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2,926,183

ORGANOTITANIUM COMPLEXES AND METHOD OF MAKING SAME

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The present invention relates in general to stable water soluble organic complexes of titanium and more especially to a stable water soluble titanium lactate complex and to processes for making the same.

This application is a continuation-in-part of my co-pending applications Serial No. 544,007, filed October 31, 1955 and Serial No. 549,879, filed November 29, 1955, both of which are now abandoned.

Titanium lactates were first produced many years ago and used in dyeing processes and as mordants for dyes, for it was found that titanic acid having only slightly basic properties easily precipitates from salt solutions especially in the presence of mordant dyes to form lakes of such dyes particularly adapted for the dyeing of fabrics and the treatment of leather. The basic process used to form these titanium lactates was one wherein freshly precipitated hydrated titanic acid in the form of a paste was mixed with lactic acid and an alkali to form a double salt of titanium-alkali-lactate; or by treating the hydrated titanic acid paste with a strong acid, such as hydrochloric acid, and an alkali or alkaline earth metal lactate to form a solution of titanium lactate containing the alkali or alkaline earth metal chlorides. Since the presence of chlorides or other anions in both the double salt and in the titanium lactate solution did not interfere with the usefulness of these lactates in the dyeing trades, these earlier methods for forming titanium lactate were apparently satisfactory. It is also known that water-soluble organic compounds of titanium, useful as modifiers for synthetic resins, have been prepared by reacting an alpha hydroxy monocarboxylic acid with hydrated titanic acid, the success of the process being dependent on the use of hydrated titanic acid paste to insure against the occurrence of electrolytes and inorganic salts in the titanium compound. Other proposed methods for preparing titanium lactate include reacting relatively expensive isopropyl or other alkyl orthotitanates with lactic acid.

Although these earlier methods have proven satisfactory for the limited purposes for which the titanium compounds were intended, the methods of preparation are expensive, complicated, and time consuming and hence wholly inadequate to cope with the rapid expansion of commercial uses for titanium lactate. There is, therefore, an acute need for a relatively simple and inexpensive process for producing a pure titanium lactate complex which is not contaminated with various other metal salts.

It is also well known that the prior art titanium lactate double salt complexes are relatively stable at a pH below 7.0 but that such complexes are unstable on the alkaline side. It would also be desirable to produce a titanium lactate complex which would be stable in aqueous solution at a pH as high as 8.0 or 9.0. Such complexes would be useful in the dyeing industry which employs alkaline dyes, or useful for the treatment of proteinaceous fibers to increase their resistance to degradation in alkaline laundering processes.

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An object, therefore, of the present invention is to provide a process for producing a substantially pure titanium lactate complex from a relatively inexpensive source material and in a simple and convenient manner applicable to the production of the complex on a commercial scale.

A further object of the invention is to provide a superior method for producing a substantially pure titanium lactate complex which is stable up to a pH of 9.0 so that the titanium lactate complex produced is amenable to a wide variety of applications in industry.

A further object of the invention is to provide a stable titanium lactate salt solution which is useful for treating proteinaceous fibers to increase their resistance to degradation in alkaline solutions.

These and other objects, features and advantages hereinafter described are accomplished by the instant invention which, in its broadest aspects, comprises reacting an aqueous extraneous-metal-free solution of titanyl sulfate with an alkaline earth metal salt of lactic acid, filtering the mixture to recover a substantially pure acidic titanium lactate complex. The titanium lactate produced is stable at any pH up to 9.0.

As used herein, the term "extraneous-metal-free," which is used simultaneously with the term "purely" will be understood to mean substantially free of metals other than titanium, that is to say metal impurities such as vanadium, chromium, manganese, copper, lead and similar metals which are present in commercial grades of titanyl sulfate.

More particularly, the process of the instant invention comprises preparing a purified aqueous solution of titanyl sulfate by reacting an alkaline earth metal hydroxide, carbonate, or oxide with an aqueous solution of a commercial grade relatively impure titanyl sulfate to remove the extraneous metal values therefrom as insoluble sulfates, oxides or oxysulfates, reacting an alkaline earth metal lactate with the purified titanyl sulfate solution in an amount such that the lactic acid introduced is substantially equivalent to the titanium in said titanyl sulfate solution, together with sufficient hydroxide, oxide or carbonate of an alkaline earth metal to react with any sulfate ions in excess of those precipitated as insoluble calcium sulfate by said lactate, agitating the mixture, filtering the agitated mixture to recover a substantially pure aqueous solution of acidic titanium lactate complex having a pH value in the range of from about 1.0 to 2.0, and then altering the pH value by treating the complex with a base.

