.

Glycerine serves as a carbon and energy source for many microorganisms. It may be used under both aerobic and anaerobic conditions of growth, depending on the nature or the organism and the conditions of growth. For this reason many of the culture media for growing bacteria and yeasts utilize glycerine. The use of dilute glycerine in media enhances the growth of a number of bacteria and for this reason, it is an important constituent of numerous media such as Petroff's, Conrad's bile medium for typhoid blood cultures, Bordet-Gengou medium for pertussis (whooping cough bacillus), Long's medium, Sabouraud's and many basic media.

Another use for glycerine by the bacteriologist is in the differentiation and identification of species of bacilli by their ability to attack it with the production of acid or acid and gas. It is especially useful in the cultivation of the Tubercle bacillus, since its inclusion in the culture medium appreciably increases the oxygen uptake. Some forms of yeasts use glycerine in their culture media.

Glycerine in higher concentration than used for nutritional purposes is widely used as a bactericide to inhibit the growth and multiplication of microorganisms, and has been used as a preservative for vaccines since the early days of the vaccine preparation. This action of glycerine as a germicide is due probably to the withdrawal of water from the bacteria rather than by interference with the nutrition of the bacteria.

To obtain a differentiating stain it is necessary to stain the nuclei of the organism one color and the cytoplasm another. The stain most commonly used for staining both plant and animal nuclei is haematoxylin, and the most frequently used haematoxylin staining solutions are those containing glycerine. The best known of these are Delafields haematoxylin and Ehrlich's haematoxylin, both invented in the last century and still widely used. The purpose of the glycerine in these two staining solutions is twofold, namely (1) to retard the action of the haematoxylin so that the nuclei take up the stain intensely before the other parts of the tissue become heavily stained, and (2) to retard the evaporation of the staining solution. Several other stains used for tissue and bacteria staining also include glycerine in their formulation, such as Giemsa stain and carbol methyl green-pyronin.

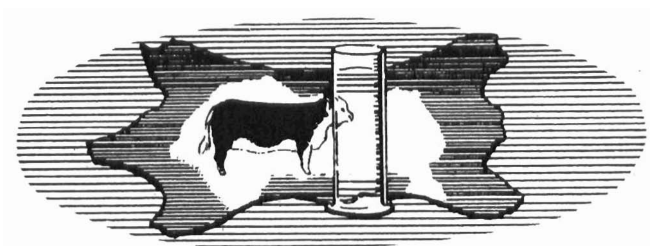
In the pathology laboratory, in addition to the staining of the tissue, glycerine is used for embedding tissue in the preparation of the so-called "Frozen Section". Here a thick solution of gum arabic with glycerine as a plasticizer is used to embed the tissue prior to freezing. After staining, these frozen sections are mounted on microscope slides with a glycerine jelly and covered with a cover slip that is held in place with glycerine while the slide is examined. Another instance in which glycerine is used in the pathology laboratory is in the preparation of sections for microscopic study of tissues which contain fat. These are embedded, directly from water without dehydration, in gelatine to which a small amount of glycerine has been added. Here the glycerine acts as a plasticizer. The sections are then cut and affixed to the microscope slide with glycerine albumen adhesive and after staining are cemented to the glass by means of glycerine jelly. Glycerine jelly is used for these fat-stained preparations because it not only acts as a plasticizer but also tones down the undesirable yellowish tinge of the gelatin, thereby rendering the stained sections more clearly visible under the microscope.

Apart from microscopy and culture media, glycerine has a number of other uses. For example, it is used in medical and biological museums, where glycerine jelly is frequently used for the display and protection of biological specimens. It is used for the same purpose in botany and zoology. The specimens are frequently kept embedded in glycerine jelly in hermetically sealed glass jars with bevelled walls to give a clear view.

Glycerine jelly is often colored with dyes or pigments to produce injection masses which are used in museum specimens for the display of blood vessels, etc.

With potassium hydroxide, glycerine is used to clear specimens for the demonstration of ossification centers. Because it does not fluoresce in ultra violet light, it is used as the mounting medium in fluorescence microscopy, which is much used in the diagnosis of tuberculosis. Other uses of glycerine include its use as a dehydrating agent, and for softening brittle tissues, thereby facilitating their sectioning prior to staining.

Most of these laboratory uses of glycerine have been practiced for years. A fairly recent use in this field was as a microscopic mounting medium for the examination of specimens taken from the interior of meteorites, which when examined under a high power revealed fossilized biological cells of a type unknown on earth.



LEATHER

Preparations formulated with glycerine are important in all aspects of leather manufacture from the initial treatment of the green hides through the utilization of the ground scrap leather, and include pre-tanning and tanning solutions, fat liquoring preparations, liming and depilatory compounds, dyeing and staining preparations, adhesives and finishes.

Glycerine is a valuable solvent for many substances, including dyestuffs used to color leather. Because of its penetrating action, glycerine helps to assure the more even absorption of these dissolved substances. Since it is a heavy, syrupy fluid, its bodying action helps suspend and disperse many insoluble materials. Its smoothness and oiliness make it a valuable lubricant but one that has the advantage of being completely miscible with water and alcohol.

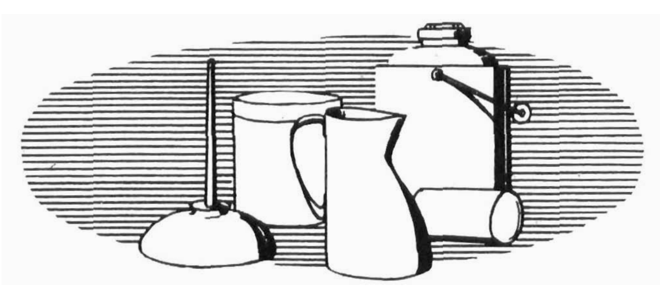
The most important properties of glycerine so far as the leather industry is concerned are its plasticizing and hygroscopic or humectant action. It helps to maintain the moisture content of the leather, thus preserving its tensile strength, stretch and flexibility. Although most applications of glycerine in the leather industry are based on its physical properties, its chemical properties are utilized in the production of chrome liquors for tanning. Here glycerine converts sodium bichromate to basic chrome sulfate when mixed with sulfuric acid and water.

Fat liquoring utilizes the lubricating, softening and penetrating effects of glycerine to help restore leather to its original strength and elasticity, following liming which removes natural fatty acids from the leather. Combined with different oils and chemicals, it can be used in fat liquoring heavy leathers, light leathers, suede and calf. In treating suede, the glycerine in the original fat liquoring provides for cleaner buffing, and for quicker and better wetting the backs of the skins. After coloring and washing, the suede calf is fat liquored again with a glycerine containing composition. Vegetable tanned leathers such as bag, case, and strap can be oiled off with a combination of glycerine and sulfated oils.

Leather adhesives containing glycerine are often made and kept more flexible by the hygroscopic and plasticizing action of glycerine.

Leather finishes at best are a very complicated mixture of various kinds of materials chiefly because finishing techniques and formulations are still considered an art with little application of scientific principles. The finisher relies on "feel". The value of glycerine as a softener and plasticizer in finishes has long been recognized and is used in many old and new formulations. Glycerine, added to lacquer emulsion type finishes, will improve the strength and resiliency and diminish the cracking of the leather. Bottom finishes of the casein-shellac type also utilize glycerine. In recent years, synthetic alkyd resins made with glycerine have been finding increasing use in finishes for leather. Glyceryl phthalate resins of this type first proved their value when used in connection with nitrocellulose in lacquers. Because they can be modified in various ways to meet individual requirements, the alkyds have become the most important resinous components of modern protective and decorative finishes for leather.

Adding glycerine to processing preparations improves the strength, flexibility, pliability, and other properties of leather in its numerous applications in the industry.



LUBRICANTS

Valuable by itself for many lubricant applications, glycerine is also an important component of, or additive to, greases and related products. Applications for glycerine-containing products range from the lubrication of fine laboratory instruments to that of powerful diesel engines.

The wide range between freezing point and boiling point of glycerine makes for its effectiveness as a lubricant under a wide range of conditions, especially at low temperatures. It has a low fire hazard, and it is also a wholesome and non-toxic substance. The latter property accounts for its frequent use in food processing equipment as well as for lubricating diagnostic and surgical instruments.

Of major importance is the ability of glycerine to stand up under the action of hydrocarbon and other organic solvents and vapors that remove ordinary lubricants. It is used for instance as a lubricant in special pumps for handling propane and butane. In these, lubrication and sealing at the gland are provided by a reservoir containing glycerine that entirely surrounds the stuffing box and prevents gas from reaching it. Glycerine, combined with potassium soaps, is also used for the stuffing boxes of high duty agitation equipment on pressure reactors and the like. Other glycerine-soap combinations are suitable for the lubrication of taps and other moving parts in pipe systems carrying a hydrocarbon gas that liquefies under pressure. Glycerine too, is used extensively in the production of grease-like lubricants which are resistant to hydrocarbons and suitable for use at low temperatures. In addition to their use with solvent vapors, glycerine-based lubricants are also employed on the moving parts of containers or dispensers of explosive or corrosive gases. It has been pointed out that glycerine should be used for all lubrication on the mechanism of gas (acetylene and oxygen) welding equipment for the same reason it is used as a lubricant on oxygen equipment in operating and hospital rooms, to preclude ignition by static electricity.

