SUGGESTED FORMULAS FOR PARAFFIN FILMS.*

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The popular propaganda for "Ambrine" has brought the subject of paraffin-film treatment of burns into prominence. The results are said to be better than are obtained by other methods of treatment; however, neither "Ambrine" nor any other preparation could accomplish "miracles." The principle of the method is supposed to be mainly if not solely mechanical; the film of paraffin, being impervious, forms a protection to the exposed tissues. On the other hand, it can readily be removed when desired. Perhaps the paraffin also forms a sort of scaffolding for the feeble granulations.

The method at least deserves scientific investigation. Such investigation, however, is hampered by the optimism which has developed in the minds of even medical men, regarding the efficacy of this treatment, resulting from the sensational accounts of the use of the secret French preparation, "Ambrine," in the present war. Another serious obstacle is the secrecy of the preparation so exploited, since it complicates any attempt at improvement. If the principle of paraffin films is a useful one, it is open to question that "Ambrine" is the *ne plus ultra* of these films. It is one of the disadvantages of the secrecy that we do not know what attempts have been made to secure the best possible preparation; and in the absence of this knowledge, it is reasonable to suppose that the preparation is capable of modifications which might be improvements. Perhaps extensive investigations have already been made in this direction; but of this we know nothing. If they have been made, we do not know whether or not all the possible lines of modification were taken into account.

The subject was brought to my attention by Dr. George W. Crile, and after weighing the foregoing considerations, it has seemed to me worth while to devise a series of paraffin combinations, so that the advantages of the various types of films could be tried out fairly. Since I started on this investigation, two Ameri-

Editor's Note—In an article by P. N. Leech, Ph.D., in the *Journal of the American Medical Association*, May 19, 1917, p. 1497, *et seq.*, the following formula for a paraffin film is given: Paraffin (M. P. by U. S. P. method 47.2° C.), 97.5 Gm.; asphalt varnish, 3 to 5 drops; olive oil, 1.5 Cc. The paraffin described in the U. S. P. does not seem to answer the purpose as well as paraffins ranging in melting points about 47° C.; that used by Dr. Leech was from the Standard Oil Co., melting point given by producers at 120–122° F. The asphalt varnish was obtained from Remien and Kuhnert Co., Chicago.

The method of preparation is described: "About 10 Cc. of asphalt varnish (B. Asphaltum) is placed in a beaker and heated on a steam bath for one-half hour. From 3 to 5 drops, delivered from a 1 Cc. pipette, are then placed in a casserole, and 1.5 Cc. of olive oil added. The mixture is heated and stirred for a few minutes until perfect solution is effected. To this is then added, with stirring, the paraffin, which has been previously melted. When the preparation is cooled, a brown solid is obtained. The physical factors of this paraffin mixture are: melting point 45.4 C. (U. S. P. method); plasticity, 28.5; ductility, 29; it is very pliable and strong at 38° C., and adheres exceedingly well to the skin, although it detaches easily."

Some manufacturers of these preparations add eucalyptol and also coloring matter, alkannin and gentian violet.

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can preparations have been placed on the market. Both have followed the French example of keeping the composition secret, and both therefore are open to the foregoing objections. The secrecy makes a systematic comparison of the different films difficult. However, I have compared the physical properties of these commercial preparations with the formulas which I have given herein. Since experimentation with preparations of unknown composition cannot add much of permanent value to our knowledge, and is apt to be largely wasted, it seems worth while to publish the formulas and properties of our preparations without awaiting their clinical trial. Indeed, the very object of this publication is that they may receive such clinical trial.

In planning the formulas for these waxes, I intentionally avoided a slavish imitation of the pretended composition of the proprietary preparations. On the contrary, I have aimed to make the formulas simple, each containing at most two constituents; to make the manipulations so simple that the preparations could be made independently, and if possible extemporaneously, by any pharmacist, and would thus be accessible to any surgeon who cared to try them; to vary these formulas so as to produce preparations with properties which differ considerably, and to devise simple methods for comparing the relevant physical properties. I have intentionally refrained from adding any deodorant, antiseptic, coloring matter, etc. I believe that the first step should be to determine the suitability of these films from a purely mechanical standpoint. After the suitable type or types have been selected, it will be an easy matter to modify them by such additions.

The significant properties of the films appear to concern in the first place the melting point. This should be not much lower than 48° C., and not much higher than 53° C. Within this range, I incline to believe that the melting point is practically immaterial.

