SOME MODERN DISINFECTANTS.

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THE NATURE OF DISINFECTION.

As the health of man is so largely dependent on the health of animals, and the spread of nearly all diseases among men and animals is susceptible of control if proper methods of combatting the contagion are followed, it is a matter of considerable importance to understand where the dangers of infection lie and what are the best methods of destroying their cause. This process we call disinfection.

The primary cause of all diseases being recognized to be a bacterium, or sometimes a parasite, the source of infection may be removed by destroying the parasites or germs. Bacteria, in multiplying either inside or outside the animal body, often form compounds, frequently gases, that are exceedingly disagreeable, so that these dangerous enemies are often easily recognized. Different substances may be used to counteract these disagreeable odors, and it is sometimes thought that by destroying the noxious odors all danger has been removed. This, however, is not the case, as many substances will act as deodorizers which are not germ destroyers. Again, we have other substances which will retard the action of germs and prevent their multiplication, but will not kill them, while a true disinfectant destroys the germs, counteracts and destroys the disagreeable odors resulting from decomposition, and hence prevents danger of further spread of disease. It is to this latter class of substances, especially modern disinfectants, that attention will be called in this article, and the comparative merits of some of them, as developed by their use, will be pointed out.

THE MERITS OF SOME DISINFECTANTS.

STEAM AND BOILING WATER.

The best disinfectants, where they can be applied, are steam and boiling water. There are some practical objections to them, however, on account of the difficulty of always obtaining them in a convenient place, and the injury to the walls of a room, articles of furniture, bedding, clothing, etc., resulting from their use. Hence, disinfectants which are more conveniently applied and do not injure materials with which they are brought into contact are preferable.

CARBOLIC ACID.

Though many new disinfectants have been recommended in its place, carbolic acid, so long known, has retained its position as one of the best disinfectants in surgical work, as well as for general purposes, when there are no practical objections to its use. In solutions varying from one-half of 1 per cent to 5 per cent in strength, it is a valuable destroyer of all disease germs. For disinfecting stables, barns, outhouses, fæces, expectorations, etc., a 5 per cent solution should be used. Its odor and poisonous properties are sometimes objectionable. Küppe and Laplace found that crude carbolic acid when treated with sulphuric acid gave a product the disinfectant properties of which were increased with an admixture of cold water, but diminished in warm water. If this mixture is to be used, it should be prepared by stirring the sulphuric acid slowly into the carbolic acid with a wooden paddle in a wooden or iron receptacle. Fränkel found that when crude carbolic acid was distilled it yielded a product boiling between 185° and 205°, which in a 5 per cent solution killed anthrax spores (among the most difficult to destroy) in twenty-four hours. Treated with sulphuric acid, the cold solutions again showed stronger disinfecting properties than the warm, which was supposed to be due to the fact that the sulpho-acids formed had weaker properties as disinfectants.

SUBSTITUTES FOR CARBOLIC ACID.

Subsequently, others succeeded in dissolving cresols, crude carbolic acid, etc., in various soap solutions which could be substituted for the more expensive pure carbolic acid. A number of such products as creolin, lysol, cresolin, cresin, etc., were offered as substitutes for carbolic acid, all being solutions in resin soap of the cresols and similar hydrocarbons. These preparations behaved differently when dissolved in water. Some gave clear solutions, others milky solutions, due to a partial decomposition of the compounds. An effort was then made to discover a substance which would dissolve these materials more readily and always give a clear solution. It was found that salicylate of sodium or some of its derivatives formed suitable menstrua, and the name solveol was given to a number of such preparations.

Many articles have been written upon the action of these materials of various origin, showing that all had about the same value. A pure preparation of the cresols, a mixture of ortho, meta, and para cresol, was also put on the market under the name tricresol. It was found that this tricresol was about as soluble in water as carbolic acid, had three times its efficiency, and only one-third its poisonous properties.

One of the preparations mentioned above, viz, creolin, is composed very largely of hydrocarbons, which are with difficulty soluble; it yields on the addition of water an emulsion. Sirena and Misuraca treated tuberculous material, such as sputum, with a 3 per cent to 5 per cent solution of this substance one to two days and could notice no destruction of the germs. Tried upon anthrax bacilli and spores, its antiseptic properties were not marked.

A great many results where lysol has been used have been reported. Gerlach, who studied the subject thoroughly, concluded that lysol is more active than carbolic acid and creolin, and that disinfection of the hands is possible with a 1 per cent lysol solution; it is said to be more serviceable than any other agent in disinfecting sputa and fæces. A 3 per cent solution, used as a spray upon the walls, will make them germ free, and as compared with carbolic acid, sublimate, and creolin it is much less poisonous.