The antifreeze properties of glycerine combined with its lack of toxicity make it an ideal lubricant in machinery used for foods. For example, in hardening rooms where cans of ice creams are conveyed at low temperatures, glycerine is used as the lubricant for the conveyor, and in food plants it is used to lubricate moving parts, other than in motors.

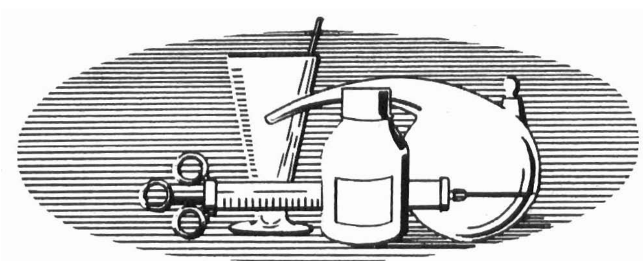
When glycerine and glycerine-containing lubricants are used with rubber goods, they serve not only as lubricants, but also as extenders for the life of the rubber. This in marked contrast to the action of mineral oil and similar lubricants which cause brittleness and deterioration of the rubber in comparatively short time. As a lubricant for rubber parts and surfaces it has been used in extruding processes, as a mandrel and core lubricant and as a mold lubricant. It is particularly suitable when used as a lubricant in the rubber forming of light metals.

Dispersions of colloidal graphite in glycerine are extensively used as lubricants for rubber surfaces. Similar dispersions are valuable as lubricants for oxygen compressors, stopcocks and as special purpose lubricants. Another glycerine dispersion, in this case glycerine with powdered copper and graphite, is used as a lubricant for threading and said to be particularly suitable for preventing galling or burning together of threaded connections in gas turbines.

Glycerine can often play two roles, as in its use in an extrusion process in which the glycerine acts as an hydraulic fluid and lubricant at the same time, or in the fabrication of ceramic parts from metal oxides, where it also plays a dual role. Glycerine is an important component of many modern greases made with hydrocarbon oils and soap. The glycerine, which may be present as a by-product of saponification during the manufacturing of the grease or as an additive, serves a number of useful purposes in this type of lubricant. It aids in stabilizing the structure of the grease, reduces the change of consistency, increases the lubricating power and prevents increase in the coefficient of friction at all temperatures below 90° C., and causes a greasy film to be deposited at higher temperatures.

Studies on sodium soap mineral oil systems have shown that the addition of glycerine increases the surface activity of the soaps at given concentrations, but the temperature at which the surface activity is attained remains unaffected. The presence of glycerine in a grease having a soda base also enables a nonpolar oil to wet the soap. As for the fiber structure of greases, glycerine is essential for the production of long fibers in ordinary practice, because the oil can wet the soap in its presence. Polar compounds such as glycerine, promote fiber growth by facilitating the recrystallization from the gel form.

Cohesive grease, suitable for lubricating chassis bearings, may consist of oil, aluminum stearate, polymerized isobutylene as a thickener and up to 2 percent of glycerine. The addition of glycerine to aluminum soap greases is said to reduce the difference between the unworked and worked penetration values, and to improve the resistance of the greases to working. Glycerine is used as a dispersant in the formulation of extreme pressure lime-based greases containing a lead soap, or with lithium or other metallic soaps in lubricants for specialty equipment employing shielded or sealed bearings and operating under wide temperature ranges.



MEDICAL AND PHARMACEUTICAL USES OF GLYCERINE

U.S.P. glycerine has for years been one of the most widely used chemicals in the field for pharmaceuticals and drugs. It is recognized as non-toxic and acceptable for these uses by every country. For example, the British Pharmaceutical Codex lists glycerine or a glycerine derivative twenty-seven times as a drug or component of drugs. The U.S.P. lists it in nineteen applications and the National Formulary eighty six. Glycerine's use in pharmaceuticals is mainly as a vehicle for drugs, or to maintain moisture in a preparation used for topical application. Being completely non-toxic, it can be used safely for internal or external treatments.

Glycerine is a frequent component of calamine lotions, acne lotions, expectorants, eyewashes, nose sprays, gelatin capsules, contraceptive jellies and creams, ear drops and poison ivy solutions. In addition, small pox vaccines are often made in a glycerine vehicle, and phenol in glycerine has long been a standard treatment for ear ache. The combination of phenol in glycerine has now been adapted for another use, that of injection for relief of pain in patients with cancer. Glycerine is also used as a vehicle and solvent for digitalis for intramuscular injection, and in sclerosing solutions for treatment of varicose veins and hemorrhoids.

Glycerine plays an important role in preparation for treating wounds. A solution of alcohol and glycerine may be used as a wet dressing to keep a wound soft, maintain drainage and prevent infection. Dressings soaked with glycerine can be changed more easily and with less discomfort to the patient since they do not dry out and adhere to the skin. Glycerine in wound dressings acts as a dehydrating agent and thus causes a flow of lymph to the surface, carrying with it toxic products of infection as well as bacteria. It reduces the tissue swelling and intra-tissue pressure, thus allowing a greater blood supply. Glycerine, besides being hygroscopic, is antibacterial in high concentrations and thus the bacteria discharged into the dressing become prey to this action.

Glycerine is used, too, in conjunction with various of the antibiotics. In the case of penicillin, it is also used in the fermentation medium where it stimulates penicillin yields during the submerged growth of the penicillium mold, and in the fermentation method of producing chloramphenicol.

Glycerine has found rather extensive use in the various preparations for topical administration of antibiotics. It is widely used in the preparation of ointment bases used as vehicles for applying penicillin to pyodermas, infected wounds and the like. A solution of glycerine is recommended as a solvent for streptomycin and isoniazid, while glycerine based creams and ointments have been suggested for incorporating bacitracin and dihydrostreptomicin.

In dermatology, a supersaturated solution of sulfanilamide in glycerine has proved a successful remedy for many types of acute, infectious skin conditions. By itself, or in combination with other materials it is an excellent vehicle for antiseptics. Urea peroxide in anhydrous glycerine, in concentrations of from 0.2 to 20 percent, is an effective antiseptic for use in tubercular abcesses, surface wounds and as a skin disinfectant. In the presence of water, urea peroxide breaks down into urea and hydrogen peroxide, while the glycerine not only stabilizes the urea peroxide but when applied to a wound draws plasma from the tissues and thus washes out the bacteria.

In the field of optometry, glycerine finds its most frequent use in the compounding of preparations for soothing and treating the eyes. The maximum proportion of glycerine considered suitable for eye lotions is six to eight percent. It is also often used in the preparation of opthalmic ointment bases.

Glycerine is an important ingredient of many contraceptive formulas being marketed today. Laboratory research on 90 contraceptive preparations including jellies, creams and suppositories showed that some of the most effective preparations contained a percentage of glycerine as high as 85% in combination with spermicidal ingredients. Tests were carried out on human semen and on the basis that effectiveness was directly proportional to the power of the contraceptive preparation to immobilize the spermatazoa.

Probably the best known use of glycerine in medicine is as the derivative, nitroglycerine. This has been used for years in the treatment of angina pectoris. The action here is as a vaso-dilator, thus relieving the pain accompanying the attacks. Other glycerine derivatives used in medicines are those used as so-called tranquilizers and iodinated glycerine which is employed as an expectorant in asthma therapy.

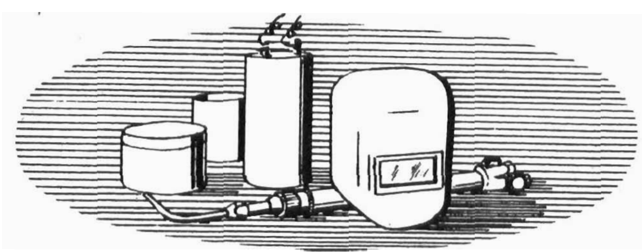
In the surgical field, glycerine is used for osmotic drainage of the uterus and peri-appendicial abcesses, and with other drugs as a vehicle in urethra disinfection. In cases of laryngeal paralysis resulting in the immobilization of the vocal cords, Teflon powder (a tetrafluoroethylene polymer) mixed with glycerine has been found to be the best material to inject into the pharynx to correct this condition and restore normal speech.

Another use of glycerine in the area of the mouth and pharynx is a 10% urea peroxide in anhydrous glycerine for the treatment of infections in this area. The solution is non-toxic and effective against a wide spectrum of bacteria and fungi. It is said to be far more effective than a gargle, since it can be swallowed and the viscosity of the glycerine causes the solution to adhere to the tissues. It has the added advantage that it can be successfully used on small children who could not gargle.

As pointed out earlier, glycerine draws moisture from the tissue and for this reason has been chosen as the vehicle for icthyol in burn therapy. The glycerine plays three roles in this treatment. One, it dehydrates the burns while keeping the skin flexible, prevents cracking of new epithelium and quickly eliminates intradermal edema; second, it is sticky and thus reduces cross infection by trapping exudates, and third it accepts and keeps antibiotics and bacteriostatic agents in contact with the wound.

