

# NEW PRODUCTS FROM FISH OILS

## Part II - Polyamino Fatty Acids Derived from Fish Oils

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### ABSTRACT

The work reported in this paper is directed toward finding new uses for fish oils and consists in studying the chemical derivatives of their constituent fatty acids. Among these derivatives are the polyamino fatty acids, which should have excellent surface-active properties, owing to their highly polar and polyfunctional character. They therefore may find use as fungicides, corrosion inhibitors, detergents, and ore-flotation agents.

In the preparation of the polyamino fatty acids, amination of the double bonds in unsaturated fatty acids and esters was attempted by three methods.

The first method involved the conversion of polyhalo acids to polyamino acids by the reaction with liquid ammonia. Initial work done on the various haloacids prepared from the reaction of purified oleic acid with hydrobromic acid, with hydriodic acid, and with bromine.

The second method involved (1) the reaction of tetranitromethane with the double bonds and (2) the subsequent reduction of the nitro groups. Only the reaction between tetranitromethane and oleic acid and their reaction products were investigated in this phase of the program.

The third method involved the alkylation of potassium phthalimide with the addition products of hydriodic acid and of bromine to methyl oleate in an attempt to provide an intermediate for the synthesis of polyamino fatty esters. The hydrolysis of the phthalimido groups on these compounds to produce amines will be the subject of further study.

### INTRODUCTION

Fish oils contain components that are unique in chemical structure and that are not common in animal or vegetable oils. These components possess an unusually high degree of unsaturation: that is, they contain a large number of carbon to carbon double bonds. Relatively little work has been done on the investigation of derivatives of fish oils, owing to the difficulty in separating the pure compounds from complex mixtures in the oils and to the instability of the unsaturated compounds when in contact with air.

#### WORK AT SEATTLE LABORATORY:

The work at the Seattle Technological Laboratory has been directed toward finding new uses for fish oils. The investigation of chemical derivatives of the constituent fatty acids in fish oil has been the major project. The importance of this work has been described by Stansby (1956). In this investigation, the type of derivative chosen is such as to take advantage of the unique character of unsaturation.



Fig. 1 - Methanol-urea countercurrent distribution of urea inclusion compounds of long-chain fatty substances.

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Polyamino fatty acids<sup>1/</sup> are a class of derivatives that may be prepared by utilizing the unsaturated portion of fish-oil fatty acids. Polyamino fatty acids have potentialities as copolymers, as complexing agents, as sequestering agents, and as fungicides, corrosion inhibitors, detergents, ore-flotation agents, and other surface-active agents. Their preparation, in essence, involves the addition of ammonia to the double bonds.

**LITERATURE RESEARCH:** The scientific literature shows that very little work has been done on the lower homologs (C<sub>2</sub> to C<sub>8</sub>) regarding amination of the double bonds and that no work has been done on the higher homologs. The patent literature reports a considerable number of processes for the amination of olefins, using high pressure, high temperature, and usually a catalyst of reduced cobalt or nickel oxide (Teter 1947, Teter and Olson 1950). This high-pressure catalytic amination with ammonia has been carried out with several of the olefins of lower molecular weight (C<sub>2</sub> to C<sub>6</sub>). The yields per pass of material over the catalyst is poor (10 to 15 percent). Thus recycling of materials is required to increase the yields.

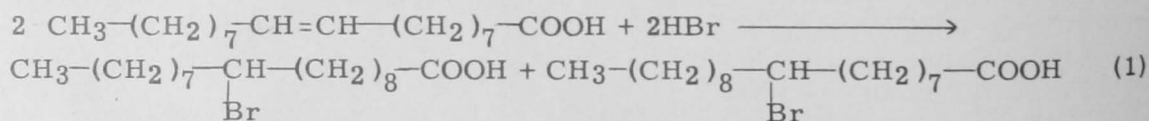
Groggins (1952) has listed several aminating reagents and amination reactions. The aminating reagents listed are (1) liquid ammonia, (2) aqueous ammonia, and (3) ammonia in an inert solvent. Aqueous ammonia almost always produces secondary and tertiary amines. A problem that arises in the use of ammonia is to find an inert solvent that will readily dissolve both the ammonia and the compound to be aminated and that will be easily removable. The amination reactions listed by Groggins are (1) the conversion of halogen compounds, (2) the replacement of sulfonate or sulfate groups, (3) the conversion of alcohols, and (4) the reaction of ammonia with hydrocarbons.

