Some detergent amines, amides, and quaternary ammonium compounds were patented:

American Cyanamid Co.—*U. S. 2,413,755; 2,426,891.*
Arnold, Hoffman & Co., Inc.—*U. S. 2,410,788.*
Celanese Corp. of America—*U. S. 2,408,127.*
Commercial Solvents Corp.—*U. S. 2,413,248.*
E. I. duPont de Nemours & Co.—*U. S. 2,414,050.*
General Aniline & Film Corp.—*U. S. 2,426,293.*
Th. Goldschmidt A.-G.—*Belg. 450,966.*
I. G. Farbenind. A.-G.—*Ger. 718,071 Cl. 12o; Belg. 448,523; 449,417; 450,587.*
Harris—*U. S. 2,406,329.*
Malkeinus—*U. S. 2,421,707.*
Martin Dennis Co.—*U. S. 2,407,645.*
Nostrip, Inc.—*U. S. 2,419,404.*
Parke, Davis & Co.—*U. S. 2,406,902.*
Rohm & Haas Co.—*U. S. 2,416,264-5.*
Soc. pour l'ind. chim. à Bâle.—*Brit. 581,339.*
Victor Chemical Works—*U. S. 2,406,423.*

Two other detergents were a special phenol-lactone ester (I. G. Farbenind. A.-G.—*Belg. 450,233*) and higher alcohol ester of boron or phosphorus compounds (N. V. Chemische Fabriek Servo & Rozenbroek—*Dutch 56,089*).

A Review of the Technical Applications of Soybean Lecithin*

W. K. HILTY, Ross and Rowe, Inc., New York City

SINCE the introduction of lecithin into this country from abroad some twenty-odd years ago, there has developed a new industry devoted solely to the recovery and marketing of this commodity. The lecithin industry in itself is comparatively small but robust, serving today a host of varied industries. It is a tribute to the few enterprising individuals who, recognizing the potentialities of lecithin, introduced it to American industry.

The acceptance of lecithin by industries who use it advantageously was a slow process. Those who introduced it had to begin with only a limited knowledge of its basic properties and functions. Potential users in most cases adapted it to their processes only after prolonged experimentation. Considerable knowledge of the applications of lecithin has accumulated but, aside from patented uses, relatively little information is to be found in published literature. The recovery and purification of lecithin from solvent extracted soybeans is generally known to this group and will not be considered in this paper.

In the interests of clarity and convenience the applications of lecithin will be segregated into two general classifications:

1. Those based on its surface active properties.
2. Those based on its chemical properties.

The applications based on the surface active properties are most numerous and offer unlimited potential new uses. Lecithin, basically, is a surface active substance, and a clear understanding of what is meant by a surface active agent is fundamental. Fischer and Gans (1) define a surface active agent as a compound which in small relative quantity modifies the physical properties of a heterogenous system by adsorption at an interface. The change is considerably greater than any law of mixtures would predict. The term wetting agent is often used instead of surface-active agent and in a sense further defines a surface-active agent. Bartell (2) states that one of the most commonly occurring phenomena is the wetting of solids by liquids. Processes involving wetting are encountered continually. Life itself is possible only because certain liquids are properly wetting the different solid constituents of the body. Important technical processes are fundamentally dependent upon the degree of wetting of solids by liquids. Surface active agents are not new; soap, the commonest, has been used for centuries; and sulfonated oils have been used for a long time. However, the greatest advance in development of surface active agents has been since 1925 when a number of synthetic products appeared. With these came a clearer understanding of the functions and properties of surface active agents. Most surface active agents have a fairly large molecular structure having a long chain aliphatic group known as the hydrophobic group and a solubilizing group commonly called the hydrophilic group.