Over the past several years, much work has been done on the preservation of tissue and cells, both of humans and animals. Today, as a result of this work, red blood cells (erythrocytes) are frozen and stored for long periods of time, thus making available a given type of blood cell when required without searching for donors in times of emergency. Recent studies have also shown that bone marrow could be stored in the same way, and used following exposure to atomic radiation, which destroys the marrow and the native ability to regenerate this type of cell. Marrow which has been stored in a frozen state, when injected will operate to regenerate new marrow.

Similar to this is the use of frozen bull semen in the breeding of pure bred cattle. Glycerine, used as the medium for freezing, maintains the proper atmosphere of osmotic pressure so that on thawing the cells are motile. This use over the years has led to the development of preservation of human spermatozoa for artificial insemination. Successful use of this procedure has been demonstrated by achieving pregnancies and progeny with frozen human semen.



METALS

Glycerine is used in many phases of the metal industry, but in metal finishing it has attained an outstanding reputation for facilitating production and improving results. Perhaps nowhere is glycerine's usefulness in metal finishing more evident than in several widely used electrolytic processes, one of which is electropolishing. The solutions used in this process are generally acidic and contain certain organic materials, among which glycerine is prominent.

Glycerine first attained its pre-eminence as a major constituent of phosphoric acid baths for polishing stainless steel. Subsequently, its value in baths of sulphuric acid was confirmed in both laboratory investigations and plant operations. For example, in a process for making and finishing stainless steel spinning jets for extruding rayon, the blank is first polished by making it the anode in an electrolytic bath consisting of roughly half and half phosphoric acid and glycerine. The process is said to supplant the time-consuming machine work previously used and to give a smooth finish and high polish throughout the orifices.

Electropolishing is particularly well suited to objects not readily adaptable to mechanical polishing, as in the polishing of stainless steel hypodermic needles. Relevant to this, various metallurgical studies, including electron-refraction observations, have shown electropolished surfaces to be more resistant to corrosion than those polished by mechanical means. The specimens used in these tests were of stainless steel which has been polished in equal parts of glycerine, sulfuric acid and water.

Glycerine-containing solutions may be used for polishing both ferrous and non-ferrous materials. In one process, brass, bronze, copper, cobalt and nickel, as well as ferrous metals are anodically polished in an aqueous solution of an alkali metal salt of boric, thiosulfuric or orothophosphoric acid and glycerine. In this process, the work is chilled during the process. Other electropolishing processes make use of glycerine-containing baths. An apparent correlation has been noted between the efficiency of electro-polishing copper and the viscosity of the anodic layer. Mixtures of glycerine and phosphoric acid were found to be more effective than the acid alone. In a representative process for electropolishing brass on a production line basis a versatile orthophosphoric acid-lactic acid bath containing nearly 25% of glycerine is employed.

Anodic treatments for aluminum have long used glycerine as one of the components. In the formation of anodic protection coatings on magnesium and magnesium base alloys, glycerine is used in the electrolytic bath. Here glycerine is used because it contains polar groups and retards the formation of gases, thereby assuring a more uniform coating of the metal surface. It also has been used for some years in the electrodeposition of such metals as nickel, cadmium, zinc, and tungsten.

Electrostripping, the reverse of electrodeposition, is a valuable process in refinishing operations. In the refinishing of hollow ware, for example, the use of a sulfuric acid-glycerine solution has been suggested for stripping chromium and nickel from the base metal. A similar electrostripping solution can be used for removing nickel from steel and chromium from brass. It is also useful in controlling the chemical activity of individual components of alloys or metal combinations when other stripping methods are used. It plays a useful role too in rapid removal of oxide coatings from aluminum surfaces at room temperature without attack on the aluminum itself. Glycerine may be a useful component of materials for coloring anodized aluminum. Direct printing of dyestuffs on the anodic film may be achieved by means of a rubber stereo with a solution containing glycerine. The dyes are fixed by steaming. Compositions for coloring other metals surfaces make similar use of glycerine. In the coloring of copper and brass articles, glycerine has been suggested to promote evenness and prevent too rapid drying of the color.

In addition to electrolytic and chemical processes, purely mechanical methods for finishing metals also make use of glycerine's combination of properties. In the barrel finishing of metals, glycerine is useful; first, for its viscosity which maintains the abrasive in suspension and intimate contact with the parts, second, because it is easily rinsed off when the operation is finished.

Another field of metal working in which glycerine plays an important role is in the soldering and welding of metals. It is an important constituent of spatter-preventives, soldering fluxes, certain electrode coatings, and antifogging and fire-proofing compounds. In welding, glycerine's most important direct production use is the spatter preventive compounds. As a component of the anti-splatter and anti-flash products it acts as a plasticizer. The compounds are readily washed off with water or metal cleaner solution.

Glycerine is also used effectively to prevent adhesion to dies and jaws of automatic resistance welding machines. As welding aids, anti-splatter compounds save a lot of man hours. Descaling, grinding, wire brushing, and other cleaning operations are greatly minimized or completely eliminated.

Another glycerine product used in many welding shops is glycerine-litharge cement. While not used directly in welding operations, this luting compound finds frequent use when heat exchangers and similar weldments are pressure tested.

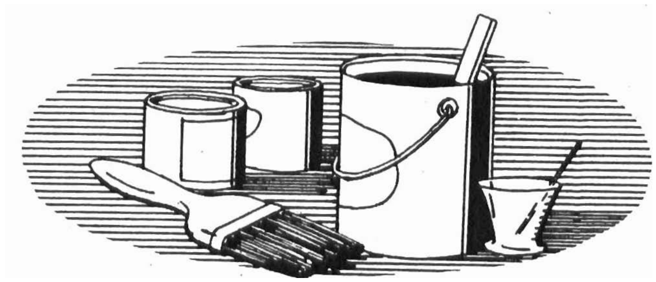
The compound is a paste type of mixture of glycerine and lead oxide, and it is extremely useful as a sealer or "dope" for pipe fittings and other threaded connections. This glycerine-base cement is also an excellent pipe cement for permanent use. It sets up a hard bond of great strength, and the setting time depends on the litharge. As a constituent of soldering fluxes and pastes, glycerine plays another important role. The glycerine additive gives the flux adequate surface tension to insure thorough wetting of parts to be joined. It is used in the common zinc chloride and muriatic acid solutions to prevent water spatter when heat is applied to the flux. These fluxes are applied by brush and ten percent glycerine has been recommended to be added to the flux as a plasticizer.

In semi-automatic and fully-automatic welding equipment, glycerine is often found as an additive to the coolant. Its tendency to super cool at low temperatures rather than crystallize makes it an outstanding permanent base anti-freeze for the packaged inert-arc and submerged-arc units whose nozzles are water cooled.

Another aspect of the metal industry in which glycerine finds use is in the manufacture and fabrication of wire products. Here glycerine and the synthetic alkyd resins made with glycerine find a number of applications. For example, glycerine may be a useful component of the chemical compositions used to remove any dirt or scale which may have accumulated on rods or wires during hot rolling. The addition of glycerine to chemical derusting and descaling solutions greatly facilitates the removal of dirt, oil, colors and the like without affecting the derusting action. Relative to this is a method utilizing glycerine for neutralizing pickling acid and inhibiting rusting. In this procedure, directly after pickling, the metal is rinsed in a solution containing caustic alkali, glycerine and sodium metaphosphate. This is said to give results superior to the usual oil methods.

When tempering of wire is required, glycerine and its solutions will bridge the gap between oil and water. The higher the ratio of glycerine to water, the milder the quenching action. Highest elasticity and maximum hardness are obtained when glycerine is the major constituent.

Coatings based on alkyd resins are outstanding for their toughness, durability, resistance, elasticity and high insulating properties. A number of alkyd resins are designed for use in protective or insulating coatings. In some cases, alkyds form the sole resinous materials for the wire coats, but more often they are used in conjunction with other film-forming materials. Alkyds can be used as flexible resins for attaching asbestos to copper wire, or in combination with urea-formaldehyde resin to bond glass silver to wire to form an insulated electrical conductor. Fabrics, paper and other sheet material used to protect and insulate wire conductors are often impregnated with compositions based on alkyd resins. Varnished electrical insulating cambric is often prepared with alkyd resins, and various cellulosic materials impregnated with appropriate alkyd resins are recommended as insulating wrappings for cables because of their superior dielectric strength.



PAINTS

For more than forty years — the period during which the modern paint industry has developed — glycerine's usage has steadily increased with the constant expansion of the paint field. Not only has the utility of glycerine grown in volume, but it has been greatly diversified to meet the demands of progress.

It may be said that the modern era in paint technology began with the introduction of ester gum, which has been called the first important contribution of the synthetic resin chemist. A product of the reaction of rosin (abietic acid) with glycerine, ester gum made possible the development of uniform vehicles having properties far superior to those previously possible with rosin-based products. Ester gum varnishes are low priced, neutral (when made with tung oil) and fast drying as compared with natural resin varnishes. Although synthetic resins have since been developed, ester gum still finds extensive use.

Substantial modifications have been developed. One of these was the development of so-called resinous alcohols, reaction products of rosin, glycerine and fatty acids. Resinous alcohols are viscous, noncrystallizing liquids, soluble in many organic solvents and compatible with fatty acids and fatty oils. The physical properties of the materials suit them particularly for use in high quality varnishes and alkyd resins.

Aside from rosin, other natural resins have benefited from combination with glycerine. Thus to make a material suitable for use in lacquers, copal resin is dissolved in linseed fatty acids. Linseed oil is then added and the mixture esterified with glycerine. The resulting alkyd-like product is light fast and particularly suitable for tin can lacquers.

