INCREASE OF BACTERICIDAL ACTION OF GERMICIDES BY VARIATION OF p_H.*

BY PAUL GOEDRICH.[1]

Whereas the bactericidal properties of acids and alkalies have been very well studied, very little is known about the combined action of acids and germicides.

It was our object to study the influence of organic and inorganic acids on the bactericidal effect of germicides from various angles to determine: *First,* if all types of commonly used germicides are influenced by a lowering of p_H; *second,* if this influence is in a direct proportion to the lowering of p_H; *third,* if the p_H alone is the deciding factor in this respect; *fourth,* how far the germicidal effect of acid is in itself responsible for a change in bactericidal efficiency; *fifth,* whether the increased action of low p_H solutions of germicides is restricted to one specific type of organism or applies to all of the most commonly found pathogenic organisms.

In order to investigate the degree of change in the bactericidal effect of germicides on various types of organisms by lowering the p_H of these solutions—as well as the action of the acids alone, the F. D. A. phenol coefficient technique was used at a temperature of 20 degrees Celsius.

For the determination of the p_H a glass electrode was used.

It was found that germicides of all commonly used types respond with an increased germicidal potency, when the p_H is lowered; this increase is much more marked in the lower p_H range, than in the higher ones. This is explained by the fact that it takes only a minute amount of acid to lower the p_H near the neutral point. For instance to reduce the p_H from 7 to 4.5 one needs to add only 1 cc. of a normal HCl solution to 30,000 parts of water p_H 7.

As there is ample evidence of the bactericidal action of acids we found it necessary to investigate whether or not the action of the acids themselves might not have been responsible for the found increase in germicidal effect of low p_H solutions of germicides. Solutions of organic and inorganic acids were tested bacteriologically at the same p_H as the germicides, acidified with the identical acid, and it was found that the germicidal effect of the acids themselves was always considerably lower than the action of the germicide, and on the other hand the combined action of the germicides plus the acids was found to be higher, far in excess of all proportions to the action of either one of the two components.

In regard to these findings it was interesting to investigate if the acid salts would not have a similar effect on the action of germicides. It was found that this is actually the case and a considerable increase in germicidal power resulted by the addition of acid salts to germicidal solutions.

This suggested experiments with acidified germicides plus the addition of neutral salts. It was found that the addition of neutral salts increases the efficiency of the tested germicides to a higher degree than acids alone.

A comparison of germ-killing effects of a given germicidal solution at a constant concentration and at a constant p_H revealed that sometimes less ionized acids or acid salts might possess better activating properties than higher ionized ones.

These findings point to the conclusion that it is not the p_H value alone which decides the effect of a given germicide, but that also a quantitative factor is involved, depending upon the particular acid or acid salt used. The influence of low p_H germicides is especially remarkable on spore-bearing organisms. This demonstrates itself clearly in the case of B. subtilis spores, which after being exposed for two hours to the influence of a regular 5% phenol solution showed no killing action, whereas an acidified solution of same phenol content produced a killing effect after ten minutes.

These tests were also made with different types of organisms, for instance: Cocci, B. Coli, B. Typhous, spore-bearing organisms and fungi. It was found that they all responded in the same way.