LECITHIN has a molecular structure commonly associated with surface active agents. The long chain fatty acid groups constitute the hydrophobic group, and the phosphoric acid-choline group, the hydrophilic group. Lecithin is generally used in nonaqueous systems since it is not soluble in water. It is widely used in systems composed of solids dispersed in fatty vehicles. Specifically, one of the earliest established uses of lecithin was its use in chocolate coatings. Here we have a heterogeneous mixture consisting of cocoa butter, sugar, and cocoa fiber. Sugar, a hydrophilic solid, is not readily wetted by cocoa butter. Since the introduction of a small amount of lecithin in the order of 0.25% produces thorough wetting of the sugar by the cocoa fat, the viscosity of the mixture is reduced sometimes by more than 50%. Chocolate coatings can be produced with stabilized viscosities and reduced cocoa butter. The confectionery industry uses lecithin as an emulsifying agent in fat containing confections. Thorough emulsification of the fat results in improved eating qualities, facilitates cutting and wrapping, and longer shelf life; 1% of the fat content is used. Lecithin has long been used by the margarine industry where it serves as an antispattering agent and a means of keeping the milk solids from sticking when margarine is used for frying. Here we have a water in oil emulsion in which milk solids are dispersed. When margarine is heated as in frying, water is driven off and the

* Presented at the 21st fall meeting of the American Oil Chemists' Society, Oct. 20-22, 1947, Chicago, Ill.

milk solids are precipitated. Lecithin added in the amount of 0.10% to 0.25% acts at the fat and water interface prevents coalescence of the water with the result that the evolution of water is gradual and small droplets prevent spattering. At the same time wetting the milk solids with the surrounding fat causes them to remain freely movable without sticking.

The development of bread dough is a complex physical and chemical phenomenon. Interface modifiers can and do exert profound changes. Lecithin, when added to doughs to the extent of 3 to 4 ounces per 100 pounds of flour, produces more even dispersement of the shortening and a drier handling dough and retards staling. Pan lubricants are made more effective with the addition of 0.5 to 1.0% lecithin. In the production of icings better flow and higher gloss is possible when lecithin is added, again because it promotes thorough wetting of the sugar by the shortening. The biscuit and cracker industry have used lecithin for many years in short-bread type of cookies. The incorporation of lecithin to the extent of 1%, based on the weight of shortening, gives a more uniform batter and results in cleaner webs and dies.

Emulsions technology, as is well known, is extremely complicated. The use of surface active agents as emulsifiers, stabilizers, etc., are requisites in emulsions. Lecithin finds widespread applications in emulsions for many purposes. It is used as the emulsifying agent or as a stabilizer. The amount of lecithin to use will vary depending upon the type of emulsion, degree of stability required, etc., but most generally lies between 1 to 5%. The cosmetic industry uses considerable quantities of lecithin in creams, lotions, lipstick, and permanent hair wave preparations. In certain creams, particularly the so-called nutrient creams, as much as 5% of lecithin is used, while in others only fractional percentages. The emollient properties of lecithin are also utilized in soap products, particularly liquid and powdered industrial hand soaps.

IN the industrial field lecithin has many applications in protective coatings, leather, textiles, rubber, and plastics. In the production of paints and printing inks considerable time and energy are expended in grinding pigments. The grinding operation is not for the purpose of further reducing the particle size of pigment particles, but to disrupt aggregates of pigment particles into individual particles and to wet the pigment particles with the grinding vehicle. A vehicle with poor wetting properties necessitates longer or repeated grinds. A vehicle with good wetting properties, on the other hand, will require only minimum grinding. Poor wetting vehicles, to which a surface active agent is added, very often become good wetters. Since most paint and printing ink vehicles are oils or varnishes, an oil soluble wetting agent will prove most effective. Lecithin is one of the most effective surface active or wetting agents for paint systems. Paint systems are complicated in that the large number of pigments used each have their peculiar properties. The same is true of vehicles which range from raw linseed oil, through bodied oils and varnishes to synthetic resins which may contain glyceride oils or be only a solvent solution of the resin. The working properties of a given pigment dispersed in raw linseed oil, for example, may be altogether different if dispersed in a short oil alkyd resin. Surface active substances can alter working properties of pigment dispersions markedly. A dispersion having a short buttery consistency may become free flowing by adding a surface active substance such as lecithin. Surface active agents in some dispersions produce less length or give the dispersion a slight puff. Hence the use of lecithin in controlling sagging or curtaining in architectural enamels. Flooding and silking are phenomena peculiar to the paint industry. They occur usually when two or more pigments are used in the formula and shows up as a mottled appearance in the case of flooding and as minute streaks in the case of silking. Silking, however, can occur in single pigment systems. The cause of neither phenomenon is clearly understood. There are many theories. Nevertheless, lecithin often does help in correcting this condition.

