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ORGANO-TIN AND LEAD CHELATES

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9 Claims. (Cl. 260—429.7)

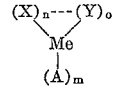
This invention relates to certain new organo-metallic compounds which may be characterized as alkyl and aryl metallo-chelate compounds, wherein a metal atom of a polyvalent character is bound centrally within the atom, partially through metal-carbon bonds, and partially through metal-oxygen bonds in a chelate ring, and also to a method for the production of these compounds.

Metallo-organic compounds fundamentally can be as varied as structural combinations will permit and often are characterized by combinations of very unusual properties. In the instant case, the organo-metallic-chelate compounds prepared are characterized by their containing metal and organic groups, wherein the metal can be made available as such and the compound has usefulness in such applications as the prevention of dental caries where the therapy involved can be based upon the addition of tin to a diet.

It is accordingly a fundamental object of this invention to provide organo-metallic compounds in a form such that the metal is available, but in small quantity and it is available partially as a chelate and in part as an organo compound.

Other objects and advantages of the invention will in part be obvious and in part appear hereinafter.

The compounds, which are embodied in this invention may be described as having formulas which can be written by reference to the following drawing and explanatory text:



wherein the respective arbitrary substituents indicated are defined as follows:

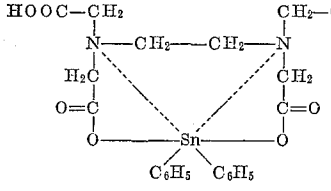
Me—is any metal, trivalent or higher; *m* being an integer of value at least 1, and sufficient to satisfy the requirements of the formula

X—is any organic group forming part of a chelating moiety, and

Y—is any organic group forming part of a chelating moiety, both X and Y, being selected from the group consisting of COO^-, RO^-, RHN^-, RSO_2, RS^-, in which R is any alkyl, aryl, etc. and R may be a connecting or spacing moiety between X and Y, *n* and *o* being integers which have integral values sufficient to satisfy the formula of the compound.

A—is an organic group connected to Me by means of an electron donating linkage through a coordinate bond, *m* being an integer of value at least one.

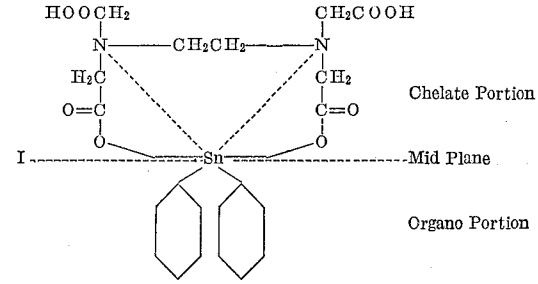
From the formulas given by the drawing and definition it will be apparent that the compounds are characterized by a structure in which the metal atom is part of a fused chelate ring and, in addition, carries organic appendages, a typical one being the following:



Inasmuch as certain of these compounds prepared in

accordance with this invention have indicated usefulness for a variety of combinations of properties, it is sufficient merely to mention here a few of the said compounds. Thus the following is a representative list of a few typical compounds made in accordance with this invention: diphenyl tin (IV) chelate of ethylenediamine tetraacetic acid, dimethyl tin (IV) chelate of ethylenediamine tetraacetic acid, diphenyl lead chelate of ethylenediamine tetraacetic acid, dimethyl lead chelate of ethylenediamine tetraacetic acid; the same tin, lead chelates of hydroxyethylethylenediamine triacetic acid; diethyl-Sn-chelate ethylenediamine tetraacetic acid.

In considering compounds of this character and how their properties render them useful for a variety of purposes, it is of value in developing the concepts to recognize that good chemical theory states that in physiological processes metals are transported from cell to cell or within tissue through chelation reactions. That is, chelation may be looked upon as a rather natural phenomenon in which the metal is literally plucked from one environment into another. Thus the chemistry of certain synthetic amino acid compounds indicates that they involve only a special case of chelation and are of value because in the special case the metal is bound within a five or six member ring. The compounds involved in this invention have properties which become quite interesting, because the metal at a sort of mid plane, as indicated in the drawing below, is chelated via two of its valences while the remaining valences are occupied by ordinary organic groups. That is the metal in being transported through a physiological system, for example, might, under certain circumstances, surrender the organo groups more readily than it would the chelating groups. Thus the compounds, taking the diphenyl tin chelate of ethylene diamine tetraacetic acid as typical, can be formulated as follows:



It will thus be seen that above the line through the middle of the compound, which may be looked upon as a sort of plane, a chelate ring is involved and that below the line ordinary organo-metallic connections are involved.

The method of preparation of these compounds is direct and illustrated in the examples which follow. It should be understood that the compounds are synthesized by determining in advance the form of structure desired and then putting those components of structure together.

