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## 3,457,177 MONOAMIDOTRIPHOSPHATE DETERGENT COMPOSITIONS

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415,499, now Patent No. 3,405,168, dated Oct. 8, 1968.  
Divided and this application Dec. 5, 1967, Ser. No.  
707,904

Int. Cl. C11d 3/066

U.S. Cl. 252-152

6 Claims

### ABSTRACT OF THE DISCLOSURE

Aqueous detergent and dispersant compositions con-  
taining at least 0.01 weight percent N-substituted mono-  
amidotriphosphates are disclosed. The preferred N-sub-  
stituent is an alkyl or monohydroxy alkyl containing from  
1 to 11 carbon atoms.

This application is a divisional application of applica-  
tion S.N. 415,499, filed Dec. 2, 1964, now U.S. Patent  
3,405,168 granted Oct. 8, 1968.

Ordinarily manufacturers who make detergents for use  
in hard water formulate their products using several differ-  
ent types of materials for several definite desired results.  
For example, although materials (such as fabric bright-  
eners, antiredeposition agents, fabric softeners, fillers,  
water, sequestrants and surface active agents) that are used  
in the formulation of so-called "built" detergents are  
usually blended together, by the manufacturer starting  
with his stocks of the individual materials. The particular  
reasons for using each of the aforementioned types of ma-  
terials in any given detergent formulation are well known  
by those in the art and need not be detailed here. There  
has been a strong desire for many years, however, by those  
in the detergent art, for a class of chemical compounds  
having the ability to both sequester water "hardness"  
ions (such as  $\text{Ca}^{++}$ ,  $\text{Mg}^{++}$ ,  $\text{Fe}^{++}$ , and the like) and serve  
as a surface active agent having detergent, foaming, and/  
or dispersant properties such as those of conventional  
synthetic organic detergents (surfactants).

Consequently, it is a primary object of the present in-  
vention to provide processes for the manufacture of valu-  
able chemical compounds having combined sequestrant-  
surfactant properties.

It is another primary object of this invention to provide  
novel and valuable chemical compounds having such com-  
bined (sequestrant and surfactant) properties.

It is still another object of the present invention to pro-  
vide a novel sub-class of compounds having combined  
sequestrant-surfactant properties, which compounds (in  
addition to being excellent sequestrants) are particularly  
useful as fabric softeners.

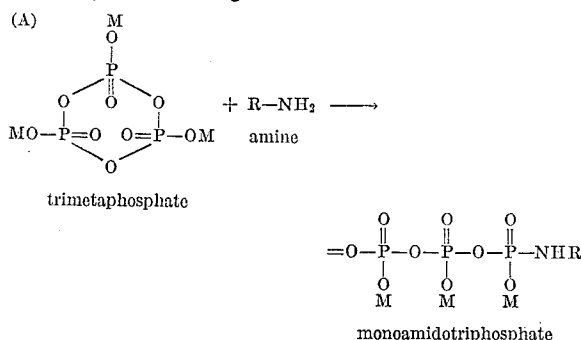
It is still another object of the present invention to pro-  
vide a novel sub-class of compounds having combined  
sequestrant-surfactant properties, which compounds (in  
addition to being excellent sequestrants) are particularly  
useful as detergents and foaming agents.

It is yet another object of the present invention to pro-  
vide a novel sub-class of compounds having combined  
sequestrant-surfactant properties, which compounds (in  
addition to being excellent sequestrants) are particularly  
useful as dispersants.

These objects, as well as others which will be apparent  
from the following specifications and claims are obtained  
by reacting together a primary organic amine having from  
1 to about 30 carbon atoms per primary amine radical  
with an alkali metal trimetaphosphate.

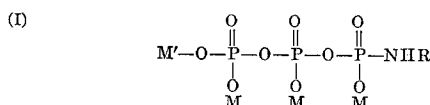
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Thus, the processes of the present invention are illus-  
trated by the following reaction:



wherein M is either an alkali metal cation,  $\text{NH}_4$ , or H,  
and at most 2 of M in the trimetaphosphate reactant are  
H, and R is an aliphatic radical containing from 1 to  
about 30 carbon atoms. These processes are preferably  
carried out in water or in an aqueous medium in which the  
alkali metal trimetaphosphate is soluble to the extent of  
at least about 0.1 weight percent.

