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COMPOUNDS OF NICOTINE

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5 Claims. (Cl. 260—270)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

This application is made under the act of March 3, 1883, as amended by the act of April 30, 1928, and the invention herein described and claimed, if patented, may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment to me of any royalty thereon.

The primary objective of this invention is the production of new compounds of nicotine which offer resistance to the often undesirable effects of moisture, dew, rain, sun, etc., and can be used effectively against injurious insects upon vegetation.

Many of these new compounds exert a fumigating effect while in the dry dust form superior to any previously known or used up to this time. This fumigating effect results from the combinations of nicotine with such volatile acids as benzoic, salicylic, etc. In addition to the advantages just enumerated, the compounds containing zinc or copper, both of which are components of fungicides, may supply the necessary fungicidal properties in addition to their insecticidal action.

The designation "fixed nicotine compound" has been customarily applied to such weather-resisting materials as the tannate, humate, bentonite, etc., compounds of nicotine. The new compounds of this invention may also be so described but they are quite different in type of chemical composition. It is believed that many of them may prove to be suitable for use in the home garden. In comparison with liquid nicotine and nicotine sulphate, the dry dusts represent more convenient physical forms and many of them possess excellent keeping properties. The natural color of many of the salts afford an additional safety factor against mistaken identification.

Important differences are to be expected in the mode of action of my compounds and nicotine bentonite considered hitherto as the most promising of the "fixed nicotine" products. Bentonite releases nicotine only by the hydrolysis and volatilization of the free nicotine and when the ratio of bentonite to nicotine increases this action is much reduced. On dry days even when hot, very little nicotine will be released. With a number of my new compounds, such as the benzoates and salicylates, the fumigating effect is increased by heat and dryness with simultaneous release of nicotine and the volatile acid. Under moist conditions, a small but definite solubility provides nicotine and metal for fungicidal and insecticidal action.

My compounds may be described as "coordinated" or double salts with the metal probably exerting an auxiliary valency toward the nicotine molecule. The nature of the acid is an essential requirement. Most ordinary acids such as boric, oxalic, phosphoric, etc., either do not serve for double salt formation or no relatively insoluble combinations exist.

The compounds of this invention are limited to the double salts of nicotine with one of the metals iron, zinc, copper, nickel, cobalt and cadmium. They are further limited in the nature of the acid used to bind the nicotine and the metal. The acid is selected from a group of acids consisting of hydrocyanic, thiocyanic, hydroferrocyanic, hydroferricyanic, chromic, benzoic, salicylic, o-benzoyl benzoic and picric acids. The acids containing the —C=N group are highly susceptible to polymerization and with the metals iron, zinc, copper, nickel, cobalt and cadmium form complex double salts with alkali and alkaline earth metals.

The acids containing the unsaturated benzene ring including benzoic, o-benzoic, o-benzoyl benzoic, picric and salicylic acids are also highly effective in double salt formation producing compounds which are generally crystalline and often quite insoluble in water. The cadmium nicotine benzoate, however, is rather soluble and separates only in concentrated solutions. The double chromates are generally fairly soluble and must be prepared from concentrated solutions. The zinc double salt, however, is very insoluble but may be secured in a finely divided crystalline form. The polymerizing tendency of the chromates is seen in the existence of many polychromates such as the dichromates, etc.

There are no doubt many derivatives of benzoic acid other than the ones here employed such as the 2–4 dichlor, p brom, (their copper salts have been prepared) which will form similar double salts. Orthochlorbenzoic acid, however, can not be used. The cost of such derivatives which may be found suitable for double salt formation appears to be prohibitive of practical application. It will require further study to establish which groups and their positions in the benzene acids which either do or do not function for acceptable double salt formation. These metals, employed in my invention, are known as of the coordinating type probably exerting as previously stated auxiliary valencies in their complexion forming compounds.

Some similar compounds have been described containing ammonia, pyridine, ethylene diamine, etc., but none containing nicotine. Most of my compounds even have no corresponding analogs in any other organic base complex salts now described in the art. In the following description when a metal salt or metal is referred to it is understood to mean one of the metals designated above.