Example I

A solution consisting of $\frac{1}{100}$ mole of diphenyl tin dichloride is dissolved in 50 milliliters of acetone and added to a solution of $\frac{1}{100}$ mole of the disodium salt of ethylene diamine tetracetic acid in 50 milliliters of water. The solution quickly becomes cloudy and is stirred for several hours. Diphenyl tin ethylenediamine tetraacetic acid precipitates quantitatively and is filtered off.

Example II

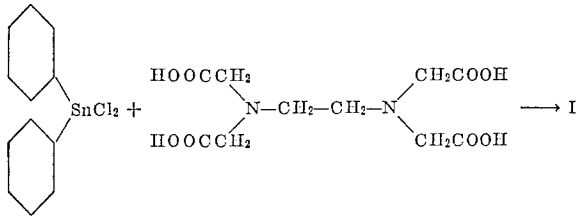
A suspension consisting of $\frac{1}{100}$ mole of divinyl tin oxide in 50 milliliters of water is added to a solution of $\frac{1}{100}$ mole of disodium salt of ethylenediamine tetraacetic acid in 50 milliliters of water. The solution is stirred for ½ hour to dissolve the divinyl tin oxide. The final product is ob-

tained by adding about 100–200 milliliters of ethyl alcohol to the solution. Methyl alcohol is also suitable. The divinyl tin IV chelate precipitates as a white solid with addition of the alcohol.

The divinyl tin chelate has the advantage of being soluble in aqueous solution thereby making it possible to incorporate unusual combinations of organic groups in water solution.

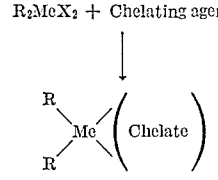
In a variant of this preparation the same product is obtained by adding solid diphenyl tin dichloride to an aqueous solution of disodium ethylene diamine tetraacetic acid and heating the mixture for a period of about 30 minutes.

The reaction which is involved in this preparation may be summarized as follows:



It will be seen from this equation that the reaction involves the simple replacement of the two chlorine atoms or the halogen atoms, if more generalized, in a direct ionic reaction with the acetic acid moieties of the ethylene diamine tetraacetic acid.

In more general form therefore, the preparation of compounds in accordance with this invention may be summarized as follows:



In other words, the organic portion of the metal compound may be of any of the organic radicals usually associated with organo-metallic halide compounds. Thus alkyl groups and aryl groups of more or less high degree of complexity can be employed. The halogen can be chlorine, bromine, iodine, and fluorine.

In the preparation of the compounds useful organometallics are typefied by: diphenyl tin dichloride, dimethyl tin dichloride, diphenyl lead dichloride, dimethyl lead dichloride, the corresponding diethyl compounds; the corresponding dipropyl compounds; and as the chelating agent for forming the chelate ring portion of the molecule I have used ethylene diamine tetraacetic acid and its disodium salt. Accordingly, in the organo-metallic compound used as the reactant, any trivalent metal compound containing one or more metal to carbon bonds, may be used. In fact any organo-metallic compound containing at least one carbon to metal bond and having a total valence of three or higher and also containing a reactive functional group such as halogen, alkoxyl, hydroxyl, oxide, acetate, etc., or in a lower valence state capable of being oxidized to a higher valence, can be used as the organo-metallic moiety which is the starting material. As for substitutions for the chelating agent used in the reaction, equivalents may be any compound capable of giving one or more coordinate bonds to the metal, the remaining valences of the metal to be occupied by ionic bonds.

Generally, the temperature of the reaction is not a critical variable but the material should not be subjected to reaction conditions for more than one hour as this would decrease the yield. It appears that hydrolysis of the reaction product would occur. The pressure and ratio of reactants used does not affect the reaction since it is a direct double decomposition reaction.

At the higher pH's above about 5, the sodium salts of the chelates will be formed.

In recapitulation, therefore, it will be seen that the generalized drawing of the formulas of the compounds may be represented as a central metal atom, fused into a chelate ring, and having its residual valences satisfied by organo-metal bonds. The organic groups may range in number from one to as many as the valence of the metal calls for and other conditions of definition will permit. In the formula the chelate ring is formed through any electron donating atoms such as nitrogen, oxygen, sulphur, phosphorus and the like, bound to the metal by a coordinate bond.

As representative compounds of the class made in accordance with this invention, diphenyl tin ethylene diamine tetraacetic acid and diphenyl lead ethylene diamine tetraacetic acid are crystalline solids of low solubility in water and organic solvents; while in the form of their alcoholates, they are soluble in polar organic solvents, such as alcohol, acetone, methyl ethyl ketone and the like. In general it will be observed from the structure of the molecule itself that it ought to have a variety of properties, and some unusual. They have such variety of properties, because the molecules exhibit the several parts and different functions of these groups bonded together to form a molecule.