The hardness of the wax may be important. The harder the wax, the more firm is the support which it affords; but, on the other hand, the softer films are probably more "soothing." It is quite possible that different cases may demand different types of films in this respect.

A further important property is the strength of the film (fragility). It involves at least two factors: (1) ductility, the coherence of the film against pulling and kneading—a property which reflects the resistance of a film against stretching; and (2) pliability, the resistance to fracture on bending.

The first of these (the resistance to pull) can be determined only roughly by comparing methods; there is no convenient quantitative measure of this, although one could perhaps be devised. The resistance to breaking can be determined quantitatively in relation to the temperature: the more fragile films will break on bending at a relatively high temperature, while the more plastic films can be bent at relatively low temperatures.[1]

General Methods of Preparation.—The mixtures were prepared simply by melting the ingredients in a water-bath, after which the mixture was heated to 145° C. for sterilization.

Melting Point Determination.—This was attempted by the U. S. P. method, which consists in drawing the melted wax into a capillary tube; cooling for a cer-

[1] Further experience indicates that ductility may be expressed quantitatively by the temperature at which a thin film breaks sharply when pulled in a straight line.

tain period; attaching the tube to a thermometer; immersing in a water-bath, and heating slowly until the melted wax begins to rise in the capillary tube.

The last clause of this method was not found very satisfactory with the more viscid fats: the slow heating gave a variable melting point usually several degrees higher than that obtained by immersing the capillary directly into the bath, which had previously been heated to the required temperature. The explanation probably lies in the viscidity of the oil when the column in the capillary tube is heated throughout, as it must be when the heat is raised gradually. Evidently the lowest melting point must be the correct one, so that our modification appears fully justified.

Determination of Hardness.—This was determined at 22° C. by trying the cakes of the preparations on each other, seeing which would indent the other. Since absolute accuracy was not necessary, the preparations were made into a limited number of groups, designated by Roman numerals, according to their hardness.

Formation of Membranes.—It was aimed to produce films under conditions which would approach physically those of clinical use. For this purpose, the preparations were melted on a water-bath. A sheet of plate glass was meanwhile warmed to from 38 to 40° C. by immersion in a water-bath kept at this temperature. When the paraffin was melted, the plate was taken from the bath and the melted wax poured on the moist plate glass and spread with a hot spatula. The plate with the film was then immediately immersed in the 38 to 40° C. water, kept there for a few minutes, and then lifted off with a spatula. This detachment of the film furnishes a preliminary idea of its general properties.

Further experience indicates that the method of preparing these films does not affect materially their significant behavior to temperature limits. Any method that yields fairly thin films may therefore be employed. At present, I make the films by pouring a teaspoonful of the melted wax on the surface of water at about 40° C.

Determination of Strength of Film.—The films were placed in a bath at 38° C. and then gently manipulated by kneading and pulling, noting their coherence, thinness of membranes that could be formed from them; the ease with which they are torn on pulling, etc.

Determination of Breaking Temperature.—The films were immersed in a bath of a given temperature for a few minutes and then bent on themselves. At the lower temperature, this causes the film to break sharply at the crease. At the higher temperatures, the films can be doubled without breaking.

The temperature at which breaking just occurs varies for each wax, and appears to be an objective and very useful index of its fragility. Since great accuracy was not necessary, the temperatures were determined only approximately, and at intervals of 5 degrees. In the table, the lower temperature is that at which the film breaks; the upper temperature that at which it can be bent without breaking.

Determination of Ductility Temperature.—The films are placed in warm water and pulled. The water is gradually cooled, noting the temperature when the film breaks with a straight fracture, without stretching.