It is quite probable that other metals such as titanium, platinum, gold, etc., would serve to produce many if not all of the corresponding nicotine complex salts but their cost would defeat the primary purpose of this invention. The process involved in the preparation of my new compounds is closely related to their usual composition as represented by the formula

$$MX_n.n(C_{10}H_{14}N_2.HX)$$

where M represents one atom of metal of the group copper, zinc, nickel, cobalt, cadmium and iron. X represents a univalent radical such as a hydrocyanic, thiocyanic, picric, benzoic, salicylic, or o-benzoyl benzoic acid radical. The valency of the metal M is thus represented by n and is 2 with all metals except iron and cobalt where it may be either 2 or 3. It is self evident that the ferrous salts may tend to oxidize in the air and can be prepared only by the exclusion of oxygen such as the double nicotine ferrous ferrocyanide. The ferrous nicotine double thiocyanate, however, is a crystalline compound easily prepared before appreciable oxidation results.

With polyvalent acids such as hydroferrocyanic with a valency of 4, n is 4, and the formula for a bivalent metal would be

$$M_2(FeCy_6).4C_{10}H_{14}N_2.H_4FeCy_6$$

For purpose of preparation one half of the acid is always used to form the metallic salt and the other half to form the equivalent nicotine salt. The applicant does not claim that the percentage of nicotine will always correspond to the general formula $MX_n.n(C_{10}H_{14}N_2.HX)$ although approximated closely with the benzoates, picrates and salicylates. The highly complex nature of the double cyanides, ferrocyanides, ferricyanides prevents an exact formulation of the resulting compound but should not obviate their usefulness under controlled conditions.

In the preparing of new compounds it should be understood that the pH range of the individual solutions and the final resulting mixture containing the precipitated double salt should be adjusted to keep within the range of pH 5–7.5. If the normal salt is desired in the greatest yield it is best to have all solutions slightly acid around pH 5 and make the final adjustment to pH 7–7.5 to complete the precipitation. Excessive acidity will tend to dissolve and disrupt the compounds while excessive alkalinity will form admixed basic salts with a lowered content of nicotine. The resulting compounds of this invention represent essentially combinations of neutral salts. The ferrocyanide compounds are very insoluble, and colloidal in nature causing difficulty in filtration. They may be found particularly adaptable to spray mixtures.

In order to spread the action of the dry powders it may be desirable to dilute them with such materials as talc, starch, kaolin and other neutral products commonly used as diluents for insecticides.

In the preparation of the copper, nickel and cobalt compounds I prefer to avoid the presence of ammonium salts which tend to prevent complete precipitation, but with the zinc, cadmium and iron salts they do not interfere; but may actually assist the crystallization of the zinc and cadmium double salts by preventing the formation of basic salts of these metals.

The double salts containing ferrocyanide and ferricyanide are probably super complex salts wherein the nicotine salts are conjugated with the metallic ferro and ferricyanides. There are two general processes employed in the preparation of my compounds both of which are based on the formula $MX_n.n(C_{10}H_{14}N_2.HX)$. Process No. 1, to be described below, can be employed with many but not all of them. It can be employed when the metallic salt can be first readily prepared and then brought into contact with the equivalent nicotine salt. For example copper benzoate can be first prepared and washed free of soluble salts and brought into contact with the nicotine benzoate dissolved in water. Copper salicylate, however, is very soluble and process No. 2 should be employed. These two processes are as follows:

Process No. 1: In water solution one molecule of the metallic salt of the metal combined with the acid selected is treated with the equivalent amount of the nicotine salt of the acid. After varying intervals of time the maximum of the nicotine salt is removed from the solution. The freshly prepared metallic salt while still wet reacts more rapidly than after drying. If the nicotine salt of the acid is not available, use equivalent proportions of a soluble salt of nicotine with a soluble salt of the acid where the metal may be sodium, potassium, ammonium, calcium, magnesium or other non-coordinating metal.

