

SOME CONDUCTIVITY DETERMINATIONS FOR ACIDITY AND ALKALINITY OF SALIVA.

By Weston A. Price, D. D. S., M. S. and F. A. Fahrenwald, B. S., M. S.

"The apparatus used in making these tests was that installed in the department of electro-chemistry of the Case School of Applied Science and was imported from the firm of Fritz Kohler, in Germany. This is said to be one of the most delicate and sensitive installations in the United States. Figure 15 shows the general arrangement of this set up. The current here is derived from three dry cells and is changed to alternating current by means of the vibrator shown. The number of vibrations, as judged by the tone produced, was approximated about 800 per second, thus eliminating any danger of electrolysis in the solutions. The conductivity cell consists of the Jena glass container indicated, (see Fig. 15) into which the solution is placed. The electrodes are thin discs of blackened platinum, and are adjustable as to the distance between them.

"The method of operating is, briefly, as follows: Assume that the solution to be tested is in the container. The resistance of the solution now, is unequal to the external resistance. In this case a small amount of current will flow across the bridge wire and to the telephone receiver. By sliding the adjustable contact back and forth, a point is reached where there is a minimum current passing through the shunt, as is indicated by a minimum sound produced in the receiver. This bridge reading is now taken, and the conductivity of the solution is slightly decreased by adding pure water. A new zero point is now found and when a sufficient number of points are so located, they form a curve, which graphically shows results of the determination.

"Figure 3 is the curve so obtained when saliva is diluted in successive stages by

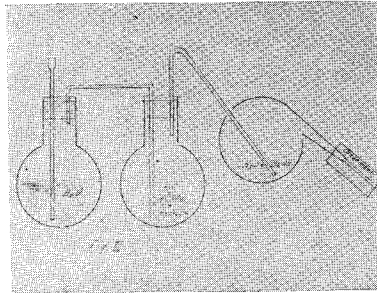
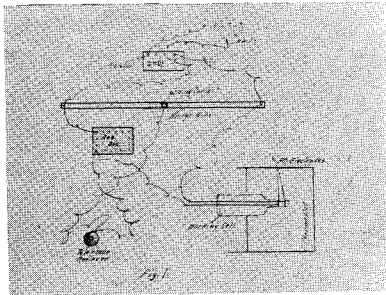
the addition of pure water. The water used in these tests was triple distilled. Ordinary distilled water was redistilled from a solution of sulphuric acid and potassium dichromate, which should oxidize all organic matter present. This was passed through a sealed tube to a vessel containing barium hydrate which should eliminate all carbon dioxide formed. The water was then redistilled from this solution and used directly, both for making standard solutions and for the dilution tests. Figure 2 shows the arrangement of this distillation apparatus.

"As compared with pure water, or the very dilute reagents used, the conduc-

ted by phenol-pothalein or methyl-orange.

"In the necessarily short time allotted to this work, it was impossible to determine the effect of various acids and alkalis in neutralizing the saliva solution, and as hydrochloric and sodium hydrate solutions were chosen, the results given here would not necessarily apply to the weaker acids and alkali solutions. Where a known amount of saliva was desired, it was either weighed in the conductivity cell, or measured by means of a special burette.

"Many alkali and acid titrations were made on the concentrated saliva solu-

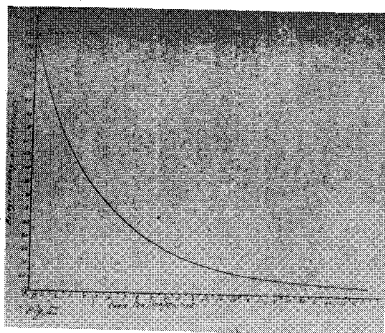


tivity of saliva is very great. Figure 3 is a curve which shows, very clearly, the decrease in conductivity upon addition of pure water. It was thought desirable to test the method first for its accuracy in determining the acid and alkali content of pure solutions. For this purpose, a solution of hydrochloric acid and sodium hydroxide were made up, using the conductivity water made for this purpose and diluting until the solutions were approximately $n=1000$, i. e. contained 1-1000 of the molecular weight of the material per liter of solution. For HCl, this is about a 0.36 per cent solution and for NaOH a .4 per cent. solution. Curves 1 and 2, Figure 4, show how well this worked out, and gave an end point which was much clearer than that indi-