The major application of glycerine, however from the standpoint of its utility in the paint field is in alkyd resins, the "backbone" of the paint vehicle industry.

In spite of the simplicity of the basic alkyd reaction, there is probably no other class of resin capable of such wide variations in physical properties and applications. The three basic constituents of oil modified alkyd resins, namely, polyhydric alcohol, dibasic acid and fatty acid, offer a number of combinations for resins with differing properties. Even when the composition of a resin is limited to glycerine, phthalic anhydride and fatty acids, it is possible to make an infinite variety of resins by varying the proportion of the raw materials, the kinds of oils and the processing conditions.

Probably the greatest single factor that has made glycerine the predominant polyhydric alcohol, is the ease with which its reactions can be controlled. It can be cooked longer than its more highly functional counterparts without undue danger of gelation, to yield viscous resins of low acid number, such as those required for architectural finishes. By varying the control, similar reactions can be made to yield low viscosity pure oil alkyds such as those that find application in latex paints. The flexibility in formulations made possible with various oil-modified glyceryl-phthalate resins greatly simplified the task of meeting a wide range of specifications with the fewest variables and the least experimental trial and error.

The application of an alkyd utilizing glycerine is largely determined by its "alkyd ratio," or the proportion of glyceryl phthalate present in the resin. The highest alkyd ratio ordinarily found in commercial products is about 65. With such resins, viscosity is very high and aromatic solvents are required. These alkyds are used as hardeners for other alkyds of higher oil content. At alkyd ratios of about 50, viscosity is still high and aromatic solvents are also required. These resins are used as vehicles for baked coatings for such items as venetian blinds, metal cabinets, cans, caps, and automobiles.

When the alkyd ratio is reduced to about 40, the viscosity is lower and solubility in aliphatic solvents is attained. These resins are usually applied by roller-coating or spraying. They find wide application in air-drying pigmented enamels, maintenance paints, metal decorating, auto and truck refinishing, and sign painting. At alkyd ratios of about 30, viscosity is still lower, and the enamels made with these resins are well suited to brushing. They are used in architectural finishes, as trim and trellis paints, and where coatings of high flexibility are needed, as for example, on toothpaste tubes. The high durability of this type of alkyd was of particular value in marine finishes during World War II.

Aside from their use as the sole resinous component of paint vehicles, glyceryl phthalate resins are outstanding for their use in conjunction with other synthetic resins and film-forming materials. In such combinations, the alkyds complement the other resins, yielding finishes superior to those obtained with either agent alone.

Glyceryl phthalate resins first proved their worth and created something of a revolution in automobile finishes when they were combined with nitrocellulose. The resulting lacquers not only speeded auto finishing schedules, but also provided better and more durable coatings. Combinations of alkyd resins with nitrocellulose made it possible to broaden the usefulness of lacquers and contribute appreciably to the progress of lacquer technology. Drying alkyds also considerably improve the properties of nitrocellulose lacquers by increasing hardness and wear resistance without undue sacrifice in elasticity. Water resistance and durability are also improved by the addition of drying alkyds.

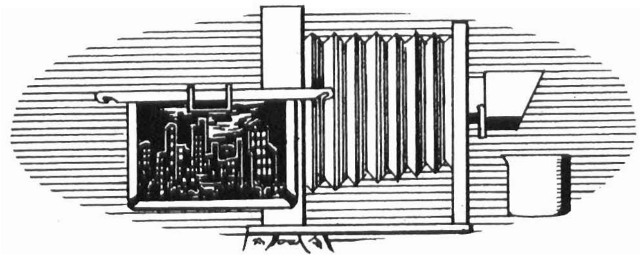
Similarly, alkyds are used to improve the flexibility, adhesion, toughness and other properties of urea-formaldehyde resins and melamine formaldehyde resins. Color, mar resistance, hardness and baking cycles are also among the characteristics improved by such combinations. Paint technologists generally agree that no other film-forming materials so adequately complement the qualities of amino resins as do the alkyds.

Alkyd resins have also demonstrated their ability to complement the properties of silicone resins.

Combinations of silicones with alkyds have led to new types of finishes with superior stability at high temperatures. In addition to this characteristic, coating films formulated with silicone-alkyds have superior hardness, abrasion resistance, adhesion and flexibility, plus a high degree of resistance to solvents, acids and alkalis. Tests have shown that such combinations also have high resistance to weathering. One silicone-alkyd blend for use in concrete water-proofing is applied like a straight alkyd and air dried. The blend is said to give better water-resistance than either material used alone. Data have also confirmed the moisture barrier possibilities of silicone-alkyd formulations on stucco surfaces.

Other synthetic coating materials are the styrenated alkyds. Such resins can be prepared by first styrenating the fatty acids, followed by esterification with phthalic anhydride and glycerine. In studies on the film properties of finishes prepared by reacting styrenated dehydrated castor oil fatty acid with phthalic anhydride and glycerine, it was found that these resins have excellent air drying and baking characteristics. It was also observed that the styrenated alkyds are faster drying than conventional short oil alkyds or amino-alkyd resin mixtures. In addition, they were found to exhibit good overall film properties.

The styrenated alkyds are low cost, fast drying enamels, in baking undercoats, and in air-drying undercoats. Indicative of their importance is the fact that some of the Armed Forces paint specifications are based on the use of fast-drying styrenated alkyd resins. Styrenated alkyd finishes are used principally on machinery and equipment in location where only fair solvent and chemical resistance are needed. Glycerine alkyds are constantly finding new uses in combinations with other resins in more and wider fields of uses.



PHOTOGRAPHY

In the chemistry of photography, glycerine is of value in many procedures and techniques. It can be used by commercial as well as amateur photographers in processing their prints. Its plasticizing and hygroscopic action make it useful in combating excessive dryness and brittleness, preventing cracking and maintaining flexibility and softness. It is an excellent solvent for many substances, and because of its viscosity serves as a suspending medium for substances that do not go into solution. For example it may be used to control the viscosity of solutions and their rate of diffusion, as in the development processing of some forms of multi-layer material. One application of this is in the method of processing immediately after exposure used in the Polaroid camera.

In photolithography, anodized aluminum plates are often used and the electrolytes used in the anodizing process often contain glycerine which acts as an inhibiting agent preventing excessive etching and producing a smooth surface on the metal.

However, a much more direct use of glycerine is to reduce grain of prints made from certain negatives, minimizing curling of prints. Glycerine is often used to advantage by commercial photographers when taking pictures of such impervious objects as bowls of fruit, plastics, metals, ceramics and statuary. Highlights, which may not otherwise appear, and brilliance not normally present, and other desirable effects are imparted with glycerine. For example in photographing oil paintings, if they are first wiped down with glycerine prior to being placed before the color camera, the excess dust is removed from the painting and much of the true color value originally applied by the artist is restored.

Coating a painting, or for that matter a photographic negative with glycerine, results in a thin uniform surface which is particularly valuable when dealing with photographic materials because the index of refraction of glycerine is close to that of the film's emulsion gelatin. This similarity of index of refraction explains why glycerine, applied with a cotton swab to the back of a gelatin negative masks the scratches or scars and results in a cleaner picture or enlargement.

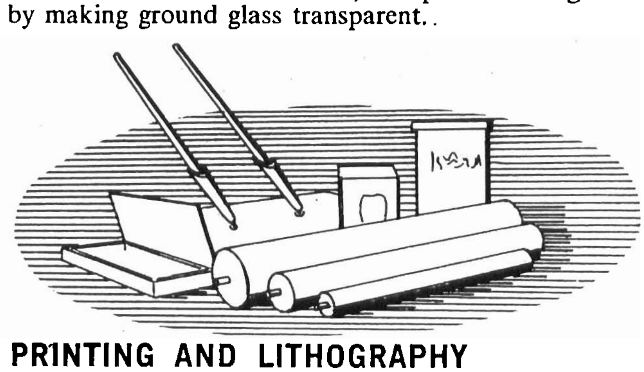
The ability of glycerine to adhere uniformly to a material, "wetting action", has been employed in photography to eliminate air bells on film during developing. (used for this purpose is a solution of 5cc of glycerine to a quart of developer). The same wetting action underlies the use of glycerine in ferrous oxalate developing formulas where the additive slows down or restrains the developing action. This ability to adhere to a surface and stay there explains why glycerine is used in formulas for certain of the inks used in writing on negatives.

Uniform coating properties plus the ability of glycerine to absorb moisture have been utilized when rush jobs do not allow normal negative drying time. Here the negative can be coated with glycerine, after the glass carrier has been removed, and the projection printed. The glycerine coating in no way affects the film, nor the quailty of the print. Should some of the glycerine remain on the film after rinsing and drying, no damage will result. Rather, benefits will accrue. The glycerine imparts flexibility and softness to film, and in the process prevents brittleness and cracking. This lubricating property of glycerine has been used especially in dry, cold climates on 35mm negatives to insure that they remain perfectly flat during projection printing. A number of proprietary products available for decurling photographic paper employ glycerine, and normally these are added to the rinse bath.

