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PROCESS FOR SOFTENING WATER AND DISSOLVING CALCIUM SALTS WITH THIO-TETRAPHOSPHATES

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Our invention relates particularly to a method for softening water, such, for instance, as water which is hard by reason of the presence of calcium or other salts, and for dissolving these salts in such a manner as to decrease or eliminate the hardness of the water, and particularly by the use of soluble thiotetraphosphates.

The object of our invention is to provide a more advantageous method for the softening of water so as to eliminate the hardness thereof, by dissolving the said salts with the aid of soluble thiotetraphosphates, that is to say, the thiotetraphosphates of the alkali metals. These thiotetraphosphates have been recently discovered by us and are the subject of U. S. Patents Nos. 2,025,503 and 2,033,913, as, for example, sodium mono thiotetraphosphate, $\text{Na}_2\text{P}_4\text{O}_{12}\text{S}$, or sodium trithiotetraphosphate, $\text{Na}_2\text{P}_4\text{O}_{10}\text{S}_3$, or the corresponding potassium or ammonium salts.

The water softening may be carried out according to our method by using the true alkali thiotetraphosphates, made in accordance with the procedures described in the above patents. We particularly recommend the sodium thiotetraphosphates for our purposes as being most cheaply made and giving excellent results, though any other soluble thiotetraphosphate or thiotetraphosphates may be used for our purposes and in our process.

While our invention is capable of being carried out in many different ways, for the purpose of illustration we have described hereinafter only certain embodiments of our invention.

The water softener made in accordance with our invention may be applied in such a manner as to soften the water containing soluble calcium salts with or without the presence of other soluble salts, as, for instance, magnesium salts, for the following uses:

As a water softener by keeping the alkali earth bases in a soluble condition.

In laundries to save soap by combining with the alkali earth bases in the washing water.

In deliming leather as in the tanning industry.

In dissolving the lime compounds which may occur in soiled textiles.

To prevent deposits of alkali earth salts forming in hot water systems.

To prevent deposits of alkali earth compounds in steam boilers and their feed lines.

To prevent deposits of alkali earth compounds in automobile water cooling systems.

To prevent the formation of alkali earth bases as precipitates in the water to be frozen in artificial ice machines.

To prevent the formation of alkali earth precipitates on the outside of cans from the cooling water of the canning industry.

To prevent streaky dyeing in textiles by keeping any alkali earth compounds in a condition of solubility.

Preventing the formation of soap spots on the cloth in dyeing.

To clean cement or brick walls from lime deposits.

As a softener for water in washing living animals or in baths for human beings.

For cleaning or washing dishes.

For softening water in which anything may be washed and thus saving soap.

Washing rayon, for instance.

Scouring wool.

Kier boiling in bleacheries.

Boiling off silk.

Causing increased penetration of dye in textiles by cleaning off traces of alkali earth compounds.

As so applied it is found that the water softening by adding an alkali metal thiotetraphosphate is much more effective than previous methods of water softening. For example, to soften the water used in laundries for the washing of fabrics, or in preventing the deposit of alkali earth compounds in steam boilers and other feed lines, with water containing soluble lime salts with or without the presence of magnesium salts, etc., we add to 1000 gallons of water containing, for instance, 48 parts by weight of calcium per million of water, in the form of soluble salts, usually sulphates, bicarbonates or chlorides, 3 pounds of a sodium thiotetraphosphate or 3.6 pounds of a potassium thiotetraphosphate as made in accordance with either of the above mentioned patents already referred to. As a result of this treatment the relatively large concentration of free calcium ions in the water is very greatly reduced or entirely eliminated by combining them into soluble only slightly ionized compounds or radicals due to the presence of the thiotetraphosphate. It will be found that in the softening of the water for steam boilers and feed lines the calcium and other similar compounds are prevented from being deposited to form a scale in the steam boilers and feed lines, notwithstanding the heating and concentration that takes place. Similarly, the water may be softened in substantially the same way in connection with any of the other water softening operations, and particularly in the other industries listed above. We have found that water may be softened in this

way, in accordance with our process, much more effectively inasmuch as less of the alkali metal thiotetraphosphate is required to completely soften the water than will be required of other materials previously used for such purposes. This can be readily demonstrated by a simple test of the water softening properties of these thiotetraphosphates. This is demonstrated by the amount of the water softening substance required to be added to keep the calcium in solution.