Process No. 2: Is generally applicable to all compounds and consists in bringing together a soluble salt of the metal with the equivalent quantity of a soluble salt of the acid such as the sodium, potassium, ammonium, calcium, magnesium or other non-coordinating metal salt and the equivalent quantity of the nicotine salt of the acid. If the nicotine salt is not available it is only necessary to use an equivalent amount of some nicotine salt with an equivalent of the soluble salt of the acid such as the sodium, potassium, ammonium, calcium, magnesium or other non-coordinating metal. The double salt obtained will contain only the acid selected from the group of polymerizing acids of this invention and, if desired, may be washed free of contaminating soluble salts. The following examples will serve to fully enable any one with a knowledge of chemistry to prepare the new compounds claimed in the invention.

Examples

1. One mol of copper acetate is added to a mixture of 2 mols of sodium benzoate and 2 mols of nicotine benzoate all in water solution. If normal solutions of these three compounds are used the precipitated copper nicotine compound forms a rather dense mixture so I prefer dilution with more water before filtration is made. A slight excess of dissolved benzoic acid will produce a mixture with a pH between 5–7. This pH may be adjusted to 7–7.5 with dilute nicotine alkaloid solution in water to secure maximum precipitation yet avoid the production of basic salts. The washed and dried copper nicotine benzoate analyzes 7.7% for copper and 37 to 38% for nicotine; theory for Cu is 7.27% and for nicotine 37.1%.

2. 1 mol of zinc acetate is added to a mixture of 2 mols of sodium benzoate and 2 mols of nicotine benzoate all in water solution preferably working on the acid side with excess of soluble benzoic acid. If normal solutions are to be mixed considerable dilution may be employed for the preparation of a highly insoluble and crystalline product. Theory for nicotine 37%; found 38%.

3. One mol of copper acetate is added to 2 mols of sodium salicylate without the formation of a precipitate when working with their normal solutions in water. This mixture may be poured slowly into water containing 2 mols of nicotine salicylate forming a greenish to lavender colored precipitate of copper nicotine salicylate. More acid compounds are green while the neutral or slightly alkaline are lavender in color. Analysis for nicotine 33%; theory 34%.

4. One mol of copper sulphate is added to 2 mols of sodium benzoate all in water solution. Filter, wash and suspend the wet crystals in 2 mols of nicotine benzoate in water solution, agitating occasionally during a period of several hours. The filtered and dried product contained 36.6% nicotine; theory 37.1.

5. One mol of copper sulphate is added to a mixture of 2 mols of sodium thiocyanate and 2 mols of an equivalent nicotine thiocyanate produced by a mixture of 2 mols of nicotine hydrochloride and 2 mols of sodium thiocyanate. Cupric nicotine thiocyanate is produced as a bright green colored product quite insoluble in water. On boiling with alkalies cupric oxide is formed.

6. Copper acetate in aqueous solution is added to a mixture of two mols of sodium cyanide and 1 mol of a neutral nicotine salt until a slight excess of copper is present. The salt to be expected corresponding to the formula expected

$$Cu(CN)_2.2C_{10}H_{14}N_2.HCN$$

loses cyanogen and a brown insoluble salt analyzing as nicotine cuprous cyanide is produced.

7. Two mols of copper acetate is added to a mixture of 2 mols of a ferrocyanide salt and 4 mols of nicotine hydrochloride. The double ferrocyanide has a bluish red color, filters well, although the gelatinous product dries slowly.

8. Two mols of zinc acetate is used instead of the copper acetate in Example 7. The product is yellowish white, highly colloidal and filters slowly.

9. One mol of copper acetate is added to a mixture of 2 mols of sodium picrate and 2 mols of nicotine monopicrate all in aqueous solution. The bright green precipitate is a very insoluble product of minute crystals.

10. Instead of copper acetate as in Example 9 use zinc acetate to form a very insoluble yellow double zinc and nicotine picrate.

11. Instead of copper acetate in Example 9 use nickel acetate to form a greenish yellow double picrate which seems to suffer decomposition on standing in the dry state.

12. Instead of copper acetate in Example 5 use nickel acetate and obtain a crystalline blue double thiocyanate.

13. Instead of copper acetate in Example 5 use cobalt acetate and obtain a crystalline pink double salt.

14. Instead of copper acetate in Example 5 use cadmium acetate and obtain a crystalline white double salt.

15. Use one mol of ferric chloride and a mixture of 6 mols of sodium thiocyanate and 3 mols of nicotine monohydrochloride. The double salt is a bluish red to red in color but turns brownish on prolonged washing probably due to hydrolysis.

