Colorimetric Determination of Salicylic Acid

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During a study of the stability of various salicylic acid derivatives, it was necessary to follow the decomposition reactions by determining the free salicylic acid produced. Because of various interferences, direct ultraviolet determination appeared impractical. It seemed advisable, therefore, to attempt to make use of the well-known ferric ion-salicylic acid reaction.

Two recent reports concerning the stability of aspirin describe modifications of the A.O.A.C. procedure (1) for salicylic acid. These reports concern the use of ferric alum reagent in reaction systems containing 50% ethanol (2) and the same color developing material in aqueous solutions adjusted to pH 2.63 (3). Both modifications appeared unsatisfactory for our need because of the very low concentrations of salicylic acid used. The resulting low absorbance values, on an instrument such as the Beckman model DU spectrophotometer, appeared to allow too great a chance for inaccuracy and imprecision.

Since it seemed probable that the low concentrations of salicylic acid (1–2 mg./100 ml.) were used in an effort to maintain fidelity to Beer's law, we were interested in determining if the method could be improved to permit use of higher concentrations of salicylic acid. The following summarizes our studies concerning the effect of ethanol concentration and the relative usefulness of ferric chloride as compared to ferric alum.

EXPERIMENTAL

Reagents.—Salicylic acid U.S.P.; absolute ethanol, reagent; ferric chloride hexahydrate, Merck reagent; ferric alum, Merck reagent.

Procedure.—Standard solutions of salicylic acid were prepared using absolute ethanol as the solvent. Aliquots of these solutions were then transferred to 100-ml. volumetric flasks, the desired amounts of the ferric chloride or ferric alum solutions were added along with additional ethanol, when desired or necessary, and the solution brought to 100 ml. After 15 minutes the color was read at 532 mμ against a suitable reagent blank. All readings were made on a Beckman model DU spectrophotometer using the tungsten lamp.

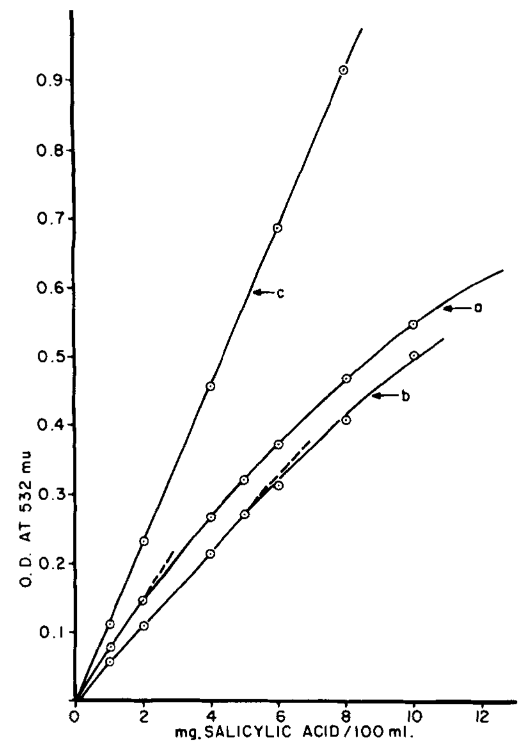

Fig. 1.—Plots showing the effect of ethanol and ferric alum concentration on the iron-salicylate reaction; 5 ml. ferric chloride (1%) in 50% ethanol system.

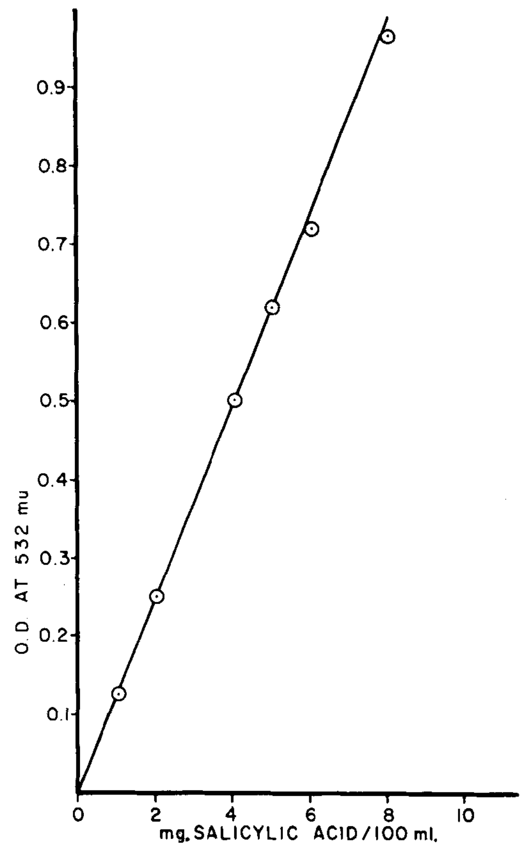

Fig. 2.—Plot showing the value of ferric chloride in gaining adherence to Beer's law despite a high ethanol concentration; 5 ml. ferric chloride (1%) in 50% ethanol system.