As will be explained hereinafter in more detail, the alkaline earth metal lactate which is reacted with the titanyl sulfate solution may be added to the solution in the form of the alkaline earth metal lactate, or the lactate may be formed in situ by the addition to the titanyl sulfate solution of lactic acid and a hydroxide, oxide or carbonate or an alkaline earth metal such as calcium, strontium or barium.

This complex is not only substantially free of excess sulfates, but the absence of substantially any extraneous metals provides a substantially pure acidic complex which is non-toxic and non-staining and hence suitable for a wide variety of applications in industry. Reference hereinafter to a substantially pure acidic titanium lactate complex will be understood to connote a titanium lactate complex having less than 0.5%, based on the weight of the complex, of extraneous cations and anions including less than 1-10 parts per million of heavy metals such as lead, antimony, arsenic, copper, manganese, vanadium, chromium and similar metals usually found in commercial grades of titanyl sulfate. Of particular importance is the acidic nature of the complex. In many instances the use to which the titanium lactate complex is to be put requires an aqueous solution having a specific pH

value. By forming an aqueous solution having a pH as low as from about 1.0 to 2.0, it has been found possible, by adding appropriate amounts of a base, to vary the pH value of the solution over an extensive range. It is, therefore, within the purview of the instant invention to raise the pH value of the aqueous acidic titanium lactate solution to a predetermined value within the range of from 1 to 9 by adding thereto specific amounts of a base.

Substantially any base may be used to raise the pH of the titanium lactate complex. Among the most suitable, however, are hydroxides, oxides and carbonates of the alkali and alkaline earth metals including magnesium. Also, nitrogenous bases may be employed and among the most effective are ammonia, ethylamine and aminoalcohols such as ethanolamine, triethanolamine, β -aminoethylethanolamine, diisopropanolamine, and N-ethylethanolamine.

Referring again to the titanyl sulfate solution used in the preparation of the titanium lactate complex of this invention, one satisfactory method for preparing the substantially pure titanyl solution is to add a relatively inexpensive commercial grade of titanyl sulfate to water and stir the mixture while heating it for a predetermined length of time and at a temperature preferably below about 55° C. to dissolve as much of the titanium values as possible. This solution is then partially cooled and to the cooled solution is added, during vigorous agitation, an alkalizing agent such as an alkaline earth metal hydroxide, carbonate or oxide, as for example the oxides, hydroxides or carbonates of calcium, barium or strontium as a powder or in the form of an aqueous slurry. Since the addition of these alkalizing materials to the solution effects an exothermic reaction, care must be taken to prevent the temperature from rising above about 55° C., for it has been found that at temperatures above 55° C., the titanium values are prone to precipitate out by hydrolysis. By retaining the temperature of the mixture in the range of from 45° C.-50° C., the alkaline earth metal will react with the sulfate values and precipitate out as insoluble metal sulfates together with any sulfates or oxy-sulfates of metallic impurities such as lead, antimony, arsenic, etc. The mixture is then filtered to separate and remove these salts from the filtrate. The latter is a clear solution substantially free of extraneous metals and is hereinafter referred to as a substantially pure or extraneous-metal-free titanyl sulfate solution. The latter usually contains from about 100-160 grams per liter TiO_2 and has a mole ratio of $\text{H}_2\text{SO}_4/\text{TiO}_2$ of about 1.1 to 1.3. Experience has shown that the nearer the ratio of $\text{H}_2\text{SO}_4/\text{TiO}_2$ is to 1, the less trouble will be experienced in filtration of the calcium sulfate values. While it may be possible by exercising extreme care in the preparation of the solution to form a pure solution of titanyl sulfate wherein the ratio of $\text{H}_2\text{SO}_4/\text{TiO}_2$ is substantially 1, this procedure is impractical. It is also possible to adjust the ratio of TiO_2 to sulfuric acid to 1 by adding excess alkaline earth metal lactate, but this expedient would be both uneconomical and impractical due to the presence in the final product of an amount of lactic acid in excess of the desired 1:1-2 TiO_2 /lactic acid mole ratio. The instant invention, however, is characterized by a relatively simple expedient for adjusting the ratio of $\text{H}_2\text{SO}_4/\text{TiO}_2$, namely by the addition of an alkaline earth metal hydroxide, oxide or carbonate to the titanyl sulfate solution in an amount equivalent to the excess sulfate values therein, thereby precipitating out the excess sulfate values as insoluble alkaline earth metal sulfate. At this point it may be well to mention that the alkaline earth metals used for precipitating the sulfate values are preferably strontium, calcium and barium, each of which forms relatively insoluble metal salts. Since the sulfates of magnesium are relatively soluble, magnesium is not too satisfactory, while the use of the remaining alkaline earth metals, namely beryllium and radium, would be excluded as impractical.

