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QUATERNARY AMMONIUM ALIPHATIC IMIDES

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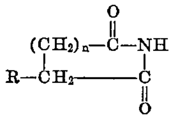
4 Claims. (Cl. 260—286)

ABSTRACT OF THE DISCLOSURE

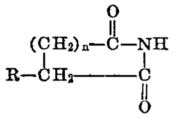
Quaternary ammonium aliphatic imides wherein the quaternary ammonium cation is microbiocidal and wherein the aliphatic imide has the structure:



in which *n* is an integer from 1 to 3 and R is either H, alkyl, or alkenyl wherein the alkyl or alkenyl has from 1 to 20 carbon atoms.

This invention relates to the preparation of relatively water-insoluble, microbiologically active compounds obtained by the reaction of water-soluble microbiologically active quaternary ammonium compounds with water-soluble salts of aliphatic imides. This is a continuation-in-part of co-pending application Serial No. 359,426, filed Apr. 13, 1964, now abandoned.

Imides which may be used in this invention correspond to the following formula:

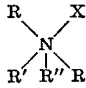


where *n* may be 1, 2 or 3 and R may be H, or alkyl or alkenyl radicals containing from 1 to 20 carbon atoms. Examples of suitable imides which may be used include succinimide, glutarimide, maleimide, adipimide and their alkyl and alkenyl derivatives.

The compounds of this invention can be prepared by mixing an aqueous solution of a water-soluble salt of the imide with an aqueous solution of a quaternary ammonium salt having microbiologically active properties. The two solutions are thoroughly mixed and are then allowed to stand until they separate into two distinct layers. The upper layer will normally contain the compound of the present invention. Layer separation is conveniently effected by conducting the reaction in a separatory funnel and drawing off the desired layer. The product usually contains some water which can be removed by distillation or drying in a vacuum oven. The aqueous product layer can, however, be used directly in any process where the entrapped water would not be harmful.

Typical examples of the quaternary ammonium compounds which may be used in this invention are the alkyl trimethyl ammonium chlorides, alkyl-benzyl trimethyl ammonium chlorides, alkyl dimethylbenzyl ammonium chlorides, alkyl dimethyl menaphthyl ammonium chlorides, alkyl dimethyl substituted-benzyl ammonium chlorides in which the benzyl radical is substituted with one or more side chains containing from 1 to 5 carbon atoms, such, for example, as methyl, dimethyl, ethyl and the like and in which the carbon atoms may all be in the same or different side chains or in which the benzyl radical bears one, two or more halogen atoms such as chlorine or bromine, alkyl pyridinium chlorides, alkyl isoquinolinium chlorides and bromides, alkyl lower-alkyl pyrrolidinium chlorides, alkyl lower-alkyl morpholinium chlorides in all of which the alkyl group may have from 8 to 22 carbon atoms and the lower alkyl group may have from 1 to 5 carbon atoms and alkyl phenoxy ethoxy ethyl dimethyl-benzyl ammonium chloride in which the alkyl radical may be iso-octyl or nonyl and in which the benzyl radical may, if desired, be substituted by a methyl radical. Various other analogs of these quaternaries may also be employed, such, for example, as cetyl dimethyl ethyl ammonium bromide or oleyl dimethyl ethyl ammonium bromide.

In general, the quaternary ammonium compounds useful as starting materials in this invention have a phenol coefficient of at least 100 with respect to both *Staphylococcus aureus* and *Salmonella typhosa* at 20° C., when determined by the standard method given in the U.S. Department of Agriculture No. 198. More specifically, they comprise the higher alkyl quaternary ammonium hydroxides, halides (chlorides and bromides), sulfates, methosulfates and the like possessing the following formula:



where R is an alkyl or alkaralkyl radical containing from 8 to 22 carbon atoms or an alkyl phenoxy ethoxy ethyl radical in which R is an alkyl radical containing from 8 to 9 carbon atoms and in which the phenyl radical may be substituted by a methyl group; R′ and R″ are methyl or ethyl radicals or members of a heterocyclic ring system such as pyridine, isoquinoline, pyrrolidine and morpholine; R‴ is a methyl radical or a benzyl group or a substituted benzyl group, such, for example, as a monochlorobenzyl radical or a dichlorobenzyl radical or mixture thereof or a methyl benzyl, dimethyl benzyl, ethyl benzyl, diethyl benzyl, isopropyl benzyl, tertiary butyl benzyl, isoamyl benzyl or another benzyl radical containing from 1 to 5 carbon atoms as side chains, either as a single side chain or a multiplicity of side chains including mixtures thereof or a menaphthyl group or hydrogenated menaphthyl group. When R′ and R″ are members of a morpholine or pyrrolidine ring, R‴ is a methyl, ethyl, propyl or butyl group. When R′ and R″ are members of an unsaturated heterocyclic ring such as pyridine or isoquinoline, R‴ is the same radical as R″. X in the above formula corresponds to a halide radical such as chloride, bromide or iodide or to any other water-soluble anion such as methosulfate.