Of the many other disinfectants (a large number of which are derivatives of those already referred to), the majority, as aseptol, europhen, and the like, are more especially intended for medical and surgical use, and are either too expensive or for some other reason, such as difficulty of solubility, not adapted to household use or for purposes of general disinfection.

FORMALDEHYDE.

For many reasons, the best results in disinfecting rooms or buildings can be secured by means of a gaseous disinfectant which will readily penetrate to all parts of a building and impregnate articles, such as upholstery, bedding, and the like, without injuring them. Sulphur dioxide was for a long time the least injurious gaseous disinfectant known, but within a few years formaldehyde gas, or its solution in water, has begun to replace the other gaseous disinfectants. Though irritating to the mucous membrane, it is not nearly so disagreeable as sulphur dioxide; it is not as poisonous, nor is it injurious to metals, wood, or fabrics.

In order that a disinfectant shall be thoroughly satisfactory, certain conditions must be fulfilled. In the first place, it should destroy surely and quickly the most resistant forms and spores of injurious bacteria. It must be a substance that can be easily used, and be nontoxic and nondestructive to mineral or vegetable matters in the concentration necessary to insure complete disinfection. Further, it should be a substance which can be applied in a gaseous condition, to secure thorough contact and penetration of the objects to be disinfected. Again, it must be a substance which is stable in character, not easily decomposed, cheap, if possible possessing an odor which dissipates quickly, and a good deodorizer. To a certain degree formaldehyde possesses all these properties, and its practical use has been the subject of a number of investigations. Commercially, we find formaldehyde in the market as a 40 per cent solution of the gas in water or wood alcohol under the trade names of formalin and formol. The formaldehyde gas and its solutions can be prepared with great ease by the partial oxidation of wood alcohol. As early as 1888 the strong antiseptic properties of formaldehyde were recognized by Low, and in 1892 Trillat published the statement that a bouillon containing 1: 50,000 of formaldehyde was not suitable for the growth of the anthrax germ. Aronson, after making similar experiments, tried the poisonous properties of the gas upon guinea pigs, and found that they could live for an hour in an atmosphere rich in formaldehyde gas. During this experiment the animals were very restless, but recovered very quickly in normal air. Zuntz had already shown that the poisonous dose for rabbits after a subcutaneous injection was about 0.24 gram per kilo.

In 1893 formaldehyde was recommended for the disinfection of brushes and combs, as well as for use to destroy the germs of diphtheria, tuberculosis, cholera, and the like on such materials as would be injured by other disinfectants.

Another authority asserted in 1893 that after one hour in solution of 1:10,000 and after fifteen minutes in 1:750 anthrax and tetanus germs were destroyed. The results further showed that in the air 2.5 per cent by volume of formalin, or 1 per cent by volume of formaldehyde gas, was sufficient to destroy fresh virulent cultures of typhoid, cholera, anthrax, etc., in fifteen minutes. Other experiments have shown that bandages and iodoform gauze can be kept well sterilized by placing in the jars containing them some formaliths, a solid preparation containing formaldehyde, and it was also possible for Stahl to make carpets and cloth materials germ free by spraying them with 0.5 to 2 per cent formalin solution for fifteen to thirty minutes without the color of the carpet being in any way affected. The researches of Pottevin in 1894 confirmed those of Aronson and Trillat that a concentration of 1: 20,000 was safely a retardent of sufficient strength.

In 1894 the deodorizing property of formaldehyde was explained to consist in a direct chemical combination of formaldehyde and sulphureted hydrogen, or with ammonium compounds and their derivatives present in fæces, decomposing animal matter, and the like. With scatol, one of the odorous constituents of the fæces, formaldehyde combines upon the addition of acid to an odorless compound.

As Walters has shown, so far as the action of formaldehyde in gaseous form is concerned, that is dependent upon the concentration of the gas, the temperature, and whether the articles to be disinfected are moist or dry. The killing of the germs appears to be better accomplished when the objects are very slightly moist (not wet), and the temperature is 35°. This is a property which has long been well known as belonging to sulphur dioxide, chlorine, and bromine.

Of the practical methods of applying formaldehyde, those in which the gas is allowed to work in statu nascendi have given the best results. Several forms of lamps have been devised in which the formaldehyde is obtained by the imperfect combustion of methyl alcohol.