Having determined the necessity for removing excess sulfate values and the amount required to bring the ratio of TiO_2 to sulfuric acid to substantially 1, the actual addition of the alkalizing agent may be made prior to dissolution of the alkaline earth metal lactate in the solution. It is preferable, however, to add the alkalizing agent to the titanyl solution simultaneously with the alkaline earth metal lactate.

The alkaline earth metal lactate may be prepared in any well known manner prior to adding it to the titanyl sulfate solution, as for example by adding an alkaline earth metal oxide, hydroxide or carbonate to an aqueous solution of lactic acid. However, since calcium lactates of various grades are common products of commerce, they may be employed in the practice of the invention in the form in which they are available.

An alternative procedure included within the scope of the invention is that of forming the lactate in situ in the sulfate solution. To this end lactic acid and a carbonate, oxide or hydroxide of an alkaline earth metal, such as calcium, barium or strontium, may be added separately to the sulfate solution to react therein and form the lactic acid salt of the alkaline earth metal. In this event it is mandatory that the lactic acid be added to the solution before the oxide, hydroxide or carbonate of the alkaline earth metal.

A preferred method of carrying out the invention is to add the lactate as, for example, calcium lactate to a substantially pure extraneous metal-free titanyl sulfate solution while continuously agitating the latter. In one embodiment of the invention the calcium lactate is added in stoichiometric amounts, i.e. in an amount such that the lactic acid introduced is substantially equivalent to the amount of titanium in the titanyl sulfate solution, together with calcium hydroxide equivalent in amount to any excess sulfate values in the sulfate solution. The addition of the calcium lactate and calcium hydroxide is preferably accomplished by making a mixture of the two powders and adding the mixture to the titanyl sulfate solution. However, it is within the purview of the invention to add the respective powdered materials separately. In this case, however, it is preferable to add the lactate first, which procedure is mandatory in the preparation of monolactate hereinafter described. The mixture is agitated for a predetermined length of time, during which time reaction occurs between the titanyl sulfate values, the calcium lactate and the calcium hydroxide, any excess sulfate values in the mixture being precipitated out as insoluble $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$. The mixture is then filtered and the filtrate and washings recovered as an aqueous solution of acidic titanium lactate.

The acidic titanium lactate solution is a complex moderately weak acid comprising a clear filtrate having a pH in the range of about 1.0 to 2.0. To adjust the pH to a higher value, the required amount of a base is added to the filtrate.

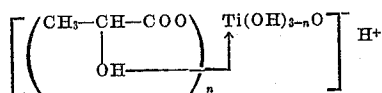
An acidic titanium lactate complex prepared by the addition of a stoichiometric amount of an alkaline earth metal lactate to the titanyl sulfate solution forms a complex wherein the ratio of titanium to lactic acid is substantially 1:2, the product being sometimes referred to as titanium dilactate. However, the invention also comprehends the preparation of an acidic titanium lactate complex, termed the monolactate, wherein the mole ratio of titanium to lactic acid is substantially 1:1. This monolactate solution is prepared by a process which is substantially similar in all respects to the process hereinabove described for the preparation of the dilactate except that half the amount of alkaline earth metal lactate is used with a corresponding increase in the amount of the alkaline earth metal hydroxide, oxide or carbonate for removal of the excess sulfate values as an insoluble alkaline earth metal sulfate.

The resulting acidic titanium lactate complex forms a

clear solution similar in all respects to the dilactate except that the mole ratio of titanium to lactic acid is substantially 1:1. Mole ratios of titanium to lactic acid between 1:1 and 1:2 may also be employed. However, ratios of less than 1 mole of lactic acid per mole of titanium have been found to result in less stable products.

