FATS AND PROTEINS RESEARCH FOUNDATION, INC.

Director's Digest

WERNER R. BOEHME
Technical Director

2720 DES PLAINES AVENUE
DES PLAINES, ILLINOIS 60018
AREA CODE 312-827-0139

October, 1976 No. 130

New Vistas and Opportunities for Animal Fats

Werner R. Boehme

(Presented at 13th World Congress of International Society for Fat Research, Marseille, September 1, 1976)

Traditionally, animal fats were among the earliest natural resources to be recycled by man. Aside from conventional food uses, from ancient times to the present, they were used as fuel to heat and light primitive man's dwellings. When man progressed beyond the dugout canoe and invented composite construction for his waterborne vessels he caulked the seams of his boats with tallow and when he discovered the wheel he soon learned the fundamental principle of lubrication which reduced the effort of pulling his cart. He must have observed soon thereafter, that wear and tear on his primitive wheels and axles were also reduced. These applications go back in time before history was recorded and, if we reflect, it must be with amazement that so little progress seems to have been made in the technology of animal fats or in the uses to which animal fats were put until well into the era of the industrial revolution.

The principle industrial consumer of inedible or technical animal fats until the mid 20th century was the soap industry, an industry whose technology has developed from its early beginnings with wood ashes and fat to its present high degree of scientific sophistication as the modern detergent industry. Perhaps the restrictive covenants of the early soapmakers' guilds were a factor in suppressing new applications for animal fats.

As an industry, the renderers in recent decades have been the suppliers of not only numerous grades of refined animal fats but also of the accompanying protein products such as meat meals, keratinaceous products such as hydrolyzed feather and hair meals, dried blood, collagenous fractions such as gelatin, glue and even the hydrolysates used in cosmetic formulations. Our topic today, however, is not to discuss the protein products of the renderer but to point out a few of the diverse opportunities which are open to the consumers of animal fats in the challenging world of the 1970's.

Why the 1970's? Economic circumstances of the '40's and '50's opened great new opportunities to the renderer and also put some severe stresses on the rendering industry. The greatly enlarged post-war demand in the developed countries for more meat on the table increased the amount of recovered animal fat available far above that predicted by the secular growth curve of their populations. At the same time, the development of synthetic detergents based on petroleum greatly reduced the demand for tallow-derived soap. More animal fat was available than could be utilized and the consequence was a drastic and prolonged fall in the prices of animal fats.

The rendering industry rose to meet the challenge. In succeeding years the nutritional value of renderers' fats as a source of energy and of essential fatty acids in poultry and livestock rations became universally accepted and now represents the largest single use of technical animal fats. Nutritional studies still represent the largest single research category to be supported by the Fats and Proteins Research Foundation.

Let us review the uses to which the inedible animal fats are put today. Figure I illustrates the disposition of inedible animal fats produced in the United States for the year 1975.

A resurgence of interest in the use of animal fats for the manufacture of soaps has taken place in recent years because of concern over the slow biodegradability of many synthetic surfactants and this interest has now intensified as a result of the sky-rocketing cost of the petrochemical raw materials used in surfactants. According to the projections of the U. S. Department of Agriculture's Economic Research Service, lower prices of animal fats, in part engendered by a price cross elasticity with palm oil which can substitute for animal fat in most industrial applications, can result in an increased substitution for petrochemical raw materials. The Economic Research Service further determined that at present costs, which have been quite stable for several years, natural fats have a price advantage in the manufacture of detergents and that the lower prices expected over a long term will result in a large expansion of markets for natural fats and oils.

Although the traditional tallow soap has excellent detergent qualities and imparts a pleasing softness to laundered fabrics in soft water, its cleansing properties suffer severely in water of even moderate hardness. The most popular phosphate builders so commonly employed in laundry detergents until recently have now

Lime soap dispersing agents have the property of preventing the precipitation of the calcium and magnesium salts of the long chain fatty acids when used in hard water and the presence of phosphates is not necessary when LSDAs are used. LSDAs are compared in terms of their lime soap dispersing requirement (LSDR) which is the amount of LSDA required to prevent precipitation of a lime soap curd from a solution of sodium oleate in hard water under carefully standardized conditions. The lower the LSDR, the higher the lime soap dispersing activity. Table I enumarates a number of surfactants evaluated as lime soap dispersing agents and includes nonionic, anionic and amphoteric structures. That LSDA activity does not necessarily parallel detergent activity is illustrated by linear alkylbenzenesulfonate (LAS) which is an excellent detergent but a very poor LSDA. Some LSDAs, however, are both excellent detergents and lime soap dispersants.