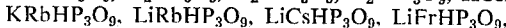
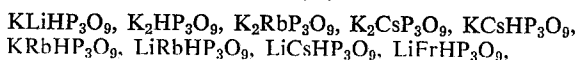
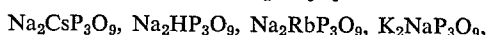
The valuable combination sequestrant-surfactant com-  
pounds of the present invention are water-soluble or water-  
dispersible N-substituted monoamidotriphosphates having  
the structure



wherein R is hydrophobic aliphatic radical containing  
from 1 to about 30 carbon atoms, M is selected from the  
group consisting of alkali metal cations and ammonium  
ions, and M' is selected from the group consisting of  
 $\text{R}-\text{NH}_3^+$  cations, ammonium cations,  $\text{H}^+$ , and metallic  
cations. Generally, those N-substituted monoamidotriphos-  
phates containing from about 12 to about 30 carbon atoms  
in the R group are useful as fabric softeners; those that  
contain from about 6 to 11 carbon atoms in their R group  
are more useful as detergent active materials, foaming  
agents, or wetting agents; while those that have R groups  
containing fewer than average of 6 carbon atoms are use-  
ful dispersants (as well as being valuable sequestrants).

Thus, a preferred sub-class of the N-substituted mono-  
amidotriphosphates of the present invention has particu-  
larly valuable utility as dispersants for such materials  
as, for example, clays in aqueous media and encompasses  
those materials that are soluble in water to the extent of  
at least about 0.1 weight percent and have the struc-  
ture of Formula I, above; except that R is a hydrophobic  
aliphatic radical containing from 1 to about 5 carbon  
atoms.

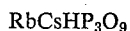
Typical examples of these compounds (which have  
such unexpected combined dispersant-sequestrant prop-  
erties) include products resulting from reacting together  
[via a reaction such as that of reaction (A), above]  
one or more inorganic trimetaphosphates with one or  
more primary aliphatic amines containing from 1 to  
about 5 carbon atoms. Useful trimetaphosphates include,  
for example, (where " $\text{P}_3\text{O}_9$ " represents the trimetaphos-  
phate anion) the alkali metal trimetaphosphates such as  
 $\text{Na}_3\text{P}_3\text{O}_9$ ,  $\text{K}_3\text{P}_3\text{O}_9$ ,  $\text{Li}_3\text{P}_3\text{O}_9$ ,  $\text{Rb}_3\text{P}_3\text{O}_9$ ,  $\text{Cs}_3\text{P}_3\text{O}_9$ ,  $\text{Fr}_3\text{P}_3\text{O}_9$ ,  
 $\text{Na}_2\text{KP}_3\text{O}_9$ ,  $\text{NaKHP}_3\text{O}_9$ ,  $\text{NaLiHP}_3\text{O}_9$ ,  $\text{NaCsP}_3\text{O}_9$ ,



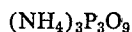
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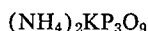
$\text{Li}_2\text{KP}_3\text{O}_9$ ,  $\text{Li}_2\text{HP}_3\text{O}_9$ ,  $\text{Li}_2\text{RbP}_3\text{O}_9$ ,  $\text{Li}_2\text{CsP}_3\text{O}_9$ ,  $\text{Rb}_2\text{NaP}_3\text{O}_9$ ,  
 $\text{Rb}_2\text{KP}_3\text{O}_9$ ,  $\text{Rb}_2\text{LiP}_3\text{O}_9$ ,  $\text{Rb}_2\text{HP}_3\text{O}_9$ ,  $\text{Rb}_2\text{CsP}_3\text{O}_9$ ,