16. Use one mol of ferrous ammonium sulphate dissolved in water and add to a mixture of 4 mols of sodium thiocyanate and 2 mols of nicotine monohydrochloride. The precipitated double salt is a brownish white crystalline product.

17. One mol of ferric chloride is added to a mixture of 6 mols of sodium benzoate and 3 mols of nicotine monohydrochloride. The double salt is a very insoluble buff colored product.

18. One mol of ferric chloride is added to sodium salicylate and nicotine salicylate just as in Example 17. The purplish red double salt is precipitated and can be readily filtered.

19. To a mixture of two mols of potassium ferrocyanide and 4 mols of nicotine hydrochloride a solution of ferric ammonium sulphate containing one molecular equivalent of Fe'''. The blue double salt is quite insoluble and filters with some difficulty leaving a gelatinous product.

20. If instead of copper acetate in Example 7 nickel acetate is used, a greenish blue double salt of nickel nicotine ferrocyanide is produced.

21. If one mol of zinc acetate is used to precipitate a mixture of one mol of potassium dichromate and one mol of nicotine alkaloid a colloidal yellow zinc nicotine double salt ih obtained.

22. If one mol of copper acetate is added to 1 mol of potassium dichromate and 1 mol of nicotine alkaloid a yellow double salt of copper nicotine chromate is obtained. The solutions should be fairly concentrated as the product is fairly soluble in water.

23. If one mol of zinc acetate is added to a mixture containing 2 mols of sodium o-benzoyl benzoate and 2 mols of nicotine o-benzoyl benzoate a white crystalline double salt is formed.

24. If one mol of copper acetate is added to a mixture containing 2 mols of sodium o-benzoyl benzoate and 2 mols of nicotine o-benzoyl benzoate a light blue double salt is formed. The product is quite insoluble and forms a powder of low specific gravity.

25. As in Example 3 use cadmium acetate and obtain a white insoluble crystalline double salt of cadmium nicotine salicylate.

26. As in Example 3 use cobalt acetate and obtain a pink colored double salt of cobalt nicotine salicylate.

27. Using 1 mol of zinc chloride and 4 mols of potassium cyanide and 2 mols of nicotine hydrochloride I obtain a white crystalline double salt of zinc.nicotine cyanide. The use of some ammonium chloride seems to help the product form fine crystals which are easier to filter.

28. If zinc acetate is used as in Example 3 a white, highly insoluble, crystalline zinc nicotine salicylate is obtained.

29. If nickel acetate is used as in Example 3 a light greenish blue crystalline salt is obtained.

In the examples given above the acetates of the metals have usually been employed as leading to purer products which are to be the subject of scientific study but in commercial practice it is advisable to use the sulphates of the metals and calcium salts of the acids whenever possible, since the resulting calcium sulphate ($CaSO_42H_2O$) is nonhygroscopic and need not be washed out of the material when the resulting nicotine double salt is to be employed as an insecticide in dust form. In some cases it will be necessary to restrict the chemicals employed to those available on the market.

Having thus described my invention, what I claim for Letters Patent is:

1. A double salt of nicotine and a metal, said salt comprising copper nicotine benzoate.

2. A double salt of nicotine and a metal, said salt comprising zinc nicotine benzoate.

3. A double salt of nicotone and a metal, said salt comprising ferric nicotine benzoate.

4. A double salt of nicotine and a metal chosen from the group consisting of iron, zinc, copper, nickel, cobalt, and cadmium having an acid radical selected from the group of acids consisting of picric, benzoic, o-benzoyl benzoic, and salicylic.

5. A double salt having the general formula

$$MX_n.n(C_{10}H_{14}N_2.HX)$$

where M is a metal chosen from the group consisting of iron, zinc, copper, nickel, cobalt and cadmium; n is an integer corresponding to the valency of M; and X is an acid radical selected from the group of acids consisting of picric, benzoic, salicylic, and o-benzoyl benzoic.

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