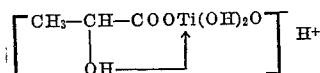
The titanium lactate complexes may be represented by the following formulae:

Generic—

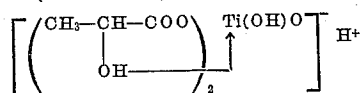


where $n=1$ to 2

Species A (where $n=1$)—



and Species B (where $n=2$)—



The products of this invention are not only useful as mordants in dyeing processes for treating fabrics and leather, but because of the high purity of the product, effected by the absence of metals, as well as the acidic nature of the complex which permits a wide range of variations in the pH value, the complex is found to be useful in textile applications and as a cross linking agent for cellulose, polyvinyl alcohols and similar organic compounds.

To a clearer understanding of the invention, the following examples are given which will be understood to be illustrative only and not in limitation of the scope of the invention.

EXAMPLE I

Preparation of titanyl sulfate solution

A clear substantially extraneous metal-free titanyl sulfate solution suitable for preparation of the acidic titanium lactate complex was prepared as follows:

A total of 1500 grams of a commercial grade titanyl sulfate was placed in a four liter beaker. To this was added 760 milliliters of water and the mixture stirred slowly overnight. An additional 740 milliliters of water was then added and the mixture stirred and warmed for from 2 to 3 hours keeping the temperature below 55° C.

The solution was then cooled to 25° C. and a slurry consisting of 287 grams of calcium hydroxide in 400 milliliters of water was then slowly added with rapid stirring and cooling to keep the temperature below 45° C. The mixture, the total volume of which was roughly 2½ liters, was filtered on a large Büchner funnel. The volume of the filtrate was 1930 milliliters and that of the cake about 500–700 milliliters.

The clear filtrate was analyzed as comprising titanium and sulfate ions in the ratio of 1.24 moles SO_4^{2-} /1 mole titanium and the concentration of titanium as TiO_2 was 122 grams per liter.

A spectrographic analysis of the solution prepared in accordance with the above example showed extraneous metals to be present in amounts as follows:

SbO ₂ -----	<1 p.p.m. (parts per million).
Cu -----	2 p.p.m.
Pb -----	6 p.p.m.
Mn -----	1 p.p.m.
V -----	1 p.p.m.
Cr -----	1 p.p.m.
As -----	Not detectable.
Na -----	<10 p.p.m. (in solution).

The above figures are indicative of the high purity of

the titanyl sulfate solution to be used in the preparation of the titanium lactate complex by the process of this invention, the effectiveness of the process being illustrated especially well by the fact that the metal-free titanyl sulfate solution contains less than 6 parts per million lead, whereas a commercial grade titanyl sulfate used in the preparation of the complex contains about 100 p.p.m. lead.

EXAMPLE II

Preparation of acidic titanium lactate complex 1:2 mole ratio ti/lactic acid

Using the clear extraneous metal-free titanyl sulfate solution prepared in the manner hereinabove described, 1 liter of the solution containing 122 grams (1.52 moles of TiO_2) and 182 grams (1.89 moles) of sulfate ion was added to 468 grams (1.52 moles) of calcium lactate pentahydrate (U.S.P.) powder and 27.4 grams (0.37 mole) of calcium hydroxide (C.P.) powder with stirring, the amount of calcium hydroxide added being sufficient to react with 0.37 mole of excess sulfuric acid in the sulfate solution. During initial stirring the mixture became thick but subsequently thinned out. The mixture was stirred vigorously for about an hour and then allowed to stand overnight to aid filtration. The mixture was filtered on a Büchner funnel. The filter cake was roughly from 400–500 milliliters in volume and was reslurried with water to its original volume (1 liter) and again filtered and washed with a small amount of water. The filtrate and washings were combined yielding 1340 milliliters of acidic titanium lactate solution. When analyzed this solution had a TiO_2 concentration of 76.5 grams per liter and a pH of about 1.7.

A portion of this solution was evaporated by heating it in an evaporating dish at a temperature of about 100° C. and formed a fine dry light tan colored powder which readily dissolved in water.

Another portion of this solution was used to treat cloth. The pH of the solution was raised to 8.5 by the addition of ethanolamine.

A piece of 5 ounce wool flannel cloth was immersed for 30 minutes at room temperature (about 25° C.) in this alkaline solution and then removed and squeezed-dried on a wringer. The treated cloth was then laundered by washing the treated cloth for 30 minutes in an aqueous solution containing 0.5% of chip soap (sodium stearate), 0.3% Na_2CO_3 and 0.1% Na_2BO_3 . The washed cloth was then rinsed with water and allowed to dry. The treated cloth retained substantially the same shape and size and had the same appearance and hand as the original untreated cloth.