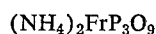
$\text{Cs}_2\text{NaP}_3\text{O}_9$ ,  $\text{Cs}_2\text{KP}_3\text{O}_9$ ,  $\text{Cs}_2\text{HP}_3\text{O}_9$ ,  $\text{Cs}_2\text{LiP}_3\text{O}_9$ ,  $\text{NaH}_2\text{P}_3\text{O}_9$ ,  
 $\text{KH}_2\text{P}_3\text{O}_9$ ,  $\text{LiH}_2\text{P}_3\text{O}_9$ ,  $\text{RbH}_2\text{P}_3\text{O}_9$ ,  $\text{CsH}_2\text{P}_3\text{O}_9$ ,  $\text{FrH}_2\text{P}_3\text{O}_9$ ;  
 the ammonium trimetaphosphates  $[(\text{NH}_4)_2\text{HP}_3\text{O}_9$ ,



and  $(\text{NH}_4)_2\text{P}_3\text{O}_9$ ]; the mixed ammonium-alkali metal  
 cation trimetaphosphates such as  $(\text{NH}_4)_2\text{NaP}_3\text{O}_9$ ,



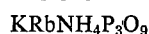
$(\text{NH}_4)_2\text{LiP}_3\text{O}_9$ ,  $(\text{NH}_4)_2\text{RbP}_3\text{O}_9$ ,  $(\text{NH}_4)_2\text{CsP}_3\text{O}_9$ ,



$\text{Na}_2\text{NH}_4\text{P}_3\text{O}_9$ ,  $\text{K}_2\text{NH}_4\text{P}_3\text{O}_9$ ,  $\text{Li}_2\text{NH}_4\text{P}_3\text{O}_9$ ,  $\text{Rb}_2\text{NH}_4\text{P}_3\text{O}_9$ ,  
 $\text{Cs}_2\text{NH}_4\text{P}_3\text{O}_9$ ,  $\text{NaKNH}_4\text{P}_3\text{O}_9$ ,  $\text{NaLiNH}_4\text{P}_3\text{O}_9$ ,



$\text{NaCsNH}_4\text{P}_3\text{O}_9$ ,  $\text{KLiNH}_4\text{P}_3\text{O}_9$ ,  $\text{KC}_s\text{NH}_4\text{P}_3\text{O}_9$ ,



$\text{LiRbNH}_4\text{P}_3\text{O}_9$ ,  $\text{LiCsNH}_4\text{P}_3\text{O}_9$ ,  $\text{LiFrNH}_4\text{P}_3\text{O}_9$ ,



$\text{RbFrNH}_4\text{P}_3\text{O}_9$  and  $\text{CsFrNH}_4\text{P}_3\text{O}_9$ .

Typical examples of the primary aliphatic amines having from 1 to about 5 carbon atoms include methylamine, ethylamine, isopropylamine, tert-butylamine, n-propylamine, allylamine, 2-aminobutane, isobutylamine, n-butylamine, 2-amino-2-methylbutane, 5-amino-1-pentene, 2-amino-n-pentane, isoamylamine, 2-methyl-n-butylamine, n-amyamine, ethylenediamine, 5-amino-3-nitro-1-pentene, tetramethylenediamine, 2-hydroxy-n-propylamine, 2-hydroxy-ethylamine, 3-amino-n-pentanol-2, 2-aminopropyl alcohol, 1,2,3-triaminopropane, 4-amino-n-pentyne-2, 2,3-dichloropropylamine, 2,2,2-tribromoethylamine, 3-nitro-1-propylamine, methyl-3-aminopropyl ether, ethyl-2-aminopropyl thioether, and the like.

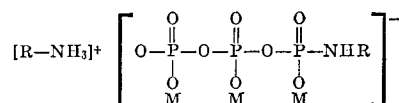
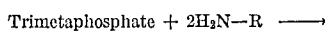
Another preferred sub-class of the valuable N-substituted monoamidotriphosphates of the present invention has particularly valuable utility as general purpose detergents and foaming agents. This sub-class encompasses those materials that are either soluble in water or readily dispersible in water and have the structure illustrated by Formula I, above; except that R (in this particularly preferred sub-class) is a hydrophobic radical containing from about 6 to about 11 carbon atoms. Typical examples of these compounds (having combined detergent and foaming sequestrant properties) include products having the structure illustrated by Formula I, above, resulting from reacting together [via a reaction like reaction (A), above] one or more of the aforementioned useful trimetaphosphates with an aliphatic primary amine containing from about 6 to about 11 carbon atoms such as, for example, n-hexylamine, 3-amino-n-hexane, 1,3-propanediamine, 4-amino-n-heptane, 2-amino-n-heptane, diethylethylenediamine, n-heptylamine, trichloro-n-octylamine, n-octylamine, 2-ethyl-4-methyl heptylamine, 4-fluoro-n-decylamine, 3-amino-hexylalcohol, n-nonylamine, 6-nitro-1-heptylamine, methyl-6-aminoheptyl ketone, 2-chloropropyl-3-aminopropyl ether, 7-amino-n-heptaldehyde and the like.