Julius v. Braum and co-workers (1937) have discussed the advantages of liquid ammonia over aqueous or alcoholic solutions for use in the preparation of primary amines from organic halogen compounds. In general, the action of aqueous or alcoholic ammonia on organic halogen compounds is not well adapted to the preparation of primary amines because secondary and tertiary amines and some quaternary ammonium halides are formed. The use of liquid ammonia should favor the formation of primary amines.

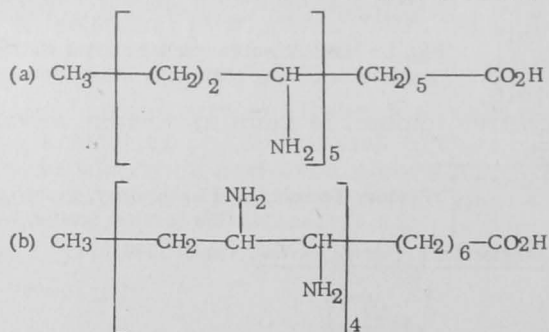
Harwood (1952) has given a good review of the syntheses of amines.

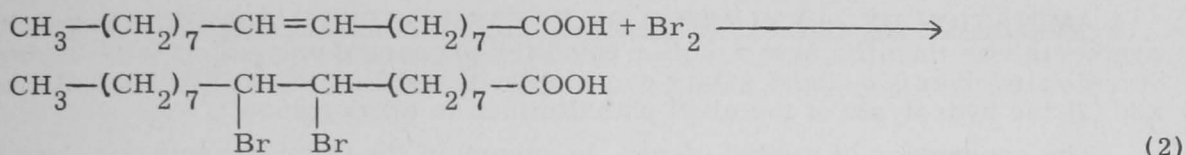
#### DISCUSSION OF EXPERIMENTS

**AMINATION WITH LIQUID AMMONIA:** The work at the Seattle laboratory began with the attempt to convert long-chain polyhalo fatty acids, which had been prepared from the unsaturated fatty acids of fish oils, to polyamino acids by amination with liquid ammonia. The initial work was carried out on purified oleic acid in order to avoid the complications that arise from the complex mixture found in fish oil and to simplify the investigation of the reaction and of the products. Three types of haloacids were prepared from oleic acid by the addition of hydrobromic acid, of hydriodic acid, and of bromine to the double bond. These reactions can be represented by equations 1 and 2, where the reaction of hydriodic acid is the same as that of hydrobromic acid:



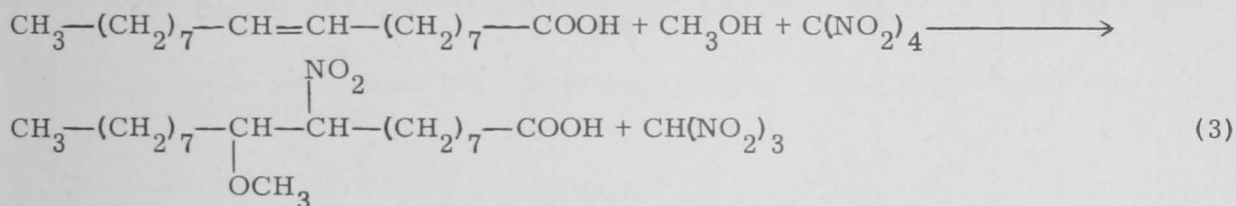
<sup>1/</sup>For example, the formulae of some polyamino fatty acids may be as follows:



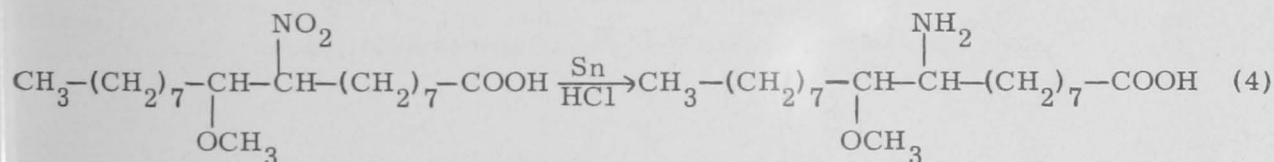


The reaction of these haloacids with ammonia was complicated by the fact that they solidified at the temperature of liquid ammonia. In the purification of the reaction products, every attempt to crystallize the long-chain amino acids (or diamino acids) failed. Work was therefore directed toward finding a method of synthesis that would be more successful.

**AMINATION BY REDUCTION OF NITRO GROUPS:** Another method that was attempted for the synthesis of polyamino acids involved (1) the reaction of tetranitromethane with the unsaturated fatty acids and (2) subsequent reduction of the transferred nitro groups attached to the long-chain acids. Whitmore (1951) has shown that, in methyl alcohol, tetranitromethane adds to double bonds. With oleic acid this reaction can be expressed according to equation 3.



The reduction of the nitro groups is represented by equation 4.



Neutralization equivalents were used to check whether or not the reaction proceeded with oleic acid. Various solvents were studied to determine which one was conducive to a reaction that would give a good yield of the desired product. In all but one of the solvents studied, the products were oils and would not crystallize.

In a reaction of tetranitromethane with methyl oleate, the one exceptional solvent (dry pyridine--absolute ethanol in 2.5:1.0 ratio) produced a crystalline product melting at 72° to 74° C. With this reaction, however, the product decomposed on standing at room temperature. The supernatant liquid from the crystallization produced an oil that could not be crystallized. Separation by a five-stage methanol-urea countercurrent distribution (figure 1) of an ether-extracted portion of the oily product gave five fractions, of which the first three had iodine numbers ranging from 44 to 65 and of which the last two had iodine numbers of 0.

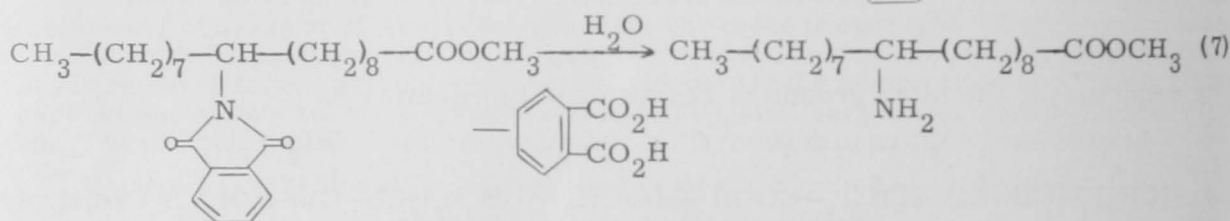
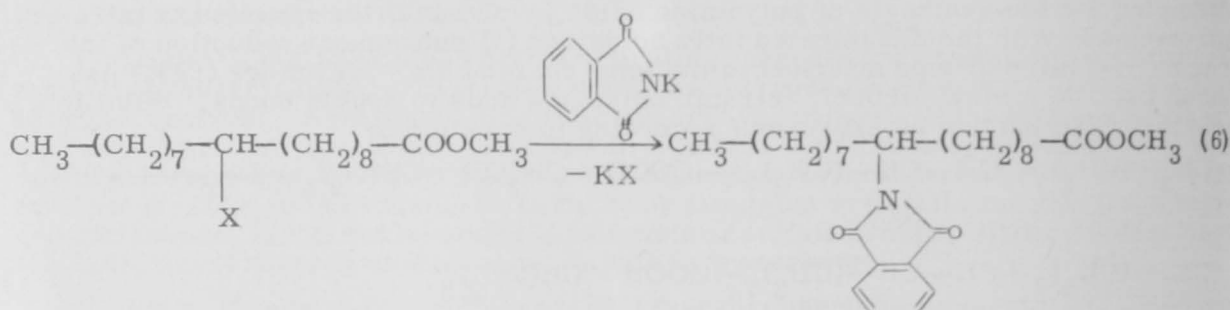
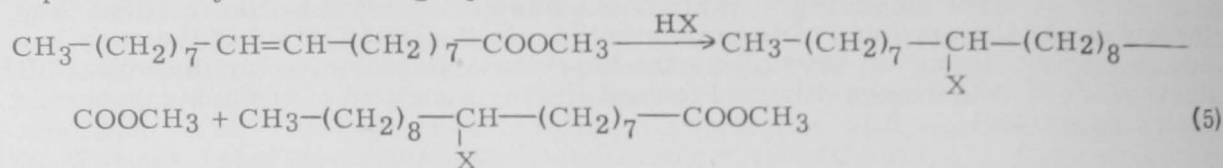
A tin and hydrogen chloride reduction of the crystalline product was carried out, and the reaction product was isolated. This product has not as yet been identified. Analysis of the infrared spectra will show whether or not the reaction has produced an amino acid ester.