Although the removal of grain in poor negatives can not readily be accomplished once the film has been processed, the adverse effects of the grain in the finished contact print or enlargement can be minimized to some extent by dipping the film in glycerine before enlargement. The effect is that of masking the grain boundaries and yielding a more desirable finished product.

In a number of instances, glycerine can be called on as an answer to many of the problems that arise when photographic materials are handled. For example a masking paste that will not dry out even after 48 hours can be made from glycerine, soft soap and whiting. Another use is in making filters of various colors by soaking cellulose acetate film in a glycerine containing dye solution which is heated for about half an hour. Where dark room light of the right color is unavailable, a light bulb can be dipped into a sodium silicate solution containing glycerine and a water soluble aniline dye of the desired color. The glycerine prevents cracking of the thin coating when the current is switched on.

Where prints must stay flat during retouching or photographic copying, an adhesive made of hard gelatin, glycerine and water applied to a glass or aluminum sheet holds the prints snugly, yet releases them at will. In the field of photographic adhesives that do not crack, crumble or dish, there are a number of commercial products as well as home formulas which contain glycerine. Glycerine has been used too as a motion picture threading lubricant, film cabinet humidifier, antidust measures for camera interiors, and print focusing work by making ground glass transparent..



PRINTING AND LITHOGRAPHY

Glycerine is one of the basic raw materials of the printing and ink industry. By itself or as a component of ester gums or alkyd resins, glycerine enters extensively into the formulations of many types of printing inks, stamp pad inks, duplicating and copying inks. It is used for various paper treatments and in the manufacture of printers' rollers.

Of the physical properties that account for the many and varied uses of glycerine, as such, the most important are its solvent action and its hygroscopic or humectant effect. Glycerine is used in plateless engraving or thermographic inks, in silk screen inks and in typographic water color inks. The latter are based on vehicles consisting essentially of gum arabic, dextrin, glycerine and water. In the case of silk screen inks, the glycerine helps to control the drying rate and assists in keeping the screens clean. In inks for plateless engraving, glycerine inks grip the powdered pigments and extenders, and remain moist, while oil based inks have a tendency to dry out and not hold the pigments as well.

In the production of printing inks which are stable on a typographic press, consisting of gels of pigment, glycerine and sodium silicate, glycerine appears to be unique in its ability to produce a dispersible gel with silicates and gelling pigments.

Glycerine is used quite differently in intaglio or rotogravure printing inks. Suitable inks can be made by combining an appropriate coloring substance with an aqueous solution of a casein-formaldehyde reaction product. The addition of glycerine to this improves the dispersion of the pigment, flow of the ink, rate of initial set, penetration and stability. The glycerine, while acting as a "freeing-out" agent, also tends to slow down the action of the water in the vehicle on the size and fiber of the paper, and also acts as a temporary plasticizer.

Glycerine has long been a standard component of hectograph, duplicating machine, and other types of copying inks. It is a suitable humectant for the preparation of halo-free stencil duplicating inks that are also free of "show-through". It is also included in some blocking out compositions designed for duplicating equipment.

A more unusual use is in the preparation of inks which leave a homogeneous, electrically conductive deposit suitable for closing circuits in accounting machines. These can be formulated from graphite, kaolin, glycerine and alcohol.

Glycerine is a standard ingredient of stamp pad inks. Here it acts to prevent drying out of the ink over extended periods of time. Standard and specialized writing and marking inks are regularly formed with glycerine. Inks for marking laboratory glassware and porcelain equipment are frequently made with glycerine to improve the flow characteristics and the sharpness of writing. Such effects are also utilized in the formulation of the more familiar writing inks. In addition, the hygroscopic action of glycerine is brought into play to prevent drying on the pen point.

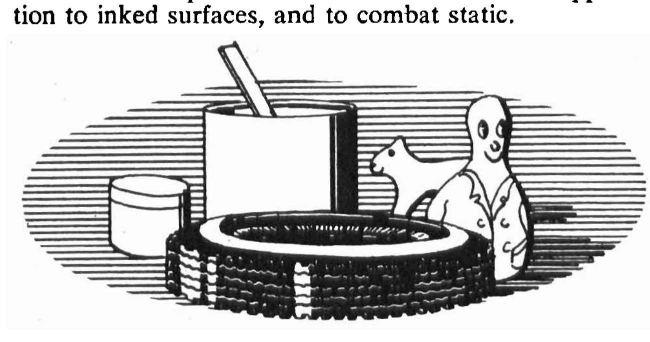
Glycerine is used in the newer quick drying inks. Here the glycerine acts as a lubricant for the ball point and as a thinner for the writing paste. It is rapidly absorbed by the paper, leaving the dye and pulpy substances to dry rapidly. The glycerine derived ester gums are used too in the preparation of pantograph inks with superior bonding properties.

Glycerine alkyds also used in inks, are excellent grinding vehicles, and yield inks that have good flow characteristics, dry relatively fast and hard, and have excellent adhesion and flexibility. They are particularly useful in metal decorating lithographic offset inks and in high grade coated paper inks for printing both by letterpress and offset lithography. Because the alkyds can be modified to meet many requirements, they are used in the preparation of more specialized inks, such as non-scratch and rub-proof inks and in the formulation of steam setting inks widely used by the food industry. They are often used to improve or complement the properties of other resins and raw materials in the manufacture of various types of inks.

But glycerine's use in the making of inks is not its only use in the printing industry. Composition rollers are most often made of a gelatin-glycerine combination. Here the glycerine serves to maintain the necessary resilience of the rollers, because it prevents undue drying that would result in a loss of tack and eventual hardening, brittleness, and cracking. Although other kinds are in use, the composition roller remains the best known and widely used means of picking up and carrying and distributing ink evenly and smoothly to type plates or cuts. They are made of glue and glycerine as the basic ingredients. So called winter rollers and summer rollers require variations in the ratio of glue to glycerine in order to meet the needs of changing weather conditions. The proportion of hygroscopic glycerine is lower in the summer when the atmosphere and the air of heated pressrooms show high humidity. In addition to these, there are the coated rollers, which have a thin coating of the glue glycerine combination over a rubber base. These can be recoated as needed, retaining the rubber base.

Glycerine is used with gelatin in another phase of the printing industry, the photo-gelatin or collo-type process, used for the printing of fine art subjects and the like. In this process, a true photographic reproduction is obtained without the use of lines or screens. The method depends on the fact that chromatized gelatin becomes insoluble in water to the extent that it is exposed to light. The gelatin plate, after exposure, is sponged with water and then an etching solution of glycerine and water.

In the casting of large mats, particularly in the case of halftones, there is a tendency for the mat to wrinkle and harden. This can be avoided by rubbing the back of the mat with glycerine. Since glycerine does not create steam when heated, no bubbles are formed under the mat. Occasionally, glycerine is used in the production of anti-offset compositions that are suitable for application to inked surfaces, and to combat static.



RUBBER

The uses of glycerine in the rubber industry today are made up of a whole series of relatively minor applications, and range from use of its lubricating properties to making use of its ready miscibility with water and its stability over a wide range of temperatures. In a number of cases, its plasticizing and softening effects are utilized, in other instances, its value as a lubricant is useful, while some applications put emphasis on its value as a pressure-transmitting medium. Aside from these physical properties, its use in the preparation of alkyd resins and ester gums gives it another role in the rubber industry.

The innocuousness of glycerine with respect to rubber, and its non-volatility make it possible to use glycerine as a lubricant in hydraulic brake systems on motor vehicles. The lubricating action and non-volatility of glycerine are also used to some extent in rubber works in mixture for the surface treatment of unvulcanized but partly processed rubber compounds in order to prevent them sticking to other similar partly processed batches on storage shelves or bins. When combined with water and talc, it is applied as a slurry before the mixture is allowed to dry. The glycerine, being hygroscopic and non-volatile, renders the lubricating talc more adherent to the rubber surfaces.

Similarly, glycerine has also been used in mixtures for mold release in molding operations. Such mixtures are painted on, or sprayed on the mold before molding, particularly in cases where the molds have complicated engraved patterns on them, such as in hot water bottle manufacture. This gives freedom from sticking of the hot vulcanized product and gives better pattern definition.

Glycerine can be used in the manufacture of puncture sealing compounds for rubber. Here its role is to provide the requisite elastic properties, prevent freezing, retain the composition suitably moist and uniform during hot weather and assist in preventing leakage of excess moisture through the puncture.

Glycerine is an excellent vehicle for many chemically active substances, and this property may be used in the production of chemical blowing agents for making expanded rubber. It has been suggested as a reaction medium in which ammonium nitrate decomposition results in the liberation of nitrogen gas. Such solutions of ammonium nitrate, being substantially non-aqueous are said to be superior gassing agents for making expanded rubber of both cellular and sponge type. The process is applicable to soft and hard rubber.

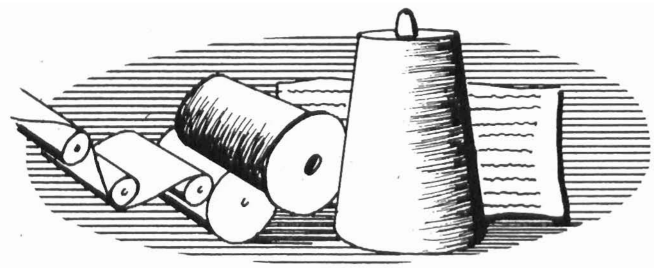
As with natural rubber, glycerine has found use in the processing and treatment of synthetic rubber. In the production of so-called "cold" rubber SBR (styrene-butadiene rubber) polymerization at low temperatures gives rubbers of improved properties. Polymerization at sub-zero temperatures necessitated the substitution of part of the water in the emulsion system by a freezing point depressant which would not interfere with the reaction. Glycerine can be used for this purpose and the total amount of glycerine present as well as the glycerine/water ratio, bears a critical relationship to the speed of reaction.