Another preferred sub-class of the valuable N-substituted monoamidotriphosphates of the present invention has particularly valuable utility as fabric softeners in addition to being valuable sequestrants. This sub-class encompasses those materials that are either soluble in water or readily dispersible in water and have the structure illustrated by Formula I, above; except that R (in this particularly preferred sub-class) is a hydrophobic radical containing from about 12 to about 30, and preferably from about 14 to about 22 carbon atoms. Typical ex-

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amples of these compounds (having combined fabric softener-sequestrant properties) include products having the structure illustrated by Formula I, above, resulting from reacting together [via a reaction like reaction (A), above] one or more of the aforementioned useful trimetaphosphates with an aliphatic primary amine containing from about 12 to about 30 carbon atoms such as, for example, primary tallow amine, n-octadecylamine, oleyl amine, primary coconut oil amine, primary hydrogenated tallow amine, n-lauryl amine, stearyl amine, palmityl amine, myristyl amine, linoleyl amine, arachidyl amine, behenyl amine, cerotyl amine, 9,10-dodecenyl amine, ricinoleyl amine, linolenyl amine, gadoleyl amine, and the like, as well as all of these (and other) having substituents on their otherwise hydrocarbyl chains that ordinarily do not react with the alkali metal trimetaphosphates.

The generic processes of the present invention involve essentially the reaction of a primary aliphatic amine with a trimetaphosphate to thereby produce one of the valuable N-substituted monoaliphatic monoamidotriphosphates described above. The reaction is believed to proceed as illustrated in Equation (A), above, when one mole of amine is reacted with one mole of trimetaphosphate. When "excess" amine (i.e., more than about 1 mole of amine per mol of reaction product) is present in the reaction mixture, the corresponding amine salt is believed to be formed:



While the trimetaphosphate and the amine can be present in the reaction mixtures of the present invention in practically any relative proportions, in situations in which the desired combination sequestrant-surfactant is intended to be subsequently isolated and/or concentrated or recovered as such from the reaction mixture, generally the molar ratio of primary amine to trimetaphosphate used in the present processes should be from about 0.2:1 and about 5:1, while if optimum results are desired, stoichiometric proportions thereof should be utilized.

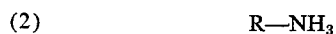
The reaction of trimetaphosphate with primary amine is preferably carried out in water (or in an aqueous system in which some trimetaphosphate can be dissolved) having a pH (when measured at about 25° C. at the one weight percent level of the reaction mixture in distilled water) between about 7 and about 10.5. Generally, competing reactions such as hydrolysis of the polyphosphate and/or formation of alkali metal chain phosphate salts also occur to a significant extent when aqueous reaction mixtures having pH's outside of this preferred pH range (for example at pH's below about 6 and above about 11) are utilized to produce the desired combination sequestrant-surfactants of the present invention. Preferably enough water should be used so that the reaction mixture is fairly fluid during the entire reaction. Thus, preferably from about 10 to about 98 weight percent, based on the total weight of the reaction mixture, of water should be utilized. When primary amines that are insoluble or only partially soluble in water are utilized in the processes of this invention, generally the application of fairly intensive agitation (i.e. stirring) applied to the reaction mixture will result in sufficient contact between the trimetaphosphate and the amine to enable the desired reaction to proceed at a sufficiently fast rate.