PREPARATIONS AND THEIR PROPERTIES

Formula No.	Composition			Melting Point (C.)	Degree[1] of Hardness at 22° C.	Fragility Temp. (Break on Bending) (C.)	A. Formation of Membrane B. Strength of Film at 38° C.; (Break on Kneading and Pulling)
0 =	"Ambrine"			51	III	18–24	A. Coherent; detaches easily; fairly soft B. Very good resistance and pulls very thin; still ductile at 33°
00 =	Petrolatum (yellow)			50.5	0	.....	
000 =	Paraffin (stock)			53	...	.....	
1 =	Paraffin Petrolatum	000 00	100 20	52	II	30–35	A. Greasy, crumbly and weak, but detaches easily and sufficiently intact B. Poor resistance, though better than 2
2 =	Paraffin Petrolatum	000	100 100	49.5	I	35–35	A. Weak, greasy, noncoherent; difficult to detach; unworkable B. Very weak; crumbles
3 =	Paraffin Petrolatum	000 00	100 300				A. Ointment consistency at 43° C.; too soft to use
4 =	Paraffin[2] Venice turpentine		110 22	52.5	II	35–35	A. Detaches well but soft and crumbly; slightly greasy B. Soft and crumbly
5 =	Paraffin[3] Petrolatum		110 11	52.5	III	35–37	A. Rather weak, although sufficiently coherent to form a film B. Soft and crumbly; very weak
6 =	Paraffin[3] Japan wax		110 22	52	IV	35–35	A. Hard but crumbly; not sufficiently coherent B. Very crumbly (practically like 5)
7 =	Japan wax			50	IV	37–?	A. Does not solidify promptly when undercooled; does not detach except by scraping B. Hard, brittle and crumbly; sets very slowly
8 =	Paraffin[3] Olive oil		110 11	53	III	35–35	A. About like 11 B. Greasy and quite crumbly; very weak
9 =	Paraffin[3] Castor oil		110 5	53.5	IV	30–35	A. Solid, but not very strong, and rather crumbly B. Quite brittle and crumbly; soft
10 =	Paraffin[3] Yellow beeswax		110 11	52.7	IV	25–30	A. About like 11 B. Fairly strong; can be pulled very thin; somewhat more brittle than "Ambrine"
11 =	Paraffin[3] Spermaceti		110 11	53.5	III	25–30	A. Soft, but very coherent, and detaches well; *very* promising B. Good, about like "Ambrine"
12 =	Paraffin[3] Stearic acid		110 11	52.25	IV	25–30	A. About like 11 B. About like "Ambrine;" a little harder and probably a trifle more brittle
13 =	Paraffin[3] Cacao butter		110 11	53	III	35–37	A. Soft, but detaches well; very promising B. Soft and breaks
14 =	Paraffin[3] Cacao butter		110 22	52	III	35–37	A. Not greasy, but soft and crumbly, and not sufficiently coherent B. Soft and fragile
15[2] =	Paraffin[3] Resina		110 11	53.5	V	30–30	A. Very slightly greasy; detaches and coheres; but not quite as good as 16 B. Like "Ambrine," or stronger
16 =	Paraffin[3]			52	IV	30–30	A. Detaches beautifully; very promising B. Rather more brittle than "Ambrine," but pulls out well; ductile at 36.5°; not at 33°

PREPARATIONS AND THEIR PROPERTIES (*Continued*)

17 = Paraffin, "embedding," M. P. 48° C.		48	III	25–30	A. Coherent and detaches quite well B. Practically like "Ambrine"
18 = Paraffin, "embedding," M. P. 52° C.		51.5	IV	24–25	A. Good film, but rather fragile B. About like "Ambrine," a little harder and more fragile and not quite as plastic
19 = Paraffin[3] Cera flava	110 22	53.75	IV	25–30	A. Strong and coherent film B. About like "Ambrine," slightly more brittle
20 = "Mulene"[4]		52	IV	16–18	A. Coherent but detaches with difficulty B. About like "Ambrine," slightly more brittle
21 = "Parresine"[4]		48	II	25–25	A. Soft, but coheres well B. About like "Ambrine," but slightly more fragile
22 = Yellow beeswax		(62 : 65 U. S. P.)	II	?–16	A. Dry, strong and coherent; not easily detached B. Fair resistance
23 = Paraffin[3] Liquid Paraffin	110 5	49.5	II	33–36	B. Just ductile at 36.5°; not at 33°
24 = Paraffin[3] *Liquid Paraffin* Beeswax	110 5 10	52	II	33–33	B. Just ductile at 36.5°; not at 33°
25 = Paraffin[3] Asphalt Varnish	110 11	48.5	II	25–28	A. Dry, very extensile, coherent, somewhat adhesive B. Just ductile at 28°
26 = Paraffin[3] Asphalt (Trinidad or Bermudez Asphalt Cement, 1 to 3%; or Texas Asphalt, 1%)	110 1 to 3	50.5–51	IV	27–29.5	A. Very pliable, somewhat adhesive B. Just ductile at 33–36°
27 = Paraffin[3] Texas Asphalt	110 5	51.5	IV	29.5–33	A. Pliable, but too adhesive B. Just ductile at 33–36°
28 = "Soft Paraffin"		50.5	III	26.5–28.5	A. Much more ductile than Formula 16 at body temperature B. Just ductile at 28.5°; not at 26.5°
Cacao butter		32.8	Not determined personally		
Stearic acid		56	Not determined personally		
Spermaceti		(42–50 U. S. P.) not determined personally			