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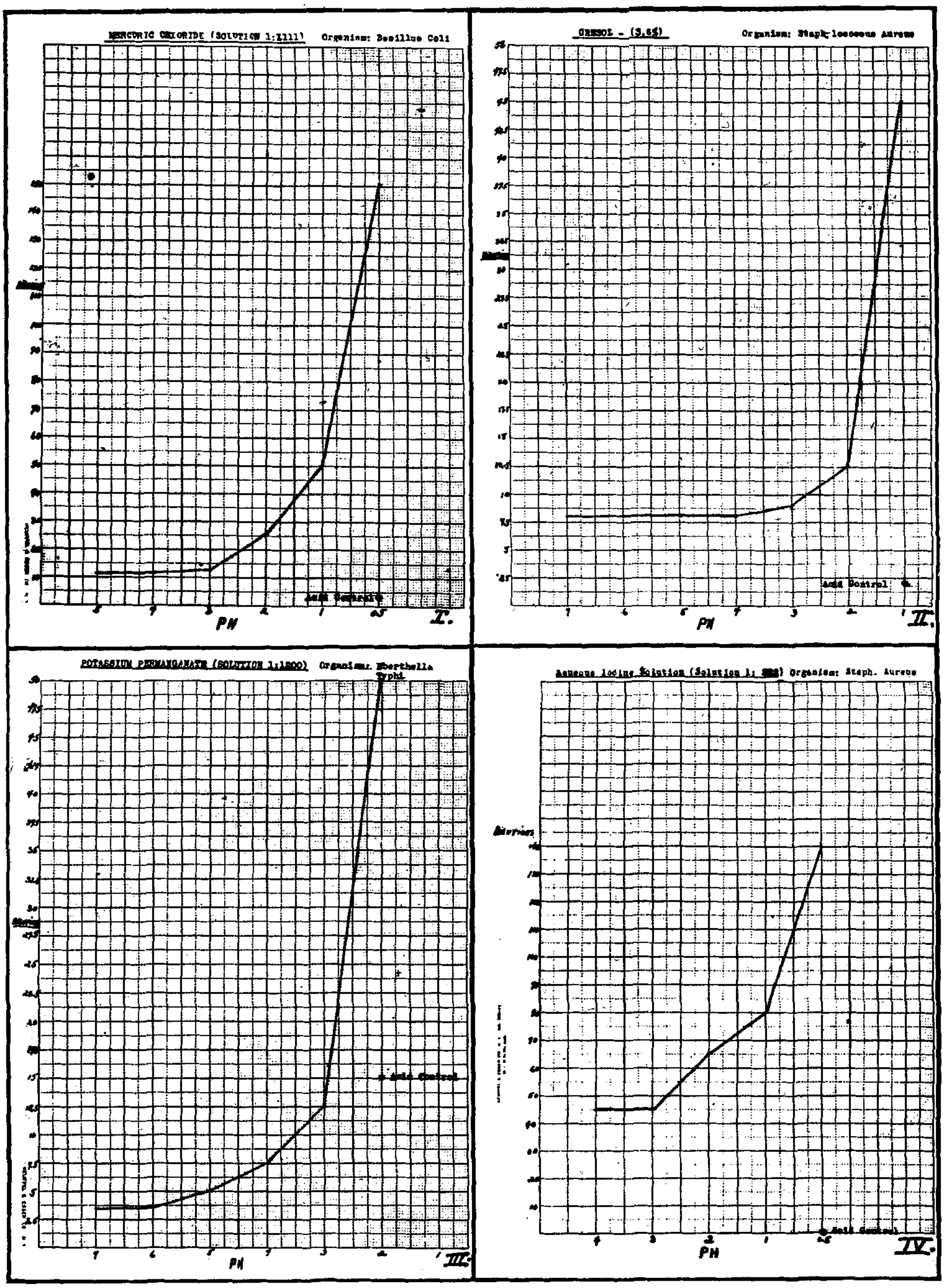

Fig. 1.—Mercuric chloride (solution 1:1111). This chart demonstrates the change in germicidal effect of a mercuric chloride solution of constant concentration at a range of p_H from 5–0.5. The test organism was B. coli. For the p_H adjustment HCl was used.

The increase starts at p_H of 4, it is very little marked at p_H of 3, is considerably higher at p_H of 2 and then ascends on a nearly vertical line up to a dilution of 1:150 at p_H of 0.5.

The p_H 5 solution was a non-acidified solution. As can be seen the mercuric chloride was germicidal under these conditions in a dilution 1:11.5 at p_H of 5, and 1:50 at a p_H of 1. A further decrease of half of one p_H brought the killing dilution up to 1:150. The subcultures were negative.

The used HCl solution at p_H of 0.5 showed an effect only up to a dilution of 1:3.5—that is essentially lower than the used mercuric chloride solution at a p_H of 5. So the germicidal effect of the acid was negligible.

Fig. 2.—Cresol (colloidal). For these tests a colloidal solution of 3.6% cresol was used. Oxalic acid was used for the adjustment of the p_H. The test organism was *Staph. aureus*. The concentration of the germicide was kept constant at the whole range of p_H from 1–7. We see here no influence of the lower p_H from 7–4. At this point a slight rise in germicidal power is noticeable which becomes more pronounced between p_H 4 and 3—and is at its height between p_H 2 and 1 with an increase in efficiency of more than 5 times compared with the effect of the same solution at a p_H of 7 or 4.