While the particular time and/or temperature employed in the processes of this invention (for reaction of the primary amine with the trimetaphosphate) is not critical, generally it is preferred that the temperature of the reaction mixtures be above room temperature and within the range of from about 25° C. to about 105° C. For optimum results it is still further preferred that the tem-

perature of the reaction mixture be at least about 40° C., and up to about 90° C. (under ambient pressures) for at least about 2 minutes of the total period in which the amine is contacted with the trimetaphosphate. If higher pressures are utilized higher reaction temperatures can also be used. Also, generally higher reaction temperatures (within the ranges mentioned) are used when relatively higher molecular weight primary amines are utilized in these processes, since the amine should preferably be melted during at least part of the reaction period.

Materials other than the trimetaphosphate and the primary amine can also be present in these reaction mixtures without substantially detracting from all of the benefits that can be obtained by practicing the present invention. Trimetaphosphates that are useful in the overall practice of this invention include all of the alkali metal (sodium, lithium, potassium, rubidium, cesium) trimetaphosphates, ammonium trimetaphosphate and mixed acidic alkali metal or ammonium trimetaphosphates (such as disodium monohydrogen trimetaphosphate, monosodium dihydrogen trimetaphosphate, diammonium monohydrogen trimetaphosphate, monoammonium dihydrogen trimetaphosphate, and the corresponding other mixed acidic alkali metal trimetaphosphate salts as well as those trimetaphosphates in which more than one alkali metal cation occurs).

While any aliphatic primary amine having the structure of Formula 2, below,



(wherein R is a hydrophobic aliphatic radical containing from 1 to about 30 carbon atoms) can be utilized advantageously in the practice of the present invention, those having from 1 to about 20 carbon atoms are preferred. Still further preferred are the primary aliphatic hydrocarbyl amines, and primary aliphatic hydrocarbyl amines that contain a single hydroxyl group substituted at some point on their otherwise hydrocarbyl group. Within this group of "primary aliphatic hydrocarbyl" group of amines, primary alkyl amines are preferred. Typical examples of some of the primary amines that can be used in the practice of this invention include all of those detailed above, as well as many others.

In the following examples, which illustrate some of the preferred embodiments of the present invention, all parts are by weight unless otherwise stated.

#### Example I

Into a conventional stainless steel mixing vessel fitted with a fairly efficient stirrer are charged 1430 parts of n-octylamine, 1700 parts of trisodium trimetaphosphate, and 15,000 parts of water. The resulting mixture is then heated, with stirring, to about 96° C. and held at this temperature for about 90 minutes. After about the first 20 minutes of this reaction period the mixture is observed becoming thicker. At the end of the 90 minute reaction period, the reaction mixture is viscous and turbid. Upon being cooled to about 30° C., the reaction mixture becomes a semi-solid gel. It can be utilized in this form directly if desired. For example, a 0.2 weight percent solution of this reaction product in water foams extensively and chelates the usual water "hardness" ions as readily as does tetrasodium pyrophosphate (on a molar basis). If desired, the reaction product can be air-dried, or dried in a forced draft oven, for example, at about 60° C. The resulting dried reaction product also mixes readily with water.

Any of the above-described valuable combination sequestrant-surfactant compounds of the present invention can be made via processes such as that illustrated in Example I, with consideration being taken only with respect to the particular molecular weight of the reactants. Thus, any of the above-described useful trimetaphosphates can replace the trisodium trimetaphosphate in Example I,

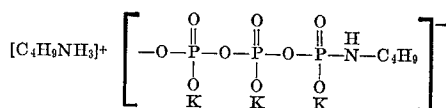
and any of the above-described useful primary amines can replace the n-octylamine. Generally, for optimum yields of the desired reaction product, it is better to utilize either somewhat lower reaction temperatures than those of Example I, or somewhat higher pressures over the reaction mixture, when relatively lower molecular weight amines (lower than about hexylamine) are utilized. For example, when monoethanolamine is the amine used, a maximum reaction temperature of about 65° C. is preferred, while when ethylamine is used, a maximum reaction mixture temperature of only about 45° C. is preferred. Otherwise excessive volatilization of these amines occurs.

Note that in Example I, the molar ratio of amine to trimetaphosphate is 2:1. Other ratios can also be used in processes like Example I, as can widely differing amounts of water, without significantly detracting from the benefits that can be derived from using such processes.