For comparison another sample of the wool flannel cloth was laundered in the same manner as that described above except that the cloth was not previously treated with the titanium lactate complex. Upon laundering the untreated cloth was badly shrunken, severely stiffened and degraded in quality.

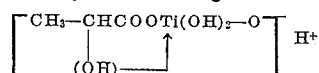
EXAMPLE III

Preparation of acidic titanium lactate complex 1:1 mole ratio ti/lactic acid

This solution was prepared similarly to the dilactate solution described above with the exception that only one-half the stoichiometric amount of calcium lactate was used with a corresponding increase in the amount of calcium hydroxide. Thus, to 1955 milliliters of the clear metal-free titanyl sulfate solution prepared as hereinabove described and containing 258 grams (3.22 moles) of TiO_2 and 347 grams (3.62 moles) of sulfate ion were added 496 grams (1.61 moles) of calcium lactate pentahydrate powder and 149 grams (2.01 moles) of calcium hydroxide (C.P.) powder with stirring. The mixture thickened somewhat initially and then became thinner. It was stirred vigorously for about an hour and then

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allowed to stand overnight to aid filtration. It was then filtered on a Büchner funnel and yielded approximately 800-900 milliliters of filter cake and 1535 milliliters of solution. The solution analyzed 119.2 grams per liter TiO_2 which represented a yield of 71%. The pH of the solution was about 1.6. The chemical analysis of the solid obtained by evaporation of a portion of this solution is represented by the following chemical formula:



The pH of this solution was then adjusted to about 9.0 by the addition of triethanolamine and the solution remained clear.

EXAMPLE IV

Preparation of acidic titanium lactate complex 1:1 mole ratio ti/lactic acid

An acidic titanium lactate complex similar to that described in Example III was prepared by adding to 200 milliliters of clear metal-free titanyl sulfate solution prepared as described in Example I, 31.9 grams (0.304 mole) of 85% lactic acid and 74.2 grams (0.378 mole) of barium carbonate to form the barium salt of lactic acid in situ in the titanyl sulfate solution. The mixture was stirred vigorously for about an hour and thereafter filtered, the filtrate being a clear solution containing about 100 grams per liter TiO_2 , the pH of the solution being 1.5. This product was found to be soluble both in water and in aqueous solutions of methyl or isopropyl alcohols.

The pH of the solution was then raised from 1.5 to 8 by the addition of β -aminoethylethanolamine. The resulting solution was clear although somewhat darker than the original acidic titanium lactate solution.

EXAMPLE V

An acidic titanium lactate complex was prepared by adding a total of 150 grams commercial grade titanyl sulfate to 76 milliliters of water and allowing the mixture to stand overnight. An additional 70 milliliters of water were then added and the mixture was stirred for one hour at 50° C. It was then cooled and 57.2 grams of strontium carbonate slurried with 415 milliliters of water were slowly added. The mixture was then filtered, the cake washed with water and analyzed for titanium and sulfate values. The solution had a volume of 608 milliliters and contained 0.35 mole of titanium and 0.52 mole of sulfate. To this solution was then added 63.8 grams (0.72 mole) of lactic acid and 76.2 grams (0.52 mole) of strontium carbonate. The precipitated strontium sulfate was allowed to settle overnight and the clear yellow supernatant solution of titanium dilactate was carefully decanted. The pH of the resulting solution was adjusted to 8.0 by the addition of diisopropanolamine. A clear solution resulted.

EXAMPLE VI

The procedure of Example III was repeated except that 112.5 grams of calcium oxide were added with the calcium lactate in place of 149 grams of calcium hydroxide. The evolution of heat at this step was greater than in Example III. The product was also slightly darker in color but otherwise substantially the same results were obtained. The pH of this solution was adjusted to 8.0 by the addition of N-ethylethanolamine.

EXAMPLE VII

The procedure of Example III was repeated except that the pH of the titanium lactate solution was adjusted to 8.0 by the addition of concentrated aqueous ammonia. The resulting solution was completely clear and showed no evidence of hydrolysis or decomposition after two months.

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EXAMPLE VIII

The procedure of Example III was again repeated except that the pH of the solution of the titanium lactate complex was adjusted to 8.0 by the addition of triethylamine. The results were substantially the same as in Example VII.

EXAMPLE IX

The titanium lactate solution described in Example II was again prepared except that the pH of the solution was adjusted to 8.0 by the addition of barium carbonate. This solution was also useful for treating cloth in order to render it resistant toward degradation during laundering.