[1] V is highest; zero lowest.
[2] Resin and Venice turpentine do not appear to mix well with paraffin, and must be kept stirred.
[3] The brand of paraffin used in these experiments was "Parawax," a trade name applied to paraffin marketed by The Standard Oil Co. of Indiana. It is a rather hard paraffin; softer varieties would be preferable. It should be remembered that the various oil refining companies have individual trade names of their own for their products.
[4] Preparations Nos. 20 and 21 are proprietary formulas.

The lower the temperature at which the film begins to break on bending or pulling, the greater is its pliability or ductility.

The individual preparations and their properties are shown sufficiently in the accompanying table. It is probable that clinical trials will introduce new factors so that the usefulness of the various preparations cannot be judged altogether from the physical results given in this paper.

(The cost of these preparations is low; paraffin, the principal ingredient, is at present about 15 cents per pound.)

For purposes of simplification the different preparations can be arranged into a number of groups. The most distinctive feature is the hardness, ranging from the stiff beeswax to the gelatinous petrolatum. It is this property, more than any other, which determines the mechanical usefulness of the individual preparations for special purposes. Aside from this, it is desirable that the preparation should have a low melting point, and that it should remain pliable at a relatively low temperature.

With these points in mind, the following grouping appears most promising; it is arranged in descending order of hardness, giving the number of the formulas under each class, in the order of preference:

Class I: Paraffin, Formulas 17, 18 and 16.

Class II: Paraffin-wax mixtures, Formulas 11, 12 10, 19, 15 and 6.

Class III: Paraffin-Asphaltum mixtures, Formulas 25 to 27.

Class IV: Paraffin-oil mixtures, Formulas 13, 23, 24, 8, 14, 9 and 4.

Class V: Paraffin-petrolatum mixtures, Formulas 5, 1, 2 and 3.

CLASS I.—*Simple Paraffins (17, 18, 16)*.—These comprise the commercial paraffins of melting points of from 48 to 53° C. They are quite hard (generally IV of the scale), and break between 25 and 30° C. They would be used when a relatively stiff film is desired, which would separate clean from the wound. Their mechanical properties are quite similar to Ambrine. They are perhaps somewhat more fragile, but the difference does not seem important. They are the simplest and cheapest agents. Presumably any available "paraffin" could be used; but when a choice is possible, samples melting close to 50° C. would be preferred. It should be understood that commercial paraffins are complex mixtures of hydrocarbons and that the various commercial brands may differ in their physical properties, such as melting point, hardness and flexibility. It is doubtful, however, whether these differences are of practical importance in the clinical use.

CLASS II.—*Paraffin-Wax and Related Mixtures*.—The addition of small amounts of various waxes, etc., modifies the properties of paraffin somewhat; but the modifications are relatively slight, and I doubt whether they have any real importance. I tried mixtures with beeswax, 10 percent (Formula 10) and 20 percent (Formula 19); and with 10 percent of one of the following: spermaceti (Formula 11); stearic acid (Formula 12); and resin (Formula 15). Nos. 15 and 19 have rather high melting points. The others stand so close to the simple paraffin that I doubt the advisability of giving them an extended trial. If experimentation should appear desirable, I would advise Formula 11 (the spermaceti mixture); or if this is too expensive, Formula 12 (stearic acid mixture).

The *proprietary mixtures of secret composition* also belong in this general class:

"*Ambrine*" (Formula 0), as I have said, approaches very closely to the simple paraffins.[2] It is rather more plastic and less brittle; but the difference does not impress one as important.

"*Mulene*" (Formula 20) also comes very close to the simple paraffins, and to Ambrine. The same remarks apply to both.

"*Parresine*" (Formula 21) is a rather different article. It is softer and more fragile than Ambrine; but on the whole it does not depart seriously from the paraffin type.

CLASS III.—*Paraffin-Asphaltum Mixtures.*—These are distinctly more pliable and more adhesive than the plain paraffin, and can be made into thinner films. Theoretically, these properties would be advantageous; practically, I doubt whether the advantages are important. The paraffin and asphalt do not form perfect mixtures and must be kept stirred.