#### Example II

Into a reaction vessel such as that described in Example I, above, are charged 100,000 parts of water, 3560 parts of tripotassium trimetaphosphate, and 3810 parts of borax (sodium tetraborate decahydrate). While the temperature of the resulting solution is maintained at about 60° C. and is stirred continuously, a total of 730 parts of n-butylamine is added slowly thereto over a period of 30 minutes. Then the resulting reaction mixture (having a pH between 9 and 10 during this entire reaction period) is stirred for an additional 60 minutes at about 60° C. At the end of this time, the solution is hazy, but very fluid, practically all of the reaction product remaining dissolved in the water.

Analysis of the resulting solution by nuclear magnetic resonance techniques indicate that about half of the trimetaphosphate charged is unreacted. Thus the resulting product is believed to have the structure



The product is as effective for softening hard water, on a molar basis, as tetrapotassium pyrophosphate. It is very soluble in water, and is therefore a valuable builder for use in liquid detergents, since it is also useful as a dispersant for soils, and as an antiredeposition agent.

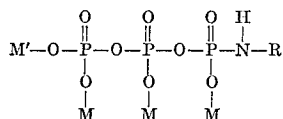
The addition of other strong bases to reaction mixtures such as those of Example II can result in the replacement of the n-butylammonium  $[C_4H_9NH_3]^+$  portion of the product by the cation of the particular base used. However, in aqueous solutions of the valuable combination sequestrant-surfactant compounds of this invention, the identification of the cation becomes unimportant, since the compound presumably ionizes to at least some extent whenever it dissolves in the water.

While even very small amounts of the compounds of the present invention are beneficial to at least some extent when they are dissolved and/or dispersed in water, it is generally preferred that at least about 0.005 weight percent (based on the weight of the resulting solution) of one or more of these combination surfactant-sequestrants be dissolved therein. For optimum results, when any of the combination detergent-sequestrants described hereinbefore, for example, is utilized, the aqueous solution should contain (dissolved therein) from about 0.02 to about 2 weight percent of the valuable combination detergent-sequestrant.

Other ways in which the compounds of the present invention can be used are as textile lubricants, flameproofing agents in textiles and other organic materials such as wood; antistatic agents; as gasoline or other petroleum derivative additives, for example as anti-icers; as flotation agents in the recovery of various valuable ores; and the like.

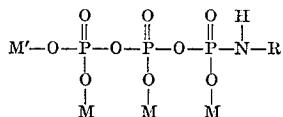
What is claimed is:

1. An aqueous detergent solution containing dissolved therein about 0.01 to about 2.0 weight percent of N-substituted monoamidotriphosphate having the structure



wherein R is a hydrophobic aliphatic radical containing from 1 to about 5 carbon atoms and selected from the group consisting of alkyl and monohydroxy substituted alkyl, M is selected from the group consisting of alkali metal cations and  $\text{NH}_4$ , and  $\text{M}'$  is selected from the group consisting of  $\text{RNH}_3$ ,  $\text{NH}_4$ , H, and alkali metal cations.

2. An aqueous detergent solution containing dissolved therein from about 0.02 to about 2 weight percent of an N-monoaliphatic monoamidotriphosphate having the structure



wherein R is an aliphatic radical containing from 6 to 11 carbon atoms and is selected from the group con-

sisting of alkyl and monohydroxy substituted alkyl, M is selected from the group consisting of alkali metal cations, and  $\text{NH}_4$ , and  $\text{M}'$  is selected from the group consisting of  $\text{RNH}_3$ ,  $\text{NH}_4$ , H, and alkali metal cations.

3. An aqueous detergent solution as in claim 2, wherein said aliphatic radical is an alkyl radical.

4. An aqueous detergent solution as in claim 2, wherein said N-monoaliphatic monoamidotriphosphate is an N-monoethanol monoamidotriphosphate.

5. An aqueous detergent solution as in claim 3, wherein said alkyl radical contains an average of about 8 carbon atoms.

6. An aqueous detergent solution as in claim 3, wherein said alkyl radical is an isopropyl radical.

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LEON D. ROSDOL, Primary Examiner

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U.S. Cl. X.R.

252-8.1, 8.8, 137; 260-501.12, 502.5