The used oxalic acid showed a germicidal effect only in a dilution of 1:2 parts of water at a p_H of 1.

Fig. 3.—Potassium permanganate (Solution 1:1200). For these experiments acetic acid was used to adjust the solutions to the various ranges of p_H from 2–7.

The test organism was the Eberthella Typhi. In this case we see the rise in germicidal effect already starting at a p_H of 6 which could be explained by the fact, that an acid content facilitates the liberation of oxygen from the permanganate and furthermore by the fact that acetic acid has in itself a comparatively high effect on *B. Typhosus.*

However this latter effect would reach its limits at a dilution of 1:15 at a p_H of 2, whereas the combined effect of this concentration of acid with the permanganate showed a killing action in a dilution of 1:50 at a p_H of 2.

Fig. 4.—Iodine (Solution 1:222). Hydrochloric acid was used to effect reduction in p_H, and *Staphilococcus aureus* was test organism. The range of p_H investigated was from p_H of 0.5–4.

We see here again the influence of the p_H starting with 3 but with a sharp turn upward with the germicidal effect raised about 50% at a p_H of 2 and nearly doubled at a p_H of 1, and further raised to an active dilution of 1:140 when the p_H was lowered to 0.5. An interesting feature of this example is that at the point where the activating effect of the acid on the disinfectant is shown at its highest, the acid alone did not display any germicidal influence at all.

Fig. 5.—On this chart the action of acidified solutions of phenol and lugol iodine solutions on *B. subtilis* spores is shown.

We see that a 5% lugol showed no spore killing effect on *B. subtilis* within 30 minutes, whereas the acidified solution showed a sporicide effect already between 5 and 10 minutes. To eliminate bacteriostatic action subcultures were made, which did not show any bacterial growth. The control with a HCl solution of the same strength as used for the acidification showed positive growth also after 30 minutes exposure.

The bacteriological tests with a 4.5% phenol solution on the same organism showed no effect even after 2 hours.

The acidified solution had a spore-killing effect between 10 and 15 minutes' exposure. Also in this case the subcultures were negative and the acid control was positive in all tests.

These experiments demonstrate the interesting fact that germicides, which do not possess any sporicide action in the used concentrations and diluted acids which likewise have no such effect, will, when combined, show a good germicide action.

Chart 5

THE EFFECT OF ACIDIFIED GERMICIDAL SOLUTIONS UPON THE SPORE-FORMING ORGANISM, BACILLUS SUBTILIS

PHENOL SOLUTION

Minutes	Phenol (4.5%)	Phenol (4.5%) plus 3.7% HCl	Subcultures	Acid Control 3.7% HCl
5	+	+		+
10	+	+		+
15	+	—	—	+
30	+	—	—	+
60	+	—	—	+
120	+	—	—	+

(+) indicates growth

(—) indicates no growth

LUGOL SOLUTION

Minutes	Lugol Solution (5%)	Lugol Solution (5%) plus (5.7%) HCl	Subcultures	Acid Control (1.8%) HCl
5	+	+		+
10	+	—	—	+
15	+	—	—	+
30	+	—	—	+

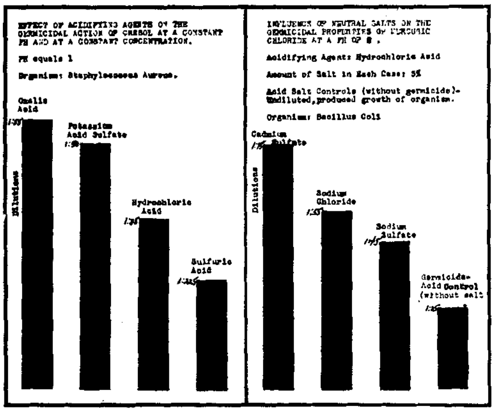

Fig. 6.—At the left side of this chart the influence of various acidifying agents on the germicidal action of a cresol solution at a constant p_H and a constant concentration of the cresol is seen.

Sulfuric acid shows the least activating influence, hydrochloric acid a much better one and acid salt-potassium-acid-sulfate about twice the action of sulfuric acid, and oxalic acid even a little more.

On the right side of this chart the influence of the addition of 5% neutral salts to an acidified mercuric chloride solution at a constant p_H is demonstrated.