EXAMPLE X-XIII

The titanium lactate solution of Example III was again prepared and the pH of the solution was raised to 8.0 with calcium hydroxide, calcium oxide, calcium carbonate, and barium hydroxide respectively. Clear and stable solutions were obtained in each case.

Although the acidic titanium lactate complexes described above are formed as clear liquid solutions and in many instances may be used as such, it is within the purview of the invention to dehydrate the liquid complex in any well recognized manner, as for instance as illustrated in Example II, to provide the complex in the form of a dry powder—the term “complex” as used herein being understood to include both the liquid solution and solid form.

From the foregoing description and examples it will be evident that the invention discloses a relatively simple economical and commercially adaptable process for preparing a substantially pure acidic titanium lactate complex, i.e. a complex substantially free of extraneous metals, chlorides, sulfates and other ions; and that by the relatively simple expedient of adding a base to the solution, the pH of the solution may be varied over a relatively wide range, thus adapting the complex to a wide variety of commercial applications.

Among the uses are the treatment of cloth to render the cloth resistant to degradation during laundering and in the dyeing industry which employs alkaline systems.

The invention may be carried out in other specific ways than those herein set forth without departing from the spirit and essential characteristics of the invention and the present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive, and all changes coming within the meaning and equivalency range of the appended claims are intended to be embraced therein.

I claim:

1. Method for producing a water soluble organic complex of titanium, stable in aqueous solution up to a pH of 9.0, which comprises reacting an alkaline earth metal lactate said alkaline earth metal selected from the group consisting of calcium, strontium and barium, with an aqueous solution of titanyl-sulfate having a $\text{H}_2\text{SO}_4:\text{TiO}_2$ ratio of 1.1:1 to 1.3:1, to form a mixture comprising titanium lactate having a mole ratio of lactate:titanium from 1:1 to 2:1, and the corresponding alkaline earth metal sulfate, adding to said mixture an alkaline earth metal compound selected from the group consisting of oxide, hydroxide and carbonate, said alkaline earth metal selected from the group consisting of calcium, strontium and barium, in amount sufficient to react with the unreacted sulfate values, and removing the titanium lactate formed from the insoluble alkaline earth metal sulfate, the process being carried out at a temperature between 25° C. and 55° C.

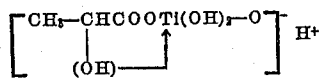
2. Method for producing a water soluble organic complex of titanium, stable in aqueous solution up to a pH of 9.0, which comprises reacting lactic acid with titanyl sulfate solution having a $\text{H}_2\text{SO}_4:\text{TiO}_2$ ratio of 1.1:1 to 1.3:1, the lactic acid and titanyl sulfate being admixed

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in amount to form a mole ratio of lactate:titanium from 1:1 to 2:1, adding to said mixture an alkaline earth metal compound selected from the group consisting of oxide, hydroxide and carbonate, said alkaline earth metal selected from the group consisting of calcium, strontium and barium, in amount to react with all of the sulfate values present in said mixture, and removing the titanium lactate formed from the insoluble alkaline earth metal sulfate, the process being carried out at a temperature between 25° C. and 55° C.

3. Method according to claim 2 in which the pH of the water-soluble acidic titanium lactate complex is varied over the range of from about 1 to 9 by adding thereto a base selected from the group consisting of hydroxides, carbonates and oxides of the alkaline earth metals selected from the group consisting of calcium, strontium and barium and nitrogenous compounds selected from the group consisting of ammonia, ethylamine, ethanolamine, triethanolamine, β -aminoethylethanolamine, diisopropanolamine and N-ethylethanolamine.

4. A stable water-soluble organic titanium complex having the formula:

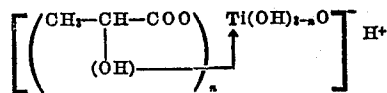


and complex being substantially free of metals selected

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from the group consisting of lead, arsenic and antimony, and soluble in an aqueous organic solvent.

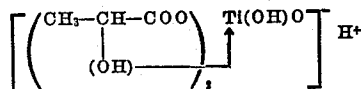
5. A water-soluble titanium lactate complex having the formula



where $n=1$ to 2

10 said complex being stable in aqueous media from pH of 1.0 to 9.0.

6. A water-soluble titanium lactate complex having the formula



15 said complex being stable in aqueous media from pH of 1.0 to 9.0.

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