A CONCENTRATED DAKIN'S SOLUTION.

BY ADRIAN THOMAS.*

During the war it was proven that Dakin's solution was a very valuable preparation for the treatment of certain surgical cases such as gunshot wounds. It was also pointed out that it could be very useful in the treatment of many other surgical cases which were not free from infection. The great difficulty with Dakin's solution is that it has been found difficult to prepare and that it must be prepared immediately before use because of its rapid decomposition.

Dakin's solution[1] as originally prepared is a solution containing from 0.4% to 0.5% sodium hypochlorite. It also contains sodium carbonate, and sodium borate or sodium bicarbonate. The alkalinity of Dakin's solution must be between certain limits and the alkalinity specified is that which will give no color with powdered phenolphthalein. However, it should give a momentary red flash when a drop of an alcoholic phenolphthalein is added. The presence of the sodium carbonate and bicarbonate has a buffer effect and keeps the alkalinity correct.

Several preparations all of about the same quality have appeared from which it has been claimed a correct Dakin's solution could be prepared by adding water to make the proper dilution. At least one claims to possess a different quality as well as a lower alkalinity than Dakin's solution and therefore to be less irritating. However, all of the preparations examined have shown a distinct alkalinity with solid phenolphthalein. The different quality of alkalinity referred to is presumably the alkalinity caused by calcium hydroxide. They have sodium salt present and consequently it may be expected to find some sodium hydroxide. True Dakin's solution contains no calcium and a definite limit is placed upon the alkalinity which is due to carbonates. If a sodium bicarbonate solution is added to these preparations the hydroxides are converted into carbonates and the excess of bicarbonate, acting along with the carbonates as a buffer, will tend to maintain the correct alkalinity, but at the same time it causes the calcium to precipitate. The presence of calcium does not appear to have any practical value, it merely gives opportunity for the claim that the alkalinity is of a different nature, but it does possess the disadvantage of causing a precipitate if sodium bicarbonate is added to correct the alkalinity.

The ideal preparation would be a concentrated solution of sodium hypochlorite in such form that by the mere addition of water a solution meeting all the requirements of Dakin's solution would be produced, but this is not possible because of the unstability of sodium hypochlorite.

To keep for any length of time sodium hypochlorite solution must be rendered considerably alkaline with either sodium hydroxide, sodium carbonate or other strongly alkaline substances. Also, the concentration of the hypochlorite must not be too great. Concentrated solutions of sodium hypochlorite decompose more rapidly than more dilute solutions and this decomposition increases with the concentration as a geometric function and not algebraically.

In August 1919, some experiments were begun to determine under what conditions a concentrated Dakin's solution would be most stable. In all, nineteen

* Section on Practical Pharmacy and Dispensing, A. Ph. A., Cleveland meeting, 1922.

[1] "Handbook of Antiseptics," by Dakin & Dunham, The Macmillan Co., New York, 1918.

solutions were made as stock solutions. Numerous dilutions of these stock solutions were made to determine the stability of the diluted solutions, their alkalinity, etc.

The most simple method of preparing a solution was found to be that of passing chlorine gas into a *cold* solution of sodium hydroxide until practically no color was imparted to a sample by adding powdered phenolphthalein and then adding sodium hydroxide solution to give the desired degree of alkalinity. Care must be taken to prevent addition of an excess of chlorine.

The large majority of these solutions were found to deteriorate very rapidly because of their high concentration, while a few showed a very slow deterioration, these being more dilute. It is impossible to prepare a hypochlorite solution which will not deteriorate to a certain extent, that is, with our present knowledge of the substance. We can only hope to find the conditions under which the decomposition is slow enough to permit us to keep the product a reasonable length of time.

Preparations may be made that will keep two or three years and be usable at the end of that period.

In the following table the results obtained with some of the solutions prepared are given. The concentration in percentage of sodium hypochlorite when freshly prepared, the concentration after standing twenty-seven months, the percentage loss per month and the alkalinity are given—the alkalinity being the number of cubic centimeters of tenth-normal hydrochloric acid required to discharge the color produced in ten cubic centimeters of the solution by powdered phenolphthalein.