After thorough mixing in the manner previously described, the organic product layer is separated from the aqueous layer (as with a separatory funnel) since two distinct phases are formed. Separation may be facilitated by the addition of an organic solvent immiscible with water. The product layer may be washed with water to remove any residual by-product salt or unreacted materials. The solvent, if any, may be evaporated and the product air or vacuum dried to a paste, wax, oil or solid.

It is not necessary to use an aqueous medium. Any solvent or solvent mixture in which the starting materials are soluble will be satisfactory. Non-aqueous solvents facilitate the separation of by-product inorganic salt and reduce the need for vacuum drying to get an anhydrous product. When a non-aqueous medium is employed, it is usually necessary to add a small amount of water to facilitate ionic reaction.

An alternative method for the preparation of compounds especially applicable to the treatment of fabric, ropes, net, woven and non-woven fabric and reticulated or convoluted materials, involves a two-step process. In the first step, the material is passed through a bath containing the anionic moiety. Excess solution is removed by methods well known to those skilled in the art. The treated material is then passed through a second bath wherein the concentration of quaternary ammonium compound is such that the material pickup will result in an equivalent amount of quaternary ammonium compound reacting with the anionic moiety, depositing the product in the most intimate way on the surface and in the interstices, convolutions and reticulations of the material.

The method of adjustment of solution concentration to achieve the required pickup is well known to those skilled in the art. The order of treatment may be reversed without affecting the biological activity or durability of the product on the material. The products of this invention may be formulated as water dispersions by dissolving them in a water-miscible organic solvent such as acetone or methanol and diluting with water or by dissolving them in emulsifiable oils such as, for example, sulfonated castor oil or pine oil and diluting with water. In preparing aqueous dispersions, emulsifying agents such, for example, as ethylene oxide condensates of alkyl phenols may be used with or without organic solvents.

It is surprising that the compounds of this invention exhibit high microbiological activity despite their relative insolubility in water. Because of their unusual combination of physical and microbiological properties, they can be used to impart laundry-resistant anti-microbial characteristics to textiles. They can also be used as the active agent in anti-mildew finishes for textiles which are resistant to leaching with water.

Although the compounds have low water solubility, they are compatible with various organic solvents, plasticizers and high molecular weight compounds. Consequently, they may be incorporated as anti-microbial agents in synthetic resins and plastics. The compounds are compatible with natural and synthetic rubber latices. Therefore, they may be used to prepare bacteriostatic films and molded objects deposited from such latices.

The compounds can be incorporated into cutting and grinding fluids without precipitation. Also, they blend well with non-ionic and anionic surface-active agents. In such compositions they retain their microbiological activity.

It will be understood that the properties of the products described herein will vary depending upon the nature of the cationic quaternary ammonium compound used in their preparation as well as the anionic compound reacted therewith.

The chemical, physical and biological properties of the products of our invention make them especially appropriate for the following application when suitably incorporated in active amounts in an appropriate vehicle, binder, medium or substrate:

1. Mildewproofing fabric, canvas, ropes, textiles, awnings, sails, tenting and other woven and non-woven reticulated materials.
2. Paint mildewstats.
3. Jet plane fuel additive to control growth of microorganisms.
4. Odor preservative agents for clothes and shoes.
5. Mildew retardant and odor suppressant for shoes and other leather products.
6. Topical antiseptics.
7. Anti-dandruff agents.
8. Disinfection agents for hair and gut of man and beast.
9. Bacteriostatic furniture dressing.
10. Surface finishes for stone, plaster, tile, cement, brick and other inorganic building materials, to retard growth of microorganisms, fungi, mold and algae.
11. Wool preservative.
12. Plant and tree spray to combat fungi.
13. Antimycoctic agents for soap wrappers.
14. Self-sanitizing brushes.
15. Mildewproofing agent in and on plastic and film.
16. Mildewproofing of cellulosics, cardboard, fibreboard, paper and cordage.
17. Contact biostat for application to film, waxes and cloth to preserve cheese, meats and vegetables and other food products.
18. Algal inhibition, especially on surfaces and in solution where low foaming is desirable.
19. Paper pulp slime control.
20. Sanitizing agent for rug, carpet, curtains.
21. Egg preservation.
22. Adhesive preservation.
23. Preservation of latex paints.
24. Preservation of metal-working compounds.
25. Additives for soap and for both anionic and nonionic detergents in liquid, bar, powder, bead, solution and other forms to impart bacteriostatic and fungistatic properties thereto.
26. Bacteriostats, fungistats and algaestats for the treatment of industrial cooling waters as in cooling towers, air conditioners and humidifiers, and for use in secondary oil recovery.