These have the advantage that the lamp can be filled and placed in the room or other closed place which it is desired to disinfect. They have the disadvantage, however, that some of the alcohol suffers complete combustion, that a certain amount of carbon monoxide and dioxide are also obtained, and that a little alcohol is lost and consequently a larger amount of alcohol is used than should be necessary. Practical experiments made by Miguel, Bardet, Trillat, and others in disinfecting rooms by means of these lamps have given very satisfactory results. The principle of the lamp is to allow the flame to burn over a wire mantle of platinum or a platinized asbestus wick.

Two simple lamps for this purpose may be described here, the one designed by Professor Robinson, of Bowdoin College, the other by the writer. The latter can be readily understood from the accompanying illustration (fig. 58), the point being the use of a wick in whole or in part of platinized asbestus. The lamp is filled with alcohol, and the wick turned up slightly and lighted in the ordinary way. After a minute the asbestus portion of the wick becomes heated to such a temperature that the platinum distributed over the surface will continue to glow and convert alcohol into aldehyde as long as the lamp remains filled. Professor Robinson's lamp is described by himself as follows:

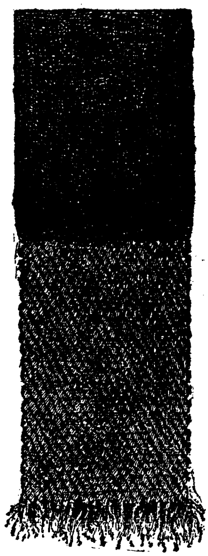

FIG. 58.—Wick for formaldehyde lamp.

I take a disk of moderately thick asbestus board and have it perforated with small holes close together. This is then platinized in the usual way, using quite a strong solution of platinic chloride. If now a shallow dish, cylindrically formed and of such size that the perforated asbestus disk will just cover its top, be partly filled with methyl alcohol, it serves as the lamp font. If the platinized disk be wet with alcohol, seized in a pair of forceps or small tongs, removed from the dish, and the alcohol lighted, it will, by the time its alcohol burns away, be heated sufficiently so that when placed over the lamp font again it will continue hot and change the alcohol to aldehyde. Experience shows that with proper depth of dish and suitable holes for admission of air, the disk keeps of a proper redness to bring about the change most efficiently. The gas may also be applied by warming its solutions and better exhausting the air in a closed vessel containing formalin. If this solution is heated, some of the formaldehyde is polymerized and converted into an inactive form.

The use of formaldehyde for the purpose of destroying the spores of smut by the action of 1:10,000 formalin solution has been recommended. In all experiments in using this material, attention must be paid to the fact whether reference is made to the formalin solution or to formaldehyde gas. It is probable that with a convenient method of generating the gas this might be used to advantage in destroying insects injurious to vegetation.

Walter has carried out a series of experiments with formalin and also with the gas which can be obtained from it. His experiments were made first by preparing different kinds of culture media to which formalin had been added in different proportions. The results of these tests upon anthrax spores, cholera, typhus, and diphtheria germs showed that the proportion of 1:10,000 or 1:20,000 of formalin, or 1:25,000 of formaldehyde gas, is sufficient to check the growth of the germs. When the gas is used, the *Staphylococcus pyogenes aureus* seems to be the most resistant, while, strange as it may appear, the spores of anthrax, so difficult to kill by most germicides, are very easily destroyed by formalin. This is one of the principles laid down by Koch that some substances would be found which were destructive to pathogenic bacteria, but were less injurious to ordinary germs.

In order to prove the value of formalin on a large scale for the disinfection of clothing, Walter used a soldier's blue mixed with red color, which he immersed in a culture of the pure germ, so that the cloth was thoroughly saturated. Strips were then cut off, placed under a bell jar, and sprayed with formalin solution varying in strength from 3 per cent to 10 per cent. The strips were left in the bell jar six hours. After that time tests were made by cultures from these strips, check strips being used at the same time. There was no change produced in the color of the cloth, and the red was, if anything, a little brighter. The germs which had penetrated deeply into the cloth were all killed, just as were those upon the surface. This can be explained probably by the fact that the articles being surrounded with the jar the gas was forced deeply into the interstices of the cloth and killed those germs which could not be reached by the solution. The 3 per cent solution gave just as satisfactory results as the stronger solutions.

The preliminary experiments that Walter made with the gas to prove the availability of formaldehyde for the disinfection of clothing, etc., without injury to the latter were satisfactory except with reference to the length of time required. This, however, was due to the practical details of the method, as the source of the formaldehyde was either the powder placed under a bell jar or a lamp used in a room which was poorly adapted to the purpose, there being too many openings for the escape of the gas.