It is extremely difficult to lay down specific rules for the use of lecithin in pigment dispersions. Generally the optimum amount will be found to be around 1.0% of lecithin based on the pigment weight. The exact amount, method of addition, and point of addition can best be determined experimentally.

The use of lecithin by the leather industry is chiefly as an ingredient of fat liquors for soft leathers, such as garment leather or shoe uppers. It produces softness and fullness of feel without impairing tensile strength; 1% of lecithin in the fat liquor is commonly employed.

Lecithin is used by the textile industry as a lubricant in spinning woolen yarn, but most particularly as a softening and finishing agent to improve the hand or feel of fabrics, particularly cotton and rayon. The production of softening or finishing agents is a highly specialized art and lecithin is generally only one component of several used. Lecithin by itself will produce a very desirable soft finish on fabrics, but the finish is not as permanent as that obtained with some of the synthetic products now available.

IN the rubber and plastic industries lecithin is being successfully used as a mold lubricant. It is generally milled into the molding stock. While under pressure during molding, the lecithin between the stock and mold interface is an efficient lubricant. The molded pieces are more easily removed and have an exceptionally smooth surface. The molding of intricately shaped pieces in particular is facilitated. Approximately 0.5% lecithin is required. Certain insecticides are improved by the addition of lecithin because of its wetting and spreading properties. The U. S. Dept. of Agriculture (5) has found lecithin an effective deposit builder in nicotine, bentonite, and lead arsenate sprays for control of the codling moth using from 0.20 to 1.5 pounds per 100 gallons of spray mixture.

The applications of lecithin due to its chemical properties include its use as an antioxidant and its use for nutritious and therapeutic products. The applications of lecithin as an antioxidant are well known. There are differences of opinion as to which constituent of soybean lecithin is responsible for its antioxidant properties. It is generally conceded that the cephalin portion contributes more to its antioxidant properties than all others. Be that as it may, lecithin does show marked antioxidant effects. It has long been used in oleo oil, lard, and other edible fats.

The work of Riemenschneider and others (3) on the synergistic effects of lecithin with fatty acid esters of d-isoascorbic acid and alpha-tocopherol are also well known. Probably not so well known is its use as an antioxidant in fish liver vitamin oils. Buxton (4) has recently reported excellent results in this field using mixtures of lecithin and alpha-tocopherol. New antioxidants, many of which show greater antioxidant activity on accelerated tests than lecithin, have appeared in recent years. But lecithin in spite of its lower protective properties has certain inherent advantages. It is readily soluble in fats and oils, is a wholesome edible product, has little or no effect on flavor, and is available at low cost. Lecithin will probably always be a considerable factor in the utilization of antioxidants. In the petroleum industry (6, 7) lecithin is used as a stabilizer for gasoline containing tetra ethyl lead and as an additive in lube oils. About 10 pounds of lecithin per 1,000 barrels of gasoline is used to inhibit clouding, also to counteract corrosion of fuel tanks and liners, particularly in aircraft. About 0.5% lecithin is used in lube oils.

As for applications that have to do with nutritional or medicinal uses, soybean lecithin contains approximately 3% of choline, recognized as an important dietary factor. Specifically, clinical tests have shown the effectiveness of lecithin in prevention of fatty livers and in the treatment of psoriasis. The utilization of vitamin A and carotene are also enhanced by lecithin. Research is being continued on this field, but already lecithin is being utilized in considerable quantities for both human and animal nutrition.

The uses outlined are all fairly well established; however, the versatility of lecithin and its present low cost have stimulated research for new uses in entirely new fields. The possibilities for new applications are virtually unlimited.

REFERENCES

1. Fischer, Earl K., and Gans, David M., "Dispersions of Finely Divided Solids in Liquid Media." "Colloid Chemistry," Vol. VI P., 286-326, J. Alexander.
2. Bartell, F. E., "Wetting of Solids by Liquids," "Colloid Chemistry," Vol. 3, p. 41-46, J. Alexander.
3. Riemenschneider, R. W., Turer, J., Wells, P. A., and Ault, W. C., Oil & Soap *21*, 47 (1944).
4. Buxton, L. O., Ind. & Eng. Chemistry *39*, 225 (1947).
5. Steiner, L. F., Arnold, C. H., and Fehey, J. H., U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine.
6. Sollman, I. E., U. S. Pat. 1,884,899.
7. Rathbun, R. B., U. S. Pat. 2,208,105.