Laboratory no. of prep.		Initial conc.	Concentration after standing 27 months.	Percentage loss per month.	Alkalinity cc N/10 HCl to discharge color produced with powd. phenolphthalein in 10 cc.
$NaOH + Cl_2$	10	4.82	2.75	1.59	5.4
$NaOH + Cl_2$	11	2.94	2.24	0.88	3.9
$NaOH + Cl_2$	12	2.51	2.04	0.69	3.4
$NaOH + Cl_2$	13	2.04	1.76	0.51	3.5
$NaOH + Cl_2$	14	1.51	1.40	0.27	3.2
$NaOH + Cl_2$	15	4.61	2.72	1.52	9.9
$NaOH + Cl_2$	16	2.79	2.12	0.89	6.3
$NaOH + Cl_2$	17	2.33	1.89	0.69	5.9
$NaOH + Cl_2$	18	1.87	1.59	0.55	5.1
$NaOH + Cl_2$	19	1.39	1.27	0.32	4.0

The most suitable concentration of hypochlorite was found to be about 1.5%. This concentration requires two volumes of diluent for each volume of concentrated solution to give the proper concentration for clinical use. It is about the same concentration as the "Stock solution" usually obtained by the Dakin method, yet it is sufficiently dilute to prevent too rapid decomposition. The proper alkalinity appears to be between 3 and 3.5. This is sufficient to preserve the solution, yet when diluted with two parts of a 1% solution of sodium bicarbonate the specified alkalinity of Dakin's solution is obtained.

Dakin's solution has the advantage over some of the other chlorine disinfectants in that it will dissolve pus and necrosed tissue. Unlike some preparations of a similar type this Dakin's solution is not intended for use as a general disinfectant, but is intended for surgical use. By diluting with sodium bicarbonate a

product is obtained which does not give a precipitate that must be removed, and which meets the requirements of a true Dakin's solution.

This preparation when diluted with sodium bicarbonate is not a substitute for Dakin's solution nor is it superior to Dakin's solution, but it *is* a Dakin's solution in that it contains the same materials as the original Dakin's solution though the method of preparation is different. The inert salts will not be found in this preparation in exactly the same quantity as in the original Dakin's solution, but in the latter it will be noted that the proportion of inert salts is not always constant.

The advantage of this preparation over Dakin's solution prepared by the usual methods whenever it is needed, is that no titration or testing is required to produce a Dakin's solution for clinical use, after the concentrated solution has been prepared. It is only necessary to dilute the concentrated solution with a one per-cent solution of sodium bicarbonate and it is ready for use. The advantage of this preparation over similar preparations is that no precipitate is caused when the alkalinity is adjusted by the addition of sodium bicarbonate.

Formula and directions for making Dakin's solution as described above are as follows:

CONCENTRATED DAKIN'S SOLUTION.

Decanormal sodium hydroxide	50 cc
Chlorine gas	q. s.
Water q. s. to make about	1000 cc

Fifty cc of cold decanormal sodium hydroxide are diluted to 320 cc. Into 300 cc of this solution pass just sufficient chlorine gas so that a sample will give no color upon the addition of powdered phenolphthalein. An excess of chlorine must be carefully avoided. Add q. s. of the remaining 20 cc to produce a distinct red color when solid phenolphthalein is added to a sample; 10 cc of the solution should require not over 5.0 cc tenth-normal hydrochloric acid to neutralize, using solid phenolphthalein as an indicator. Determine hypochlorite content by method given in U. S. P. for assay of the chlorinated lime, using 5.0 cc of the solution. The number of cubic centimeters of tenth-normal sodium thiosulphate used multiplied by 0.0744 gives the percentage of hypochlorite. Dilute with q. s. water to reduce the hypochlorite content to 1.5% plus or minus 0.05%. Adjust alkalinity so that ten cubic centimeters of this concentrated Dakin's solution will require not less than 3.0 cc nor more than 3.50 cc of tenth-normal hydrochloric acid to discharge the color produced by solid phenolphthalein. (Titrations for alkalinity must be made rapidly as the hypochlorite will bleach the indicator in the course of time.) This stock solution should keep at least a year without appreciable loss of strength.

DAKIN'S SOLUTION FOR SURGICAL USE.

Conc. Dakin's solution	334 cc
1% Solution of sodium bicarbonate q. s. to make	1000 cc

This solution must give no color with solid phenolphthalein and but a momentary pink flash when a drop of alcoholic phenolphthalein solution is added to a sample.

PAPER NO. 8,
CHEMICAL RESEARCH DEPARTMENT,
PARKE, DAVIS & COMPANY.