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EMBALMING FLUID

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This invention relates to embalming fluids.

In the art of embalming human bodies, it is the usual practice to remove the blood and other fluids from the vascular system and to inject therein an embalming fluid which is, in general, disinfectant, deodorant, preservative, and also capable of solidifying or firming the body tissues. To this end, solutions of formaldehyde have been conventionally employed for many years, effectually and satisfactorily. But in the use of these solutions the operators have encountered many inconveniences and much discomfort, if not suffering and danger to their health, from the physiological properties of the formaldehyde. It is poisonous, irritating to the skin and even more so to the mucous membranes, and of an obnoxious and very penetrating, characteristic odor. This makes it difficult to use in homes as well as funeral establishments. Efforts have been made to disguise or mask the odor, but quite unsuccessfully. It has also been attempted to provide some other reagent or reagents which would serve these purposes and avoid the disadvantage of formaldehyde, but without appreciable success.

It is accordingly an object of the present invention to provide an embalming fluid, which shall be free from the disadvantageous and dangerous properties of formaldehyde and which shall be as effective as formaldehyde solutions, for this purpose. Other objects will appear from the following disclosure.

In the embalming procedure, the embalming fluid is introduced either arterially into the circulatory system, and hence directly into the vascular tissues of the body, or into the natural body cavities such as the thoracic and abdominal cavities, where it must first penetrate the natural membrane linings before coming into contact with the tissues and fluids of the surrounding structure. Separate embalming fluids accordingly are employed in these two operations and they are distinguished as arterial and cavity fluids, respectively.

It is now found, in accordance with the present invention, that embalming fluids may be made of aqueous solutions which are characterized by containing a water-soluble reagent which is capable of subsequently reacting to form or liberate formic acid and/or formaldehyde when in contact with the tissues and fluids of the body. A typical class of compounds which are found capable of so reacting is represented by the organic esters of formic acid—especially with the alkyl radicals of the lower members of the aliphatic alcohols, such as methyl, ethyl, propyl and butyl formates. These esters are relatively freely soluble in water. But with increasing molecular weight of the alkyl radical the degree of solubility of the formate falls off and the viscosity of solutions of comparable concentrations increases. The methyl ester is therefore to be preferred, although the others may be used and the increased viscosity may be offset, when necessary, by the addition of small quantities of alcohol or like compatible solvent.

Such solutions of the formate esters are relatively stable and hence do not present the physiological difficulties of formaldehyde solutions. They do not irritate the skin nor the mucous membranes, nor do they present the objectionable odors of formaldehyde solutions. Nevertheless, in contact with the body cells and tissues they are as effective as free formaldehyde in preserving and firming the body structure. They are also disinfectant, deodorant and preservative in their action upon the tissues and cellular matter, and also upon the body fluids.

The firming action of formaldehyde is attributable in part at least to its reaction with the proteins, with which it combines and also apparently promotes polymerization of the protein molecule or nucleus. It is extremely rapid in such action and when brought into contact with these proteins in cellular or fibrous structures, the products of reaction may form so rapidly as to inhibit further penetration of the reagent. In this way, the reaction may be confined substantially to those areas adjacent to the points of initial contact or infusion, when free formaldehyde solutions are employed. It is, therefore, advantageous to promote the penetration of the reagent and to retard the firming action to be effected thereby. Such a modification in the action of embalming fluids is provided by the compositions of the present invention. This is true with both arterial and cavity fluids.

The alkyl formates, when dissolved in water and brought into contact with visceral tissue, hydrolyze in part to liberate the alcohol and formic acid. This reaction and the products formed are analogous to the products formed by the hydrolysis of formaldehyde alone in alkaline aqueous solution, as follows:

(1) $2HCHO+H_2O \rightarrow HCOOH+CH_3OH$

(2) $HCOOCH_3+H_2O \rightarrow HCOOH+CH_3OH$

Since 30 parts of methyl formate may be dissolved in 100 grams of water, and since methyl formate is infinitely soluble in ethyl alcohol, solu-

tions may be prepared of an effective concentration equivalent to or greater than the usual water solutions of formaldehyde, per se, and at the same time without exhibiting any tendency to vaporize therefrom. In addition to the alcohol formed by hydrolysis of the formic acid ester, it is desirable to add one of the lower alcohols, such as methyl, ethyl, or to a less extent propyl or butyl alcohols which promote initial stability of the formate, and also the penetration and solubility of the composition.

To further stabilize the solution before and during use and also to facilitate the penetrative action of the solution when introduced into contact with the vascular system generally, as well as to promote the subsequent reaction thereon, it is advantageous to use with the formaldehyde ester solution a suitable soluble acid amide, preferably of the lower aliphatic series, such as form-amide, acet-amide, propion-amide, butyr-amide, etc. These compounds appear to lower the viscosity of the fluid composition and also to retard the initial hydrolysis and reactivity of the formate ester, but subsequently to promote this reaction and the reaction on the tissues as evidenced by a decidedly effective and improved firming action when the reaction is complete.