TABLE I

Lime-Soap Dispersant Requirements (LSDR) of Various Types of Lime-Soap Dispersing Agent (LSDA) Surfactants

	LSDA, Formula		LSDR
1.	$RCOOCH_2CH_2SO_3Na$		10
2.	$RCH(SO_3Na)COOCH_3$	(TMS)	8
3,	$RCH(SO_3Na)COOCH_2CH_2SO_3Na$		5
4.	$RCON(CH_3)CH_2CH_2SO_3Na$	(IgT)	6
5.	$RO(CH_2CH_2O)_3SO_3Na$		4
6.	$RCONHCH_2CH(CH_3(OSO_3Na$	(TAM)	4
7.	$R'C_6H_4SO_2NHCH_2CH_2OSO_3Na$		6
8.	$R'C_6H_4COCH(SO_3Na)CH_2COOCH_3$		8
9.	$C_9H_{19}C_6H_4(OCH_2CH_2)_{9.5}OH$		5
10.	$RCONH(CH_2CH_2O)_{15}H$		3
11.	$RN^+(CH_3)_2CH_2CH_2CH_2SO_3^-$		3
12.	$RCONHCH_2CH_2CH_2N^+(CH_3)_2CH_2CH_2CH_2SO_3^-$		3
13.	$R'C_6H_4SO_3Na$	(LAS)	40

R represents an alkyl group derived from tallow and R' represents an alkyl group in the C_{11}-C_{13} range corresponding to commercial detergent alkylates.

(Linfield,1976)

TABLE III

Applications of "Vigor" in the Home	
Regular Laundry Use	98%
Hand Laundering	47%
Diaper Wash	4%
Dish Washing	30%
General Wipe-Up	35%

TABLE IV

Washing Machine Performance	
Entirely Clean	87%
Whitening/brightening	85%
Softness	98%
Fluffyness	94%

TABLE V

Overall Performance of Vigor	
Satisfactory	90%
Unsatisfactory	10%

The summation of Table III confirms that substantially all participants in this test evaluated it in the washing machine. About one-half also employed "Vigor" in hand laundering of more delicate fabrics. The apparently anomalous response of 4% application to diaper washing reflects the increasing use of diaper services and disposable diapers as well as the average age bracket of the panelists participating in this survey. The response to the question of softness and fluffiness of laundry washed in "Vigor" was almost unanimously affirmative and satisfaction with cleansing, whitening and brightening was almost as high (Table IV). Ninety percent of the respondents expressed their satisfaction with the performance of "Vigor" (Table V). An investigation of the 10% who were dissatisfied revealed some deficiencies in our manufacturing process for the experimental material and centered principally on handling problems (dustiness, slow solubility, fragrance). A few comments about poor sudsing and soap residues in the clothes may be attributable to the use of too much or too little of the detergent sample.

The responses to the question of water hardness are the subjective evaluations of non-technical consumers and no hardness values can be assigned with any degree of precision. It should be pointed out, however, that water used by many homes in hard water areas is subjected to softening in a mixed bed ion-exchange resin.

Searching for a lime soap dispersing agent of greater stability and efficacy than TMS, we are now evaluating the lime soap dispersant TAM (the sodium salt of the sulfated isopropanolamide of tallow fatty acids) with tallow soap. This formulation gives better detergency and shows improved resistance to hydrolysis in the higher alkalinity and water temperatures employed for laundering in the United States and especially in Europe. The principal interest to date has been in the home laundry but other potential markets less heavily supported by advertising and promotion are commercial laundries and industrial applications. Commercial laundries, for example, customarily purchase tallow soap and alkali separately but rely on a water supply that has been softened. In this industry the combination of tallow soap and a lime soap dispersant can reduce the degree of softening required or even eliminate the water softener entirely. Among other industries in which there is interest in a non-polluting detergent detergent may be mentioned the textile, metal forming and the pulp and paper reclaiming industries.