The microbiological activity of our compounds has been evaluated for microbiological stasis by the Standard Tube Dilution Test, the technique for which is common knowledge to those skilled in the art. A Difco Bacto CSMA Broth #0826 was used in the study. This test is used to determine the lowest concentration of microbiologically active compounds which will inhibit the growth of the organism in question. For a wide range of applications, the inhibition of growth rather than outright kill is satisfactory.

Briefly put, the Tube Dilution Test consists in placing 9 cc. of the CSMA Broth in a test tube which is then sterilized in an autoclave. One cc. solution of the microbiologically active compound at an appropriate concentration is added to the test tube which is then inoculated with 0.1 cc. of a twenty-four hour old culture of the organism under study. The test tube is then incubated at 37° C. for forty-eight hours and observed for bacterial growth.

The same procedure is followed for fungi. In such tests, however, the tubes are incubated for fourteen days at a temperature suitable for optimum fungal growth, usually 25° C.

The invention is illustrated by, but not restricted to, the following examples:

EXAMPLE I

A 10% aqueous solution of the sodium salt of succinimide was prepared and 100 grams of this solution was placed in a separatory funnel. To this solution was added 313 grams of a 10% solution of lauryl isoquinolinium bromide ("Isothan Q–75"—Onyx Chemical Corporation) and 100 ml. of benzene. The funnel was shaken and then layer separation allowed to occur. The benzene layer was separated and dried first on a steam bath and then in a vaccum oven to give 35 grams (100% yield) of a dark red paste, lauryl isoquinolinium succinimide.

EXAMPLE II

An additional 100 g. of the 10% solution of succinimide prepared in Example I was poured into a separatory funnel and to this solution was added 310 grams of a 10% solution of alkyl dimethyl ethylbenzyl ammonium chloride ("BTC–471"—Onyx Chemical Corporation; alkyl distribution C_{12}, 50%; C_{14}, 30%; C_{16}, 17%; C_{18}, 3%) and 100 ml. of benzene. The funnel was shaken and then layer separation allowed to occur. The benzene layer was separated and dried to give 35 grams (94% yield) of a white paste, alky dimethyl ethylbenzyl ammonium succinimide.

EXAMPLE III

Using the Standard Tube Dilution Test described above, the following bacteriostatic levels were determined (S.a.=*Staphylococcus aureus*; S.t.=*Salmonella typhosa*; A.n.=*Aspergillus niger*):

Product from—	Bacteriostatic Dilution Level vs.—		
	S.a.	*S.t.*	*A.n.*
Example I	10^6	10^5	10^4
Example II	10^6	10^6	10^4

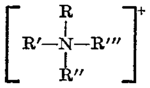
EXAMPLE IV

The product from Example II was tested against *Desulphovibrio desulphuricans* according to the procedure outlined in the report of the American Petroleum Institute Subcommittee on Biological Analysis of Injection Waters to be used for Water Flood Purposes (Mar. 17, 1958). This compound was an effective bacteriostat at 2.5 p.p.m.

Obviously, many modifications of the present invention are possible in the light of the above teachings. It is, therefore, to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

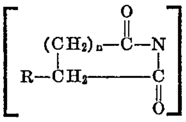
The invention claimed is:

1. A compound consisting of a quaternary ammonium cation having the structure:



$$\left[\begin{array}{c} R \\ | \\ R'-N-R''' \\ | \\ R'' \end{array}\right]^+$$

wherein R is a member of the group consisting of alkyl and alkaryl having 8 to 22 carbon atoms, and alkyl phenoxy ethoxy ethyl in which the alkyl has 8 to 9 carbon atoms; R' and R'' are selected from the group consisting of lower alkyl and saturated and unsaturated N-heterocyclic ring systems in which both R' and R'' are members; and R''' is a member of the group consisting of methyl, benzyl, halo-substituted benzyl, lower alkyl substituted benzyl in which there is at least one side chain of 1 to 5 carbon atoms, menaphthyl and hydrogenated menaphthyl; R''' being a lower alkyl group when R and R'' are members of a saturated N-heterocyclic ring system selected from the group consisting of morpholine and pyrrolidine and R''' being the same as R'' when R' and R'' are members of an unsaturated N-heterocyclic ring system selected from the group consisting of pyridine and isoquinoline, and an anion having the structure:



wherein *n* is an integer from 1 to 3, and R is a member of the group consisting of hydrogen, alkyl and alkenyl wherein the alkyl and alkenyl have from 1 to 20 carbon atoms.

2. The compound of claim **1** wherein the imide anion is selected from the group consisting of succinimide, glutarimide, maleimide, adipimide and the alkyl and alkenyl derivatives thereof.

3. The compound of claim **1** wherein the cation is lauryl isoquinolinium and the anion is succinimide.

4. The compound of claim **1** wherein the cation is alkyl dimethyl ethyl benzyl ammonium in which the alkyl has 8 to 22 carbon atoms, and the anion is succinimide.

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