The acid amides also facilitate the incorporation of metallic salts of the polyvalent metals, when used, since they promote their solubility in water, probably by complex-ion formation, producing a solution which is resistant to separation or reactions to precipitate the reagents used out of solution. Accordingly, salts of active metals such as aluminum nitrate, stannic chloride, zinc chloride, etc., may be added to these solutions without difficulty and in increased quantities. Such salts have a decided reactivity with protein material—probably of the metal with the acid radicals of the protein to form insoluble solid compounds in the nature of metallic salts.

Such reaction of the metals appears to be still further stimulated and promoted by the presence of the acid amides, which presumably react at the same time with the amino groups of the protein molecules. While the protein contents of the body are many and varied and therefore not susceptible of general conclusions as to their chemical properties and reactivities,—it seems to be consistent to infer that this embalming fluid has the effect of first penetrating, gradually hydrolying, and then combining with and polymerizing the protein matter of the body tissues whether introduced as a cavity fluid or as an arterial fluid, that the acid amide promotes these functions and also the combination with the amino radicals and polymerization of such groups, and that the metallic salts, when present, may then more effectively combine with the carboxyl radicals and form compounds in the nature of insoluble metallic salts. Since the molecular structures of the proteins, as built up in this way, are greater on account of these cumulative actions, the resulting salts are of greater molecular weight and hence more inert and more solid than can be acquired by reactions to form those of less molecular weight, and they are in fact physically much firmer. This is an effect greatly desired, and required by some, in the art of embalming.

In an embalming fluid having a composition typical of the present invention, the several components may be varied considerably, to accommodate different conditions and the particular results desired by the operator, but all manifest the improved results characteristic of the present invention. For example, methyl formate may be used and constitute from 10% to 30%, acid amide .2% to 1.0%, aluminum nitrate 2% to 10%, water 9% to 83% and methyl or ethyl alcohol 5% to 50%.

A specific and representative composition is prepared as follows:

	Per cent by weight
$Al(NO_3)_3.9H_2O$	8.33
$HCOOCH_3$	20.0
C_2H_5OH (95%)	20.0
CH_3CONH_2	.80
Water	50.87

This composition is especially effective for use as a cavity fluid and is not only free from the tendency to vaporize but also free from the toxic and irritating actions of formaldehyde. While active as a deodorant, it has no disagreeable odor of its own. It quickly penetrates the mucous membranes or linings and passes into and through the surrounding tissues and structures, and, after such penetration and dispersion is substantially complete, commences effectively to hydrolyze, liberating formic acid, alcohol, and formaldehyde, as indicated by the above equations—and thereupon exhibiting, in situ, as great a preservative and hardening action upon the proteins and tissues, mol for mol, as initially free formaldehyde is capable of doing. But this liberation of active reagents does not occur until the fluid has been applied and has penetrated into contact with the substances with which it reacts and ultimately converts in this manner.

In embalming fluids which are to be injected into the vascular or arterial system and which are referred to as "arterial fluids," as above pointed out, it is especially desirable that the astringent action of the solution shall not precede, and hence interfere with or prevent, the complete and rapid penetration of the fluid through the adjacent areas of the system. It is customary practice in compositions using free formaldehyde to add various organic or inorganic salts which may act to stimulate the penetration of the fluids or to retard the action of the formaldehyde or both. For example, alkaline compounds such as borax, sodium borate, sodium nitrate, sodium sulphate, sodium citrate, sodium benzoate, salicylic acid, etc. may be so used. Such additions may be made to the compositions herein described, though they are not necessary, since the formic acid esters herein employed are automatically regulated in their rate of action, although they are quite as complete in their ultimate effect as formaldehyde alone. These reagents also have the effect of promoting the free and complete removal of the body fluids in advance of the penetration and subsequent replacement of them by the embalming fluid—into and through the tissues and areas of the vascular system generally.

The higher alcohols, such as glycerine, ethylene glycol and capryl alcohol, have a similar effect of retarding chemical reactivity while promoting physical penetration and dispersion, especially in arterial embalming fluids.