Vulcanization of extruded sections by a continuous process may also use glycerine such as a glycerine bath for extruded sections of sponge rubber for such purposes as door seals on motor vehicles.

Acrylonitrile-butadiene synthetic rubbers are particularly useful for oil and solvent resistant uses; the higher the acrylonitrile level in the polymer, the greater is the oil resistance, but at the same time the more intractable is the polymer from the processing point of view. To help this, for most applications, it is necessary to include a fair proportion of organic ester-type plasticizer in the compound. A number of glycerine derivatives have been used for this purpose; for example triallyl ether of diglycerine and glyceryl dioleate.

Ester gums, made by reacting glycerine with rosin, are used for making stable polychloroprene latices, and these are used for coating and impregnating paper and asbestos to give extra flexible materials. These ester gums may also be used as vulcanizable plasticizers in polychloroprene latex.

The glycerine-formulated alkyd resins are used in conjunction with chlorinated rubber. Because of its excellent alkali, acid, and chemical resistance, chlorinated rubber finds extensive use as a base for maintenance paints and concrete finishes. However, as a paint vehicle it must be modified by softening with a plasticizer to improve flexibility. Alkyd resins are often used for this purpose. Good adhesion, gloss and toughness for paint that is to be applied to metal, wood or concrete is obtained with chlorinated rubber modified with an appreciable quantity of alkyd resin.



TEXTILES

Glycerine is a textile-conditioning agent used widely in the lubrication, sizing, and softening of yarn or fabric. Its effectiveness in these and similar applications is due mainly to viscosity and hygroscopicity, both properties contributing to the plasticizing action. Hygroscopic, or humectant, qualities also account for the utilization of glycerine in special treatments, such as processes to increase the wearability of fabrics or to prevent static charges on fibers. Because of impermeability to poison gas, particlularly "mustard", glycerine finds application in gas-resistant finishes. Water solubility is an asset too when glycerine serves as a lubricant. This obviates the need for strong scouring agents, which tend to injure the fabric but which must often be used to remove other lubricating oils.

As an additive to lubricating compositions, sizes, or various finishes, glycerine acts as a plasticizer, solvent, and penetrant. It prevents drying out and caking on the fiber, eliminates the dusting of sizes, and may aid in dispersing water-insoluble lubricating oils applied from a water bath.

Glycerine has been used successfully to lubricate all types of fibers in operations including spinning, twist setting, knitting, and weaving. Glycerine is oily and smooth enough for this purpose, without being sticky or tacky.

In searching for a liquid that would prevent friction by spreading and absorbing on nylon, members of The Naval Research Laboratory in Washington, D. C. evaluated glycerine as one of a group of lubricants. This study proved of special interest, in that it gave evidence of hydrogen bonding between glycerine and the nylon amide groups located on the surface of the fiber.

In contrast to this modern use for glycerine as a lubricant is the lubrication of delicate threads or fibers, where it prevents breakage and subsequently eliminates the need for harsh scouring. Also the addition of glycerine to a soaking bath for raw silk readies the silk for knitting or weaving by making it soft and pliable and by humidifying the natural gum, which acts as a sizing agent. Manufacture at high temperatures and humidity thereby becomes unnecessary.

In improving the wearability of brittle fabrics with a low fat content there is a procedure which calls for a machine dispensing a flow of glycerine over the fabric at a rate of ½ to 4½ lb. of glycerine per 221 lb. of fabric. Another process calls for preventing runs in knitwear and thereby prolonging the life of the garment. It consists of coating the threads with a compound containing glycerine; the fibers are thus strengthened and the loops of knitted goods allowed to slide over one another with a minimum of friction. This also helps protect stockings against the strain imposed by the wearer.

Glycerine has been used too as a size for woolens. The wool fibers can be processed more easily on the addition of oils containing a mixed ester of glycerine and a long chain fatty acid as a scouring agent. There have been many patents calling for compounds containing glycerine to treat wool and wool fibers. Likewise, processes have been developed and patented in many countries where glycerine-containing lubricants are added to spinning solutions for both natural and man-made fibers.

Glycerine may be added to solutions used in the twist setting and conditioning of yarns prior to weaving. It has a weighting effect and may shorten the time of twist setting by stabilizing the regain of moisture and by serving as a substitute for the water that tends to evaporate before the twist is set.

Glycerine is generally used as a conditioning agent and lubricant in the weaving or spinning of wool, silk, cotton, rayon or nylon. Aqueous emulsions of coconut oil, red oil and glycerine may be applied to silk or nylon to increase pliability and thus contribute to more uniform knitting.

Glycerine has long been considered a standard ingredient of many sizes used in slashing or finishing. It promotes the more even distribution and the easier penetration, into yarns, of gelatin, starch and other sizes. It prevents the drying and hardening of the fibers during weaving and subsequent processing, increases fiber workability, and improves the hand of finished goods by its plasticizing action on yarn or fabric. As a result, glycerine is used in various sizes and other finishes to replace or supplement sulfonated oils, or tallow, both lacking in hygroscopicity. It may also be used to solubilize or disperse ingredients other than these oils in the sizing bath.

Sizing compositions that contain glycerine as a plasticizer or lubricant cover a wide range of compounds. There are formulations based on starches, proteinaceous materials such as casein or albumin, and on rosin or combinations in compounds where the sizing is PMA or polymethacrylic acid.

Many references describe glycerine as a highly valued component or rayon warp sizings. A report made some years ago for the U. S. Institute for Textile Research emphasizes the importance of a good softener to the quality of the size itself. The report states that a higher degree of cohesion and better bodying were obtained by using glycerine, rather than sulfonated oils in combination with starches. As opposed to tallow, glycerine prevents warp ends from adhering to the drying cylinders of the slashers. It also protects fabrics against the stiffening effects of the dry heat to which they are exposed a few times during processing.

The humectant and lubricant qualities of glycerine are especially useful in standard warp sizes containing sulfonated oils, gums and starches for gelatins. Typical formulas for sizing acetate or viscose rayon may contain glycerine and formaldehyde, in addition to other sizing agents. Viscose may also be lubricated and sized with compositions based on polymethacrylic acid. PMA is a water soluble compound widely used to size synthetic materials. It strengthens and protects filaments and filament bundles but tends to form brittle films requiring the addition of a humectant and plasticizer. Glycerine is suitable for this purpose.

For reasons similar to those that apply in the case of rayon warps, glycerine is used very frequently in cotton warp sizings. In many formulations, it is employed as a solvent for substances added to prevent bacterial and mold growth in the size.

A hygroscopic agent such as glycerine is frequently a constituent of woolen and worsted warp sizings, particularly in a dry atmosphere. Glycerine often plays this role. Tests have demonstrated that glycerine in aqueous solution could penetrate wool fibers much more readily than could pure glycerine. By swelling the fiber, the water increased fiber porosity, facilitated the absorption of glycerine and produced a softening effect on the fiber.

Glycerine is a component of sizing compositions for a variety of artificial fibers. For instance, compounds containing partially neutralized polymethacrylic acid and glycerine are applicable to fibers drawn or spun from polyamides and vinyl or vinylidene polymers, in addition to the older man-made fibers such as viscose, cellulose derivatives and protein fibers. PMA-based sizes to which glycerine is added are particularly useful in slashing nylon, whether in the form of continuous filament warps or raw nylon or of spun nylon yarns. Glycerine as the plasticizer in these formulations produces good film strength and abrasion resistance.

Because of fiber affinity and lubricating capacity, glycerine is a valuable component of sizes used to make felts. Kapok, for instance, may be dipped or soaked in a hot bath that contains sodium phosphate and a wetting agent; it is thereafter oiled with latex and glycerine and subjected to the usual felting methods.

By virtue of its lubricating and moisture stabilizing action on textile fibers, glycerine serves as a valuable softener and plasticizer in many final-finishing operations. Good examples of this action include the use of glycerine to treat rayon that has lost its natural softness during finishing, preventing wool felting and shrinkage due to evaporation of hygroscopic moisture during dry weather and to produce a softening effect on cotton and lawn impregnated with an organdy finish.

Among glycerine derivatives used in textile finishing, an alcohol-glycerine condensate is particularly useful as a solvent or softening agent for cellulosic fiber threads and filaments. For example, hydrogenated glycerides may be reacted with alcohols or amines. These fully hydrogenated glycerides show great stability to heat discoloration, a property important in modern textile finishing.

Glycerine as the hygroscopic component of antistatic finishes, absorbs moisture into the electrostatically charged fibers or fabrics. It thereby increases the conductivity of such materials and produces a discharge of electricity along their surface or through the fabric. Esters of glycerine may serve the same purpose. Many patents call for glycerine as the vehicle for antistatic agents for both natural and synthetic fibers.