My discussion so far has centered on new applications for the fatty acids derived from animal fats which have been modified by sulfonation, sulfation and amidation to yield adjuvants with surfactant properties that greatly improve the detergency and the usefulness of tallow soap. Oxidative studies of long chain fatty acids have taken on a renewed importance in recent years as new uses for their oxidation products have been discovered.

That fatty acids can be oxidized to lower mono- and dibasic acids is reported in the very early literature of organic chemistry. One example of the reaction that has been developed to a high degree of commercial efficiency is an oxidation by Emery Industries who obtain azelaic acid and pelargonic acid by the ozonolysis of oleic acid. We have reinvestigated the oxidation of tallow fatty acids (which consist of both saturated and unsaturated acids) with nitric acid and with air. These studies were conducted in collaboration with Prof. Norman Deno of Pennsylvania State University and with the Stanford Research Institute. High yields of mixed homologous dibasic acids are obtained. With concentrated nitric acid the reaction proceeds smoothly at 90^{o} C. Air oxidation is conducted in the liquid phase under pressure at 125^{o} C. and is catalyzed by small amounts of a moderator such as cobalt naphthenate. Both methods give a similar product mix. Table IX illustrates the broad mixture of homologs that is obtained by oxidizing palmitic acid with nitric acid. On a weight basis it represents approximately 80% of the starting material and the average molecular weight is slightly higher than that of azelaic acid.

TABLE X

Homologous Dibasic Acid

No. of carbon atoms	Name	Industrial source	Price $/lb.
2	Oxalic	coal, petroleum	
3	Malonic	---	
4	Succinic	petroleum	.67
5	Glutaric	---	
6	Adipic	petroleum	.35-.47
7	Pimelic	---	
8	Suberic	castor oil, oleic acid	
9	Azelaic	oleic acid	.61-.69
10	Sebacic	castor oil	1.57
11	Undecanedioic	---	
12	Dodecanedioic	petroleum	2.00 +
13	Brassilic	crambe, rapeseed	
14	Thapsic	---	
15	Pentadecanedioic	---	
	The Raw Materials		
	Tallow fatty acids		.1475
	Palmitic acid		.325
	Stearic acid		.245

TABLE XI

Dibasic Esters - Applications

1. Poymers
   a) Fibers
   b) Films
   c) Coatings

2. Plasticizers

3. Hydraulic Fluids

4. Lubricants

Adipic acids is the raw material used most often in fibers, films and coatings. For plasticizers both adipates and azelates are employed. The azelates are also widely used in hydraulic fluids and lubricants are probably their most important application. Table XII itemizes the principal advantages of ester lubricants prepared from mono- and dibasic acids with higher alcohols.

TABLE XIII

CHEMLUBE vs PETROLEUM		
TEST	CHEMLUBE SYNTHETIC LUBRICANT	PETROLEUM MOTOR OIL
USEFUL TEMPERATURE RANTE	-60^0 to 400^0F	-20^0 to 300^0F
FLASH POINT	470^0F	350^0F
POUR POINT	Below -60^0F	-20^0F
EVAPORATION RATE (300^0F 22 hrs.)	1%	25%
VISCOSITY INCREASE % 64 hrs.	3%	105%
OIL CONSUMPTION (QT.)	2.44	5.0
ENGINE CRANK 0^0F. 250 RPM	12 AMPS	70 AMPS
-45^0F. 250 RPM	22 AMPS	270 AMPS

(North American Oil Co. data)

TABLE XIV

- Extend Engine Life: Superior lubricity and film strength mean less friction and wear.
- Fewer Oil changes: High dispersancy and detergent properties help synthetics hold far more contaminants in suspension, oil lasts at least 25,000 miles.
- Increase Gas Mileage: High film strength provides for a low coefficient of friction and 8 to 15 percent less gas consumption.
- Reduce Oil Consumption: By as much as 50 percent by freeing sticking valves.
- Year Round Lubrication: Provides effective lubrication from -60 degrees F to plus 400 degrees F with a pour point as low as -85 degrees.
- Fast,Easy Starts: At temperatures as low as -45 degrees F. with far less battery power drain.
- Increase Performance: Consistent oil pressure due to stable viscosity and a better seal at the rings.
- Improve Engine Cleanliness: Runs cleaner, smoother and cooler.

(CARS Magazine, July, 1976)