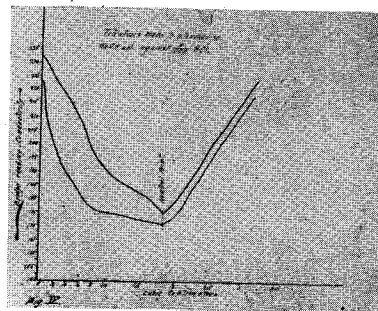
tion, but, resulting curves apparently differed in no way from the dilution curve shown in Figure 3. The probable explanation for this is that the end point, or neutralization point came so near the beginning of the curve, and, where the fall was so rapid that it was not detected. After trying for some time to remedy this difficulty, the following method was evolved, and which, so far as technique is concerned, worked very well. To a known amount of saliva solution there was added a known amount of the standard alkali solution. This, then, was titrated back with the standard acid solution with results shown in Figure 5. Curves 1, 2 and 3 show the neutralization point at 4.35 cubic centimeters of the added standard acid solution. These were triplicate

runs on alkaline solution containing no saliva. Their different relative positions are caused by the different dilutions used purposely in each case. The end points, however, check. Curves 4, 5 and 6 show the results of titrating the same amount of alkaline solution containing each 3 c. c. of saliva solution. In running these exactly as before, the end point came, in each case, at 4.2 c. c. of the added HCl solution, showing an apparent decrease in alkalinity, due to the saliva present, of 0.15 c. c. of the added acid solution. This as a measure of acidity, was all that could be wished for, but when this operation was reversed, and

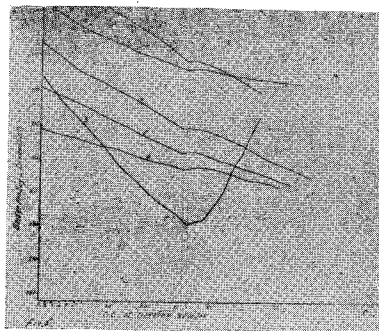
necessary, in all determinations, to dilute the saliva solution until the conductivity was very little or no greater than that of the titrating solution, in order to emphasize the end point. Other-



the saliva solution containing acid titrated with alkaline solution, the same saliva gave a decided indication of alkalinity, having apparently consumed some of the added acid. This same discrepancy was detected in seven different duplicate determinations and would seem to indicate that a certain decomposition or formation of other salts was taking place, so that as far as the stronger bases and acids are concerned, the method would seem to be worthless in connection with their neutralization of saliva, and the detection of that point by a change in conductivity of the solution. It does not, necessarily, follow that similar reactions would take place if some less active reagents were used. It was



wise, the curve would be a duplicate of the dilution curve, Figure 3, with a fall so rapid that the faint critical point would be overlooked. Perhaps, also, if these same experiments were performed with the impurities present in the acid and alkali solutions, corresponding to the salts found in the saliva, and explanations could be worked out."



From the work which has been done upon this phase of the subject there seems to be evidence to the effect that all salivas are able to combine with acids which are introduced into them from without, and it is reasonable to as-

sume that they have the same effect upon those acids which are formed in their own environment. We have also seen that this combining effect is a variable property, existing in some salivas to a greater extent than in others. It is but a step farther, then, to infer that certain salivas by their neutralizing effect may render inert much of the acid formed in the mouth by fermentation. So that in case the process of lactic acid fermentation were not completely enveloped by a non-permeable plaque or film, a saliva which is high in free alkaline compounds may be looked upon as an important inhibitive factor in the process of dental caries.

As a further substantiation of this view we have the work of Head* who found that the addition of salivas to acid markedly decreased their power of the acid to decalcify tooth substance. Also that certain salivas may under certain conditions restore a partially decalcified enamel surface to apparent normality. All of which serves to impress upon us the importance of the combining powers of the saliva upon the process under consideration. We feel that we have but begun our work in this direction and unless it appears that our method is untrustworthy we intend to continue our electrolytic tests in the hope of obtaining further information. We wish to do further work with the weaker acids and bases, and also with acids of fermentation. We have done considerable work along these lines which will not be reported at this time, as we hope to add to our results and determine, if possible, their true values.

OTHER SUBSTANCES.

In addition to those substances which directly help or hinder the process of caries there are several others which may be of greater or less importance.

Of these the suggestion of Howe* that the presence of a large amount of phosphates increased fermentation, while the presence of chlorides inhibited, may be of direct import. In such a case the rate of fermentation would not depend so much upon the nature or amount of infection present as upon the character of the media upon which it grew, phosphatic or chloride.

So also the amount and fluidity of the salivary secretion may be taken into account. It has always been said that a copious flow of saliva is inhibitive to caries, and the lower incisors have been cited as cases of immunity produced by the continuous presence of saliva. In this regard, several cases have come under our notice in which the salivary secretions were unusually large and watery, and at the same time the teeth were exceedingly prone to caries.

Thus it would be possible to state numberless theories and possible factors which might enter into a consideration of this subject. We have given, however, those factors which seemed to us to be most important and most worthy of consideration. We have attempted to state each in a fair and unbiased manner, giving the more recent opinions upon the various subjects. Our conclusions have been drawn from personal observations and are but a statement of the present view which we now hold in regard to these matters, and which subsequently be changed by further work of those who are engaged in the study of this problem. The work which we have accomplished has served to impress us with the fact that the end is not yet, that the problem is a difficult one, and that further work should be put upon it, especially in the investigation of the nature and function of the plaque, the neutralizing power of the saliva, and the self-cleansing factors of the oral cavity.

*Jour. of Amer. Med. Assn., 1912, Page 2118.

*Dental Cosmos, Vol. 54, Page 567.