Among other types of finishes calling for glycerine are flame resistant finishes, water repellency, and resistance to poison gas and wrinkle finishes. In crease-resistant finishes, the anticrease treatments frequently employ glycerine as a means of protecting the fiber against harshness or brittleness. In finishes comprising solutions of borates, stannates, or silicates, glycerine serves as a plasticizing agent. It is likewise added to finishes for making cellulosic textiles crease resistant, by the formation or deposition of a metal compound in the fiber structure. Of particular interest today is the treatment of wash and wear fabrics to impart both wet and dry crease resistance. Two patented processes for this treatment call for a condensation product of epichlorohydrin and glycerine applied to the fabric and followed with a caustic solution.

Occasionally, glycerine is used to impart luster to fabrics, as in the case of acetate fabrics delustered slightly by dyeing and finishing at very high temperatures. Treatment of such goods with an aqueous solution of alcohol containing a small amount of glycerine usually restores their original luster. Glycerine may also be used to produce gloss on certain woolen fabrics. But more often, glycerine is incorporated into finishes designed to de-luster rayons and other fabrics.

Coatings used on fabrics are usually thicker than finishes and form a continuous surface over the material. Glycerine is frequently used as a plasticizing agent to increase the flexibility of these coatings.

Modern textile finishing benefits greatly from the use of resins.

They are water insoluble and therefore applicable only by means of organic solvents or in the form of aqueous emulsions, which are heat-cured to yield insoluble, infusible materials. However, aqueous solutions or dispersions of modified alkyds may be prepared and are very useful in certain applications.

Alkyd resins are seldom used alone. More often they are combined with suitable modifiers, such as various oils, usually of the non-drying type, with fatty acids, with natural or synthetic resins and with other substances. They may also be used to plasticize or otherwise modify other types of finishes, such as urea-formaldehyde or melamine resins and cellulosic derivatives.

Although the use of glycerine-containing resins in fabric sizes is far less extensive than their use in special finishes, many processes developed over the years have employed them in this capacity. In the processes of finishing, glycerine resins find a wide variety of uses. Flame-proofing methods use these resins, even in processes where the treatment resists laundering. Correlative to this are a number of processes which treat fabrics to render them fluid-impermeable, and launderable. Alkyd resins based on glycerine and linseed oil were found to have the highest degree of water resistance.

Glycerine alkyds modified with a non-drying oil are important ingredients of protective coatings used to produce weather resistant transparent cotton netting.

Alkyds modified with non-drying or semi-drying oils, combined with urea-formaldehyde condensates may be used to make transparent fluid-impermeable fabrics. These are applicable particularly to rayon or silk fabrics.

Alkyd resins may be used too to prolong the life of textile materials, and when further modified to diminish abrasion and flexing in upholstery fabrics, improve elasticity of textiles and impart crease resistance.

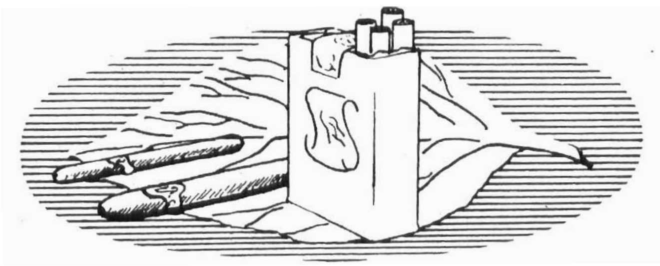
Both glycerine and glycerine-derived alkyds find wide application in many dyeing and printing procedures for textiles. Glycerine itself produces dyestuff pastes of excellent workability, promotes the fixation of dyes in printing pastes, increases color value in printing and assists in the retention of moisture in the ager. It is an ingredient of many dyes shipped in paste form since it prevents the dyes from drying out, and sticking to the sides of the drum. Its non-corrosiveness and low freezing point are desirable in this application. During dyeing, the water miscibility of the glycerine present in the dye paste and its solvent action on many types of dyestuffs aid in dispersing the latter in the dye bath, where the high boiling point of glycerine is another advantage.

Occasionally glycerine is added directly to the dye bath as was the case with the nylon dyeing formulas developed by the Nylon Task Committee during World War II to meet the washfastness and other requirements of the Quartermaster Corps. In naphthol dyeing, glycerine is sometimes used before coupling to improve stability of the naphthol solution. Other dyeing procedures in which glycerine finds application include the vat dyeing of acetate fabrics, the dyeing of cottons with direct colors, and the preparation of dyeing compounds for use on wool, silk, cotton, synthetic fibers and particularly rayon and staple fibers made from cellulose. Spray dyeing processes frequently utilize glycerine as a solvent, dispersant and suspending agent for dyes or pigments. The nonfoaming characteristics of the resulting compositions promote even dyeing. It may also be used to produce blended tints of "umbray" effects. Besides this, it has application in fluid bed dyeing, dispersed acetate dyes and azoic dyes.

The solvent action of glycerine is even more important in printing than in dyeing, because a much higher proportion of dyestuff is used, and water alone is usually inadequate as a solvent. As a polyhydric compound with wetting and lubricating properties, glycerine aids in producing smooth pastes that clear completely from the engraved printing rollers and show decreased marking off on steambox rolls. The importance of glycerine in the printing is illustrated by its widespread use in the printing of cottons. This was true decades ago and is still true today. It is also a component of standard printing pastes for woolen fabrics as well as goods containing wool. It may be employed in acid colors, vats or chrome dyes and is useful in a variety of applications, such as the spray printing of woolen upholstery fabrics.

Glycerine is also used in the printing of acetate as well as the new synthetic fibers. Acetate dyestuffs are frequently incorporated into the printing paste by mixing with a suitable thickener and a little glycerine. A few of the dyestuffs employed for cotton and rayon may also be applied to acetate, but most of them lack sufficient substantivity to the acetate fiber. However, if they are suitable, the addition of glycerine promotes uniform wetting and thus helps overcome the water repellency of cellulose acetate. The emergence of synthetic fibers, which have poor wetting properties, aroused interest in practical means of pigment applicating. Alkyd resins prepared from glycerine and dibasic fatty acids have proved particularly useful as pigment bonding agents. Often other types of resins, such as urea- or melamine-formaldehyde and related resins are employed in combination with them. The resin blends are designed to produce good fastness to washing and dry cleaning as well as other desirable properties.

Glycerine and many of its derivatives, in addition to their usefulness in the preparation, finishing and dyeing or printing of textiles have proved of value in numerous other textile uses. These include the production of dyestuffs and of manmade fibers, in which glycerine and/or derivatives serve as intermediates or as processing assistants; the synthesis of a large number of surfactants and textile specialty compounds directly or indirectly containing glycerine; the preparation of diverse products such as adhesive tapes and textile markings; and miscellaneous applications such as tests for the examination quality control of fabrics. These applications indicate the range and versability of glycerine as a textile chemical.



TOBACCO

The major use for glycerine in the tobacco industry lies in the manufacture of cigarettes though a comparatively minor amount is used in cigar filler processing and pipe and plug tobacco.

In the manufacture of cigarettes moisture control is very important in the process of converting tobacco to the finished product. Proper moisture content is rated high among the major "quality factors" of cigarettes. The moisture content of American made cigarettes is one of the things that has made them so popular throughout the world.

Although tobacco is capable of taking up moisture when subjected to high humidity, under normal atmospheric conditions most grades have a low moisture content and become brittle. Hence, in the manufacturing the tobacco may be reduced to useless dust or "fines".

To facilitate manufacture, reduce break-up losses and produce a better, fresher tasting product, cigarette manufacturers treat the tobacco with solutions containing a hygroscopic or moisturizing agent. Glycerine has long been the preferred agent for this purpose.

Glycerine may be applied to the tobacco as a simple aqueous solution or it may be sprayed on the blended and cut tobacco as a component of the so called "casing fluids". These liquids often contain a small amount of sugar, and the flavoring agents. The humectant has the function of keeping the tobacco at an optimum moisture content of 12%. To accomplish this end, the cigarette contains from 2-4% of glycerine, the percentage being made to vary according to the season and climatic conditions. Tobacco products other than cigarettes often call for glycerine in their processing. Burley tobacco used in pipe and chewing mixtures can be dipped in glycerine containing solutions similar to those used for cigarettes – and for the same purpose – to prevent drying out of the product once it is removed from its wrapper.

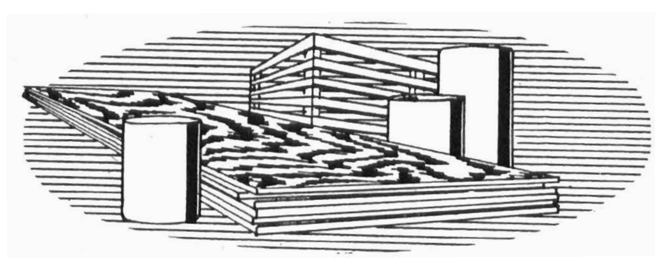
In chewing tobacco, moisture retardation is only one reason for its use. This type of tobacco product is shipped and carried in all kinds of weather and glycerine antifreeze properties keep the chewing tobacco usable at subzero temperatures.