SUMMARY.

The results of all investigations have led to the following conclusions:

1. Formalin in concentration, 1:10,000, makes the growth of tuberculosis, anthrax, cholera, typhus, pus, and diphtheria germs impossible.
2. In gaseous form a weak dilution is sufficient to check growth.
3. A 1 per cent solution will kill pathogenic organisms in an hour.
4. With a 3 per cent solution and the final addition of alcohol it is possible to make the hands germ free. Whether the skin of the hands is attacked by this method remains to be proved.

5. Spraying with formalin solution and subsequent inclosure of the articles in a closed space will easily sterilize them.

6. Uniforms, etc., can be disinfected on a large scale without injury, twenty-four hours being required.

7. Fæces are deodorized by a 1 per cent solution, and are in thirteen minutes germ free; and buildings can be readily disinfected by a 1 per cent to 1.5 per cent volume of the gas.

8. Formaldehyde is a useful etching material and preservative.

As compared with other disinfectants, such as corrosive sublimate, carbolic acid, lysol, etc., formaldehyde and its solutions have the advantage of not being retarded in their action by albuminoid matter and of not injuring the articles to which they are applied. Their use therefore seems to be well recommended and to fill many requirements which are not now fully met by other disinfectants. Especially is this the case in disinfecting rooms, clothing, bedding, railroad cars, etc.

Experiments made by Roux, Trillat, and others upon the use of formaldehyde vapor for disinfecting rooms have been very satisfactory, in that the bacilli of anthrax, tuberculosis, and diphtheria have been killed within five hours by a saturated atmosphere of formaldehyde gas. After two days of thorough ventilation no odor remained in the room, nor were the objects which had been exposed to the action of the gas in any way injured. An objection to the use of formaldehyde has been raised because it adheres somewhat tenaciously to clothing and upholstered materials and the odor dissipates slowly. This, however, can be removed by thorough ventilation or by the use of a dilute solution of ammonia, which readily absorbs the gas. Placed in a room where formaldehyde has been used as a disinfectant, this would aid in a more rapid dissipation of the odor and not injure the materials. It would seem that in formaldehyde we have at hand the most useful disinfectant yet known, the application of which is a mere detail to be easily worked out in practice.

It also appears to be useful as a means of preserving food, milk, etc. Its effect upon the digestive ferments has not been thoroughly studied, but the quantity used for preserving milk, 1 part to 10,000, should be too small to give rise to any bad result, and none has been noted in practical use. Its influence in this connection should be carefully studied before it is generally recommended.

While testing the action of this gas upon the cattle tick recently, its action upon the respiratory organs of cattle was noted. A calf was kept for five hours in an atmosphere containing about 2 per cent of formaldehyde gas. During this time there was a slight watering from the eyes and it coughed occasionally, but it did not seem to be in any special distress, and as soon as it was brought into the fresh air again it was all right and showed no bad after effects. This fact may prove of importance in disinfecting stables and the like.

Another direction in which formaldehyde promises to be of practical importance is in the disinfection of imported hides, which may carry contagion, especially anthrax. The rapid action and penetrating power of this gas bids fair to overcome the practical difficulties hitherto attending the use of disinfectants for this purpose.

In regard to the use of formaldehyde, it is of importance to know the percentage of gas which will be necessary to disinfect a room of given size and what percentage should be used in any given disease. If the alcohol used is entirely converted into aldehyde by the lamps, as indicated, 1 liter of pure wood alcohol will give 748 grams of aldehyde = 361 liters of this gas. The capacity of a room of 1,000 cubic feet is 28,684 liters, so the above quantity of alcohol would give 1.26 per cent aldehyde in a room of this size.

Experiments have shown that very much less than 1 per cent by volume of this is destructive to injurious bacteria, but an atmosphere containing 1 to 1.5 per cent by volume will give satisfactory results in six to thirteen hours in all cases. When the volume of the gas is increased, the length of time necessary for the disinfection is considerably decreased.

Of the mineral salts recommended as disinfectants in the solid form, many are deodorizers and not true disinfectants. Others, like corrosive sublimate, are too poisonous, or can not be used with good effect in presence of albuminoid matter. One should always remember the difference between destroying the cause of infection, the only safeguard, and simply removing disagreeable odors.

Boiling water and steam are excellent disinfectants when they can be applied, but best of all for general disinfection are formaldehyde gas and its solutions.

It should be noted that a 40 per cent solution of formaldehyde gas can be purchased for one-fourth the price paid for formalin, which is exactly the same thing.