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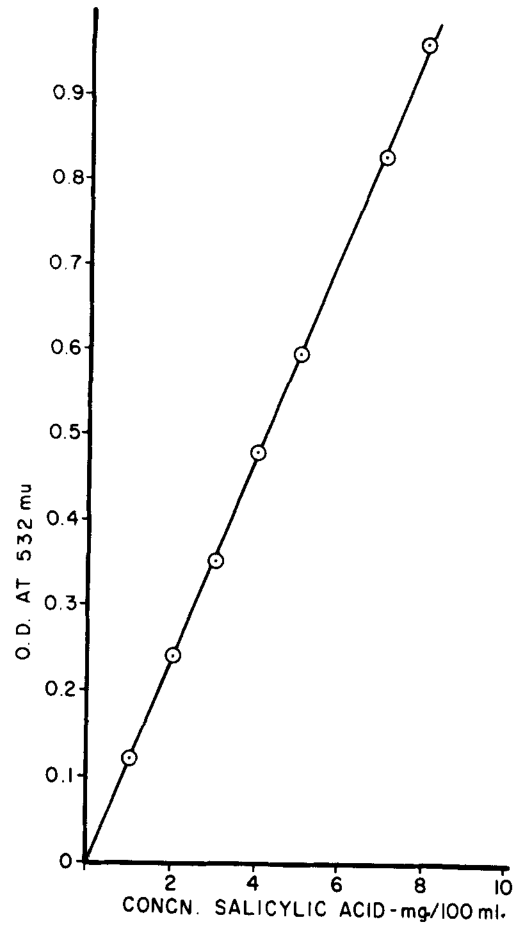

Fig. 3.—Plot showing ferric chloride to be only barely affected by ethanol concentration in the color reaction with salicylate (compare with Fig. 2); 5 ml. of 1% ferric chloride in 10% ethanol system.

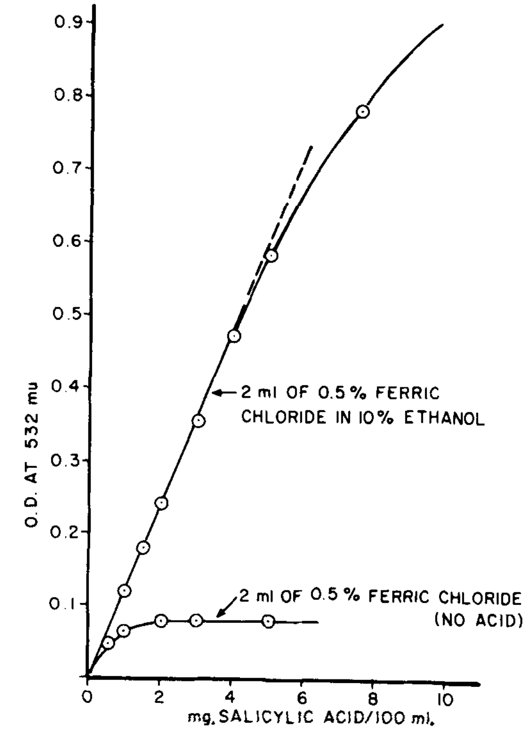

Fig. 4.—Plots showing the importance of suitably high concentrations of acid for good development of the iron-salicylate color.

DISCUSSION

As shown in Fig. 1, curve A, the use of 2 ml. of a 2% solution of ferric alum in a system containing 50% ethanol gives but limited adherence to Beer's law. Somewhat greater fidelity is achieved by increasing the amount of reagent added to 5 ml. per 100 ml. of reaction mixture (curve B). The best adherence to linearity is obtained, however, when the ferric alum reagent is maintained at 5 ml. and the ethanol concentration is reduced to 10% of the final volume (curve C). Indeed, this last modification provided not only good linearity but apparently increased the efficiency of the reagent considerably. By increasing the amount of ferric alum and reducing the alcohol concentration, sufficiently high concentrations of salicylic acid can be used so that absorbance readings in the region of maximum accuracy and precision are easily attainable.

Since some studies might require the use of sufficient ethanol to make the use of ferric alum undesirable, we studied the usefulness of ferric chloride to develop the characteristic color. This material is given as an alternate for ferric alum in the A.O.A.C. method (1). Solutions containing 0.5 and 1.0% ferric chloride in 0.1 *N* hydrochloric acid were used for color development.

As shown in Fig. 2, the use of 5 ml. of 1.0% ferric chloride in a system containing 50% ethanol provided good adherence to Beer's law. By reducing the ethanol concentration to 10%, linearity is extended to higher concentrations of salicylic acid. This is demonstrated in Fig. 3.

When the 1.0% solution of ferric chloride is replaced with a 0.5% solution, Beer's law is obeyed up to a concentration of 5 mg. of salicylic acid per 100 ml., as in Fig. 4. Although this is useful from a practical viewpoint, the use of a 1.0% solution of ferric chloride seems preferable.

The lower curve in Fig. 4, obtained with a 0.5% aqueous solution of ferric chloride (no added acid) convincingly demonstrates the necessity of an acid system for suitable color development.

CONCLUSION

On the basis of these studies, it may be concluded that ferric chloride is preferred to ferric alum as a reagent for the colorimetric determination of salicylic acid. If the latter must be used, the ethanol concentration should be kept to a minimum. In either case, preparation of the reagent in acid solution is mandatory for proper color development.

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