URETHANE POLYMERS

An important, recent, and rapidly-growing use for glycerine is as the fundamental building block in polyethers for urethane polymers. In this use, which began in 1957, it is the initiator to which propylene oxide, alone or with some ethylene oxide, is added to produce trifunctional polymers of 1000 to 4000 molecular weight. The trifunctionality provides the ability to produce cross-linked flexible urethane foams on reaction with diisocyanates. This reaction can be in the form of a one-shot process, where approximate chemical equivalents of the polyether and diisocyanate are reacted, or by the preparation of a prepolymer by partial reaction of a polyether with an excess of diisocyanate. In the latter case, the foam is produced by the addition of water, catalysts, and modifiers.

In either case, the resulting flexible foams have properties which are superior to those for foams produced from diols, particularly with respect to humid aging and resilience. This factor, plus the appreciably lower cost with respect to polyester polyols, has led to dominance of the flexible foam market by glycerine-based polyethers. Other types (other triols, tetrols, and polyesters) are used for special uses where specific premium properties command a premium price, such as the use of polyester urethane polymers in clothing innerliner, where the property of flame lamination is a major consideration.

In addition to the major use in flexible foams, glycerine-based polyethers have found some use in rigid urethane foams and particularly in urethane coatings. For the latter application, superior results are obtained at minimum cost by the use of lower molecular weight (400-1000) glycerine triols. Again, by reaction with diisocyanate such as tolylene diisocyanate, prepolymers can be prepared and blocked with phenol for baking enamels; or the prepolymers can be cured with other polyols, amines, or air-moisture to give urethane coatings which are hard yet resilient, resistant to weathering, chemical attack, and abrasion.



WOOD

The property of glycerine most valuable in the wood industry is its hygroscopic or humectant action. This, in turn, is intimately associated with glycerine's plasticizing and softening effects. Its action serves to maintain requisite pliability and combat excessive dryness which results in cracking, brittleness and crumbling.

Wood is capable of absorbing glycerine, and wood that has been impregnated with glycerine maintains a high degree of suppleness and even brittle wood impregnated with glycerine can be easily bent without cracking.

In order to make wood more receptive to glycérine, it is well dried, and while still warm, the wood is placed in glycerine or the surfaces are coated with the liquid. Wood treated in such a manner may be bent for such uses as boat building or barrel making.

Veneers, especially thin crotch and burl, are often brittle and hard to handle when dry. They may be made flexible by immersing in a solution of glue, glycerine and alcohol. The alcohol serves to speed the drying and the glycerine to impart flexibility. The quantity of glycerine may be varied according to the brittleness of the veneer, climatic dryness or conditions of use. Not only new wood is treated with glycerine, but often museum pieces and rare objects made of wood are restored and preserved by treatment with glycerine containing compositions. New wood may be protected from harmful organisms by the use of arsenical compounds in glycerine to protect the wood from termites, and fungus-proofing preparations are often made with a glycerine alkyd resin base. A glycérine-borate mixture, added to tar and cresote help to avoid splitting, checking and cracking of the wood.

The hygroscopic action of glycerine is utilized too in the manufacture of wood adhesives. Its hygroscopic action prevents the glue from becoming so dry it loses its holding properties, and due to its plasticizing action, the bonding agent continues to function under the many stresses and strains to which wood may be subjected.

The so-called synthetic glues may also use glycerine in their formulation. Urea-formaldehyde condensation products may be treated with glycerine, to give glues or wood fillers that are much less brittle and more elastic than the untreated resinous products.

Laminating adhesives, such as are used for applying veneers and in the manufacturing of plywood not only make use of glycerine, but also of the glycerine-containing resins. These glycerine resins, the "alkyds", are used in conjunction with other synthetic resins to yield improved bonding agents. Resins suitable for low-pressure laminates may be prepared by blending a melamine-formaldehyde resin with an alkyd and styrene, for example. The glycerine alkyd combined with a phenol-formaldehyde resin gives a patching compound for veneer plies in the manufacture of plywood that withstands boiling.

The first synthetic resin introduced into the paint industry was made by reacting rosin with glycerine. The resulting "ester gum" showed superior water resistance and hardness as compared with natural resin. When combined with tung oil, the ester gum yielded a varnish that dried very rapidly and had remarkable water resistance. These were the old "Spar" varnishes. Later, these ester gums were combined with phenol formaldehyde molding resins and tung oil to give even superior varnishes with greater durability and water resistance.

However today, for finishes the glycerine-phthalic alkyds occupy the dominant position among resins used in the formulation of protective and decorative coatings since they are considered to have such superior characteristics as inherent flexibility and gloss retention, excellent color retention and weathering properties, adhesion, versatility and relatively low price. With very few exceptions, the alkyd resins are modified for industrial use with oils, fatty acids and various other materials.

By varying the type and proportion of ingredients, the alkyds can be adapted to the particular job. Hence the advantages of alkyds are to be found in almost every type of finish for wood, including stains, fillers, sealers, lacquers, varnishes, enamels and any number of specialty coatings. They are also used extensively in the production of sealers, that are so widely used in finishing modern furniture. The alkyds are extensively used for lacquer sealers, thus soft elastic alkyds made with glycerine are added to provide adhesion, elasticity and toughness.

Not only alkyds but glycerine itself is used in a number of special finishes. For example, it is used in a number of so called graining inks used for simulating more expensive, often unobtainable woods for the manufacture of furniture and other products. It is also used in special compositions for making wood fire-proof, water-proof and weather-resistant, by impregnating the wood with a filler containing, among other chemicals, some glycerine, or the wood may be given a coating of metal which is sprayed on in the molten state. Here glycerine is used in the solution as protection from the vapors.

MISCELLANEOUS USES OF GLYCERINE

Aside from the use of glycerine in specific classifications, there are a number of what might be called incidental uses. For example, in the airplane industry it has been used as a de-icing coating on the wing coats of planes. And recently a product has been developed which acts as a biocide and anti-icing agent for jet fuels both in storage and use. It is a combination of diethylene glycol monomethyl ether and glycerine. Glycerine is also used in low temperature lubricants for aircraft use.

Compasses, which are used in aircraft as well as on land and sea, often use glycerine as the medium of suspension for the dial. Here it acts as an antifreeze when the compass must operate at extremely low temperatures.

Since glycerine has low compressibility, it finds application in a number of fields such as door closure fluids, gun recoil mechanisms and a medium for compression molding of ceramic parts, as well as recoil mechanisms.

Glycerine is widely used in embalming fluids, and embalmers tissue-fillers. Its use for artificial tears by the motion picture industry is well known. It finds application too in boiler scale retarders and removers, linoleum manufacture, non-slip compositions for rugs and carpets, fly papers and stable foams for preventing gasoline evaporation in storage tanks.

Glycerine rubbed into leather book bindings will keep them soft and prevent them from drying out and cracking. Applied to a suction cup backing the suction will hold longer because the glycerine keeps the rubber soft and in shape thus adhering to the surface.

Other uses of glycerine which might be considered non-industrial are such things as using about a 65% solution of glycerine in a rubber or plastic ice bag. Then place this in the freezer compartment of the refrigerator. The mixture will thicken but not harden and can be more effectively applied. It can be stored with the glycerine-water solution unit since glycerine is a rubber preservative.

Glycerine is useful too in removing stains from fabrics and rust stains from concrete by mixing with sodium citrate. It can be used as a mask on doorknobs and other hardware when painting and is easily removed when the job is finished. Hammer or axe heads can be tightened by immersing the top of the wooden handle in glycerine.

CONTENTS

Adhesives 2
Adhesives, resin 3
Adhesives, vegetable 2
Agriculture 3
Air Conditioning 5
Aircraft de-icing 27
Alkyd resins 20
Antifreeze, plants 3
Automotive 5
Bacteriological media 15
Barrier Creams 8
Beverages 6
Candies 12
Cell preservation 18
Cellophane 6
Ceramics 13
Chiropody 7
Cigarettes 26
Compasses 27
Cordite 11
Cork liners 12
Cosmetics 8
Dentistry 9
Dermatological uses 17
Door closure fluids 27
Double base powders 11
Dried fruits 12
Drug vehicle 9
Dynamite 11
Electrical 10
Electroplating 10, 18
Electropolishing 18
Electro stripping 18
Embalming fluids 27
Ester gums 19
Explosives 10
Flavor formulations 6
Flavoring materials 12
Flexible foams 26
Foliage preservation 4
Foods 11
Foods, quick freezing 12
Glass 13
Glass scratch remover 14
Glue, gelatin composition 2
Glues 2
Hair preparations 9
Inks 22
Laboratory uses 14
Leather finishes 16
Leather treatment 15
Lithography 21
Lubricants 16
Medical uses 17
Metal finishing 18
Metal treatment 18
Metal welding 19
Nitroglycerine 11
Paints 19
Paper 2
Peanut butter 12
Pharmaceutical 17
Photography 21
Plant hormones 3
Plant storages 3
Podiatry 7
Polyglycerol esters 12
Printing 21
Refrigeration 5
Rigid foams 26
Rubber 22
Rubber, synthetic 23
Soft drink extracts 6
Stain remover 27
Sucroglycerides 9
Textile, anti-static finishes 24
Textile, dyeing & printing 25
Textile lubricant 23
Textile, sizing composition 24
Textiles 23
Tissue preservation 18
Tissue staining 15
Tobacco 26
Toilet preparations 8
Tooth pastes 8
Tree diseases, treatment of 4
Urethane polymers 26
Wood 26