Similarly, infrared analysis of the crystals of the expected nitro compound will show whether or not nitration has occurred. These analyses have been postponed until the use of an infrared spectrophotometer can be obtained.

Owing to the oily character of the products, to the apparent difficulty in obtaining the products as crystals, and to the instability of the polynitro compounds, another method was sought for the synthesis of the polyamino fatty acids.

**AMINATION BY ALKYLATION OF POTASSIUM PHTHALIMIDE:** The Gabriel synthesis was thus the next reaction tried for preparing polyamino fatty acids. This reaction involves two steps: (1) the conversion of alkyl halides to alkyl phthalimides and (2) the hydrolysis of the alkyl phthalimides to alkylamines.

The conversion of methyl oleate, by means of the Gabriel synthesis, can be represented by the following equations:



Again, as stated earlier, a pure compound had to be used as the starting material for the preliminary study of the reaction. Methyl oleate was used to prepare methyl 9, 10-dibromooctadecanoate. The latter compound was purified by carrying out a six-stage methanol-urea countercurrent distribution. This step was followed by a chromatographic separation, using an alumina-packed column. A white crystalline product was obtained, which was then reacted with potassium phthalimide. The product obtained in turn from this reaction was a gray-brown crystalline solid, characteristic of alkyl phthalimides.

A similar reaction of potassium phthalimide and methyl 10-iodooctadecanoate was carried out, producing characteristic gray-brown crystals. Consequently, further study of the products is necessary.

### CONCLUSIONS

(1) The conversion of polyhalo fatty acids or esters by their reaction in liquid ammonia does not appear to be a suitable method for preparing polyamino fatty acids. This method may be made successful, however, provided a suitable mutual solvent can be found that will prevent the precipitation of reactants at the temperature of liquid ammonia and provided that steric effects in the molecules will prohibit the formation of secondary-amino acids.

(2) The method of preparing polyamino fatty acids by reducing nitro groups and utilizing the reaction of tetranitromethane may be a feasible solution to the problem if oily products are satisfactory. Owing to the long-chain character of the mole-



cules of these products, oils are to be expected. Also, the increased polarity of molecules containing polyfunctional groups will tend to produce oils. To identify the reaction products and to determine if the conversion is successful, however, crystalline products are desired.

(3) The Gabriel synthesis may possibly be the most successful solution to the problem of preparing polyamino fatty acids. Its value, however, has not yet been fully determined.

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## JAPAN LEADING PRODUCER OF FISHERY PRODUCTS

Statistics of the Food and Agriculture Organization of the United Nations show that Japan is the leading producer of fishery products, as it has been for many years. The Japanese produce approximately 17 percent of the world catch, followed by China, Russia, and the United States (which produces about 9 percent of the world catch).

It has been estimated that almost 50 percent of the world catch of fishery products was made by Asiatic countries, while somewhat over one-fourth was taken by European countries. North American countries account for about 13 percent of the total, and African countries about 6 percent.

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