While we have mentioned above thiotetraphosphates made only by the two different procedures in U. S. Patents Nos. 2,025,503 and 2,033,913, we do not wish to confine ourselves to the products of these two processes. It will be understood that there can be other processes for making soluble thiotetraphosphates and it is readily seen that there are many thiotetraphosphates wherein the oxygen atoms of a tetraphosphate may be replaced by a sulphur atom. For instance, the sodium monothiotetraphosphate, $\text{Na}_6\text{P}_4\text{O}_{12}\text{S}$ may be prepared according to U. S. Patent No. 2,025,503, but there are many other possible thiotetraphosphates, for example:

25	$\text{Na}_6\text{P}_4\text{O}_{11}\text{S}_2$	$\text{Na}_6\text{P}_4\text{O}_5\text{S}_8$
	$\text{Na}_6\text{P}_4\text{O}_{10}\text{S}_3$	$\text{Na}_6\text{P}_4\text{O}_4\text{S}_9$
	$\text{Na}_6\text{P}_4\text{O}_9\text{S}_4$	$\text{Na}_6\text{P}_4\text{O}_3\text{S}_{10}$
	$\text{Na}_6\text{P}_4\text{O}_8\text{S}_5$	$\text{Na}_6\text{P}_4\text{O}_2\text{S}_{11}$
30	$\text{Na}_6\text{P}_4\text{O}_7\text{S}_6$	$\text{Na}_6\text{P}_4\text{OS}_{12}$
	$\text{Na}_6\text{P}_4\text{O}_6\text{S}_7$	$\text{Na}_6\text{P}_4\text{S}_{13}$

In addition we may have the potassium or ammonium radical replace in whole or in any part the sodium radical, either one or both giving thiotetraphosphates containing various bases, as, for example, $\text{Na}_5\text{KP}_4\text{O}_{12}\text{S}$ or $\text{Na}_4\text{KNH}_4\text{P}_4\text{O}_{12}\text{S}$. In other words, we may write the formula of the thiotetraphosphates containing any or all of the alkali metal basic radicals in place of the Na_6 given in the above examples of the different thio-

tetraphosphates where one or more of the sulphur atoms replaces the oxygen atoms in its formula. The property of a thiotetraphosphate to give it water softening quality is probably, in our opinion, its ready solubility in water and all soluble thiotetraphosphates will be found to have the power of softening water.

While we have described our invention above in detail we wish it to be understood that many changes may be made therein without departing from the spirit of the same.

We claim:

1. A process which comprises adding to hard water a water-soluble salt of a thiotetraphosphoric acid so as to combine with an alkali earth metal to prevent the deposition of an alkali earth metal compound therein.

2. A process which comprises adding to hard water a water-soluble salt of a thiotetraphosphoric acid so as to combine with calcium to prevent the deposition of a calcium compound therein.

3. A process which comprises adding to hard water an alkali metal salt of a thiotetraphosphoric acid so as to combine with an alkali earth metal to prevent the deposition of an alkali earth metal compound therein.

4. A process which comprises adding to hard water a water-soluble salt of monothiotetraphosphoric acid so as to combine with an alkali earth metal to prevent the deposition of an alkali earth metal compound therein.

5. A process which comprises adding to hard water a water-soluble salt of trithiotetraphosphoric acid so as to combine with an alkali earth metal to prevent the deposition of an alkali earth metal compound therein.

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