☆ ☆ ☆ ABSTRACTS ☆ ☆ ☆

Oils and Fats

Edited by
M. M. PISKUR and MARIANNE KEATING

THE CHEMISTRY OF THE RESIN ACIDS. H. H. Zeiss (Ridbo Labs., Inc., Paterson, New Jersey). *Chem. Revs. 42,* 163-87 (1948).

SUNFLOWER OIL. Anon. *Food Manuf. 23,* 57-9 (1948). Description of plant erected in 1946 in Altona, 100 miles south of Winnipeg, for the purpose of increasing the supply of edible oils.

THE FATTY ALCOHOLS. L. Bert. *Soap Perfumery & Cosmetics 21,* 48-51 (1948).

CETYL ALCOHOL AND ITS APPLICATIONS IN SOAPS, COSMETICS, AND TOILET PREPARATIONS. Anon. *Soap Perfumery & Cosmetics 21,* 153, 152 (1948).

STUDIES ON METHODS OF EXTRACTING VITAMIN A AND OIL FROM FISHERY PRODUCTS. PART I. VITAMIN A POTENCIES OF OILS FROM GRAYFISH LIVERS OBTAINED BY EXTRACTION WITH PETROLEUM ETHER AND BY COOKING WITH WATER. D. Miyauchi and F. B. Sanford (Fishery Tech. Lab., Seattle, Washington). *Com. Fisheries Rev. 9,* No. 9, 19-20 (1947). Grayfish livers held at different temperatures were extracted with petroleum ether and by cooking with water. The vitamin A content of the oil extracted with petroleum ether was about 1% higher than for the oil extracted by cooking with water.

SEPARATION AND DETERMINATION OF THE STRAIGHT-CHAIN SATURATED FATTY ACIDS C_5 TO C_{10} BY PARTITION CHROMATOGRAPHY. L. L. Ramsey and W. I. Patterson (Food and Drug Admin., Federal Security Agency, Washington, D. C.). *J. Assoc. Official Agr. Chem. 31,* 139-50 (1948). The fatty acids are separated on a column of silicic acid, using methanol as the immobile solvent, 2,2,4-trimethylpentane as the mobile solvent, and bromocresol green as the indicator. The separator acids are titrated with standard Na ethylate and tentatively identified by their threshold volumes; and the identification in each case is confirmed by adding an approximately equal amount of an authentic sample of the suspected acid and testing the chromatographic homogeneity of the mixture on a fresh column. It appears that the method may be suitable for routine use in the study of fermentation, food decomposition, the composition of certain fats, and the composition of natural and synthetic flavors and esters.

FURANS IN VEGETABLE OIL REFINING. S. W. Gloyer (Pittsburgh Plate Glass Co., Milwaukee, Wis.). *Ind. & Eng. Chem. 40,* 228-36 (1948). Furfural in conjunction with naphtha was used in the fractionation of free fatty acids to obtain fractions composed of 85-98% drying acids from soya and linseed acids. The furfural extraction process has also been employed in the concentration of vitamin A from liver oils. A concentrate in 19% yield containing 82,000 units of vitamin A per gram was obtained from a dogfish liver oil having a potency of 17,500 units of vitamin A per gram. Potencies of 150,000 units of vitamin A per gram have been obtained by lowering the yield of extract. These concentrates have also had removed much of the fishy odor and taste associated with the original oil. Tall oil has been fractionated to yield a fraction with only 1.3% rosin acid and 2.9% unsaponifiable matter, the remainder being fatty acid ester. This process involves the preferential esterification of the fatty acids followed by fractionation with a mixture of furfural and naphtha.

FACTORS AFFECTING THE QUALITY OF CAKES MADE WITH OIL. H. B. Ohlrogge and G. Sunderlin (Purdue Univ., Lafayette, Ind.). *J. Am. Diet. Assoc. 24,* 213-