Typical compositions of embalming fluids, made in accordance with this invention and for use as arterial fluids, may be prepared as follows:

1. Methyl formate	30.0
Sodium borate	2.5
Sodium nitrate	0.5
Glycerol	10.0
Formamide	1.0
Water	56.0
2. Methyl formate	25.0
Ethyl formate	5.0
Ethyl alcohol	5.0
Sodium borate	3.0
Glycerol	12.0
3. Formaldehyde (as formalin)	20.0
Methyl formate	15.0
Acetamide	1.6
Sodium citrate	0.4
Glycerol	12.0
Water	41.0
4. Butyl formate	10.0
Ethyl alcohol	5.0
Formaldehyde (as formalin)	30.0
Sodium borate	2.5
Glycerol	12.0
Acetamide	0.5
Water	30.0
5. Methyl formate	40.0
Salicylic acid	2.0
Sodium borate	1.5
Sodium citrate	0.5
Sodium benzoate	2.0
Capryl alcohol	0.1
Water	53.9

The solutions as thus prepared constitute embalming fluids suitable for keeping until required, transporting and other necessary handling, in convenient form. To make ready for use, they are preferably diluted in the proportions of 6:1 or 7:1 with water, after thoroughly mixing the diluted solution, and applied by injection into the body cavities or into the arterial or vascular system. This may be done either during or shortly after the usual withdrawal of the body fluids. If introduced simultaneously with the withdrawal of the body fluid, the composition of the present embalming fluid promotes the free and complete removal of such fluids. This promotes the subsequent effectiveness of the embalming fluid.

I claim:

1. An embalming fluid which is characterized by, comprising an aqueous solution of an alkyl formate and which is capable of subsequently reacting to form or liberate the reactive formyl radical when in contact with the tissues and fluids of the body.

2. An embalming fluid which is characterized by, comprising an aqueous solution of an alkyl formate and an acid amide and which is capable of subsequently reacting to form or liberate the reactive formyl radical when in contact with the tissues and fluids of the body.

3. An embalming fluid which is characterized by, comprising an aqueous solution of an alkyl formate and a salt of polyvalent metal and which is capable of subsequently reacting to form or liberate the reactive formyl radical when in contact with the tissues and fluids of the body.

4. An embalming fluid which is characterized by, comprising an aqueous solution of an alkyl formate, an acid amide and a salt of polyvalent metal and which is capable of subsequently reacting to form or liberate the reactive formyl radical when in contact with the tissues and fluids of the body.

5. An embalming fluid which is characterized by, comprising an aqueous solution of an alkyl formate and a lower alcohol and which is capable of subsequently reacting to form or liberate the reactive formyl radical when in contact with the tissues and fluids of the body.

6. An embalming fluid which is characterized by, comprising an aqueous solution of an alkyl formate, a lower alcohol, an acid amide and a salt of a polyvalent metal and which is capable of subsequently reacting to form or liberate the reactive formyl radical when in contact with the tissues and fluids of the body.

7. An arterial fluid embalming composition which is characterized by comprising an aqueous solution of an alkyl formate, an alkaline salt, and one of the higher alcohols and which is capable of subsequently reacting to form or liberate the reactive formyl radical when in contact with the tissues and fluids of the body.

8. An arterial fluid embalming composition which is characterized by comprising an aqueous solution of an alkyl formate, an alkaline salt, and a lower and a higher alcohol and which is capable of subsequently reacting to form or liberate the reactive formyl radical when in contact with the tissues and fluids of the body.

9. An embalming fluid comprising an aqueous solution of methyl formate and which is capable of subsequently reacting to form or liberate the reactive formyl radical when in contact with the tissues and fluids of the body.

10. An embalming fluid comprising a solution of methyl formate in one of the lower alcohols and which is capable of subsequently reacting to form or liberate the reactive formyl radical when in contact with the tissues and fluids of the body.

11. An embalming fluid comprising a solution of methyl formate, a lower alcohol and water and which is capable of subsequently reacting to form or liberate the reactive formyl radical when in contact with the tissues and fluids of the body.

12. An embalming fluid comprising an aqueous solution of ethyl formate and which is capable of subsequently reacting to form or liberate the reactive formyl radical when in contact with the tissues and fluids of the body.

13. An embalming fluid comprising a solution of ethyl formate in one of the lower alcohols and which is capable of subsequently reacting to form or liberate the reactive formyl radical when in contact with the tissues and fluids of the body.

14. An embalming fluid comprising a solution of ethyl formate, a lower alcohol, and water and which is capable of subsequently reacting to form or liberate the reactive formyl radical when in contact with the tissues and fluids of the body.

15. An embalming fluid which is characterized by comprising an alcohol solution of an alkyl formate and which is capable of subsequently reacting to form or liberate the reactive formyl radical when in contact with the tissues and fluids of the body.

16. An arterial fluid embalming composition which is characterized by comprising a solution of an alkyl formate and an alkaline salt, and which is capable of subsequently reacting to form or liberate the reactive formyl radical when in contact with the tissues and fluids of the body.

17. An arterial fluid embalming composition which is characterized by comprising a solution of an alkyl formate and a higher alcohol, and which is capable of subsequently reacting to form or liberate the reactive formyl radical when in contact with the tissues and fluids of the body.

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