A mixture made with 10 percent of "asphalt varnish" possessed the desirable qualities, but since the composition of the asphalt furnished is complex and probably variable, no further experiments were made. Other preparations were made with the semi-solid asphalts, such as Trinidad or Bermudez "asphalt cement," from 1 to 3 percent; or Texas asphalt (Formula 26). These are not quite so plastic as the varnish formula, but nevertheless are quite promising. Higher proportions are less desirable, such as 5 percent of Texas asphalt in Formula 27.

CLASS IV.—*Paraffin-Oil Mixtures.*—These are considerably softer than the paraffins, and also considerably weaker (more friable); however, they are fairly coherent. They would perhaps be preferable in the early stages of treatment, since they would be somewhat emollient. The most promising is the mixture with 10 percent of oil of theobroma (cacao butter, Formula 13); then come the one with 5 percent of liquid petrolatum (Formula 23), and this with beeswax (Formula 24), and that with 10 percent of olive oil (Formula 8). That with 20 percent of cacao butter (Formula 14) is scarcely sufficiently coherent. That with 5 percent of castor oil (Formula 9) was unpromising. The mixture with 20 percent of Venice turpentine (Formula 4) had the properties of Class V, but appeared undesirable.

CLASS V.—*Paraffin-Petrolatum Mixtures.*—These differ materially from the other classes. They are very soft and might be termed "solid ointments." They are rather greasy, and crumble easily; No. 3 (75 percent petrolatum) was really a cerate and would not form a workable film. No. 2 (50 percent petrolatum) would also be practically unworkable. Twenty percent petrolatum (Formula 1) and 10 percent petrolatum (Formula 5) form weak, but manageable films. The last (Formula 5) would be worth trying when a very soft film is desired, for instance, on very sensitive surfaces.

Application to the Skin.—A selected series of preparations was applied to the skin in the same manner as they would be used clinically. A strip of skin about an inch wide was painted with the melted wax; on this was laid a very thin layer of cotton and over this was painted another layer of the wax. The adjacent strip of the skin is now painted with a second preparation, and so on. (This will be a very suitable method of comparing the preparations clinically.) The strips are

[2] In a preliminary study of paraffin mixtures in the A. M. A. chemical laboratory, Ambrine was found to contain about 96 percent unsaponifiable matter (paraffin).—ED.

covered with a bandage and left on for at least an hour. The following presented no marked differences:

"Parawax" Paraffin	(16)	"Mulene"	(20)
Paraffin-spermaceti	(11)	"Parresine"	(21)
Paraffin-stearic acid	(12)	Paraffin-beeswax	(10)
Paraffin, 48°	(17)	Paraffin-resin	(15)
Paraffin-theobroma	(13)	Paraffin-liquid paraffin	(23)
"Ambrine"	(0)	Paraffin-beeswax-liquid paraffin	(24)
Paraffin-petrolatum	(5)	Paraffin-asphaltum mixtures	(25 and 26)

Paraffin-asphaltum gave a film that was somewhat adherent, but that was smooth, strong and so pliable that it could be wound about a pencil without cracking.

CONCLUSIONS.

The preparation and mechanical properties of a series of paraffin-film mixtures suggest that the most important mechanical property of such films from the therapeutic standpoint is their hardness. It is suggested that several degrees of hardness might possess advantages under different conditions.

Surgeons who desire to experiment with the paraffin treatment of burns are urged to use simple preparations of known composition, so that their results can be compared, and so that any deficiencies may be met, and improvement made intelligently.

The physical and mechanical properties of a series of paraffin and mixtures are described. *Ordinary paraffin*, melting between 48° and 53° C.(118–128° F.), preferably about 50° C. (122° F.), appears to possess practically the mechanical properties of the French preparation, and is urged as the standard of comparison.

Paraffin-Asphaltum (Formula 26) gives a preparation of superior pliability.

The following additional formulas are suggested for clinical trial as preparations of increasing softness:

Paraffin-Spermaceti (Formula 11): Paraffin, 10 parts; spermaceti, 1 part.

Paraffin-Theobroma (Formula 13): Paraffin 10 parts; theobroma oil, 1 part.

Paraffin-Petrolatum (Formula 5): Paraffin, 10 parts; yellow petrolatum, 1 part.

In comparing these films with each other, or with proprietary formulas, claimed points of superiority should be clearly established. Finally, experience may show it to be advantageous to add to the simple combinations I have suggested one or more medicinal agents such as resorcin, eucalyptus, scarlet red, etc.