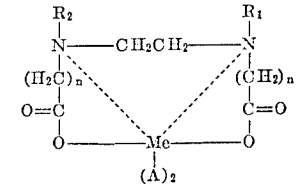
In the evaluation of the compounds it is to be noted that the tin compounds have distinct utility for the insolubilization of dental enamel and accordingly are useful in the prevention of dental caries.

Another useful application of the metals is as the metal source in electroplating baths where the peculiar properties of the compound are such that the tin metal can be made available in the bath without adding to the bath any amounts of extraneous metal ions.

The compounds have rather unusual properties, for example, the diphenyl tin salt of ethylenediamine tetraacetic acid forms an alcoholate with ethyl alcohol and methyl alcohol. With heating the alcoholate will release all the organic parts of the molecule and form a tin IV chelate of ethylenediamine tetraacetic acid. The alcoholate salt is also soluble in water, which causes the alcohol to split off.

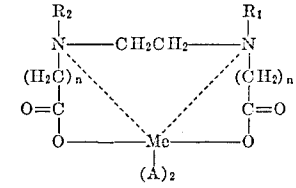
What is claimed is:

1. A chelate having a formula corresponding to the following:



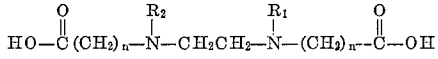
wherein R_1 and R_2 represent moieties selected from the group consisting of $—CH_2CH_2OH$, $—CH_2COOH$, and the alkali metal salts thereof; A is an organic group connected to Me by means of an electron donating linkage through a coordinate bond and is selected from the group consisting of vinyl, lower alkyl and phenyl; Me is a metal selected from the group consisting of tin and lead; and *n* is an integer having a value of at least one and not greater than two.

2. A method of preparing a chelate having a formula given by the following:



wherein R_1 and R_2 represent moieties selected from the group consisting of $—CH_2CH_2OH$, $—CH_2COOH$, and

the alkali metal salts thereof; A is an organic group connected to Me by means of an electron donating linkage through a coordinate bond, and is selected from the group consisting of vinyl, lower alkyl and phenyl; Me is a metal selected from the group consisting of tin and lead; and *n* is an integer having a value of at least one and not greater than two, the said method comprising reacting a compound selected from the group consisting of $(A)_2Me{=}O$ and $(A)_2Me(X)_2$ wherein X is selected from the group consisting of halogen, alkoxyl, hydroxyl and acetate, with a polyamino polycarboxylic acid having the formula



3. A compound in accordance with claim 1 which is diphenyl tin (IV) ethylenediamine tetraacetic acid.

4. A compound in accordance with claim 1 which is dimethyl tin (IV) ethylenediamine tetraacetic acid.

5. A compound in accordance with claim 1 which is diphenyl lead ethylenediaminetetraacetic acid.

6. The method in accordance with claim 2 in which the organo metallic compound is selected from the group consisting of diphenyl tin dichloride, dimethyl tin dichloride, diphenyl lead dichloride, dimethyl lead dichloride, corresponding diethyl compounds and corresponding dipropyl compounds, and reacted with a chelating agent selected from the group consisting of ethylenediamine tetraacetic acid, the disodium salt of ethylene diamine tetraacetic acid.

7. The method in accordance with claim 2 in which diphenyl tin (IV) dichloride is reacted with ethylene diamine tetraacetic acid.

8. The method in accordance with claim 2 in which solid diphenyl tin dichloride is reacted with an aqueous solution of disodium ethylene diamine tetraacetic acid.

9. A compound in accordance with claim 1 which is the divinyl tin chelate of ethylenediamine tetraacetic acid.

References Cited in the file of this patent

UNITED STATES PATENTS

2,228,039	Van Peski et al.	Jan. 7, 1941
2,278,965	Van Peski et al.	Apr. 7, 1942
2,859,104	Kroll	Nov. 4, 1958
2,922,738	McDermott et al.	Jan. 26, 1960

FOREIGN PATENTS

791,119	Great Britain	Feb. 26, 1958
939,028	Germany	Feb. 16, 1956

OTHER REFERENCES

Martell et al.: "Chemistry of the Metal Chelate Compounds," Prentice-Hall, Inc., 1956, pages 537 and 549 relied on.

Bock et al.: "Angewandte Chemie," vol. 70, No. 7, May 7, 1958, page 272 relied on.

Martell: "Chemistry of the Metal Chelate Compounds," Prentice-Hall, Inc. (1952) pp. 516, 536 to 543, 549 and 598.