As can be seen in all cases the addition of neutral salt resulted in an essential activation of the germicidal effect. The first column serves as a control and indicates the effect of the acidified germicide without addition of salt. Sodium chloride shows a better effect than sodium sulfate, and cadmium-sulfate shows a 3 times higher action than the control.

The controls with acidified solutions of the same salts (without the addition of the germicide) produced bacterial growth when tested under identical conditions.

So far as the practical application of these results is concerned the action of low p_H solutions on the skin and in open wounds has to be considered first.

It is not so widely known that the human skin itself has a p_H on the acid side—the average p_H being 4.5. It was found that even the very delicate mucous membrane of the eye bag of a rabbit can stand easily the influence of a $N/10$ HCl solution which has a p_H of about 1, without any immediate or later damage.

Our experiments have demonstrated that germicidal solutions of very low p_H are already restored to a p_H near to neutrality within one minute when applied to deep incisions on an animal's body, and no corrosive action which could be attributed to the low p_H could be found.

It seems to be a fact that the defensive mechanism of the human- or animal-body against acids is very highly developed.

An addition of protective colloids to acidified germicides has been found to be very beneficial, and solutions of this kind are also practically painless when applied to open wounds. Halogens and Peroxide on account of their high vapor tension are not influenced by the presence of colloids.

The action of lower p_H on various well-known proprietory disinfectants has also been investigated and similar results have been obtained.

SUMMARY.

1. Commonly used types of germicides respond with an increased germicidal effect, when their p_H is lowered by the addition of acid or acid salts.

2. This effect is not in a direct proportion to the p_H of the germicidal solutions and varies with the chemical structure and quantity of the used acids or acid salts.

3. The increased action of low p_H solutions of germicides is not restricted to any specific type or kind of organism.

4. At a constant p_H and a constant concentration of a germicide different acids show a different degree of activation of the germ killing effect which seems to be independent of the ionization of the used acids.

5. Acids or acid salts possess an activating effect on germicides which is far out of proportion to the action of the used acids or germicides alone.

6. Solutions of germicides, especially in the presence of colloids are not rendered more destructive to the skin by even a considerable lowering of their p_H.

7. Neutral salts added to germicides of lowered p_H show an appreciable activating influence on the germicidal effect.

At the conclusion of this paper I want to mention that this is a preliminary report only. Much more experimentation has been done on this subject than could be recorded and other experiments are under way. A more complete report will be presented at another occasion.

READING THE PROFESSIONAL PHARMACIST SHOULD DO.*

BY J. K. ATTWOOD.[1]

The title of this paper is, in a sense, incorrect. It should be "Reading the Professional Pharmacist Must Do If He Is to Maintain His Position as a Professional Pharmacist." With the rapid separation of professional Pharmacy from commercial Pharmacy there is developing keener competition among the professional pharmacists not on a price basis but on the basis of the ability to furnish intelligent pharmaceutical information and service to the physician and customer.

There have been works written on the art of thinking, and the importance of living, and there is certainly an art in reading drug journals. I have been attempting to acquire the art for the past quarter of a century and am still trying. Most of you present, who are in the retail drug business, are professional pharmacists and we are all more or less faced with the same problem—trying to get as much information as possible from our reading. The *Reader's Digest* has saved us many hours in our lay reading. I do wish that there were available a Pharmacist's Digest of current pharmaceutical journals, not that I mind reading a lengthy article describing a new drug which goes into all the details of its development and various experiments to determine its biological value, but because what we all want and need is the greatest amount of information in the fewest words and the final results of all the experiments, just facts. We do not read drug journals for the beauty of composition.

Most of us take about the same number of journals. I take more than half a dozen regular drug journals, two medical journals, the medical digest, one toilet goods and one trade journal. If one would attempt to read these in their entirety there would be no time left for any outside reading. The method I have used with some success is as follows: I take the journals home and peruse them, then I read the articles on new products and new procedures in compounding and some articles on salesmanship, and other articles of particular interest to me and my business. Occasionally I read an article about the methods used in foreign countries, which is really of no particular value for application but which is very interesting. Those that I feel that my prescription men should read I indicate by page number and initials of the persons to whom it will be of interest. The articles on toiletries I mark with page number and initials of girls in the Toilet Goods Department. Articles on collections I mark with the initials of the office manager. These two

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