THE PROTECTIVE ACTION OF SOAPS ON ZSIGMONDY'S GOLD SOLS

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Zsigmondy has shown that in aqueous solution a soap can act as a protective colloid towards a gold sol. The object of the present investigation was to extend these results, since a special interest attaches to the study of the protective action exerted by electrolytic colloids, and in the particular case of the soaps. The effects due to a number of substances of similar type can be compared.

The gold sols were usually prepared by the nucleus method of Zsigmondy, whilst the soaps were prepared from the carefully purified acids whose alcoholic solutions were neutralized by the requisite amounts of alcoholic sodium or potassium ethylate. The soaps then obtained were recrystallised from alcohol and carefully dried. In the present work the expression "gold number" has the meaning attached to it by Zsigmondy, *i. e.*, the number of milligrams of soap (or other protective colloid) just sufficient to protect 10 cc. of the red gold sol against colour change produced by the addition of 1 cc. of a 10 per cent NaCl solution under specified conditions. The greater the gold number, the less is the protective action due to the colloid. These numbers have been determined for a series of soaps at different temperatures and concentrations. Within the limits of the experimental error of the measurements and with the soap concentrations employed, the gold number of a given soap solution was not found to vary with time during the period required for a long series of measurements (see later).

Table I shows the influence of the concentration of a sodium oleate solution on the gold number towards three gold sols. In making these measurements 10 cc. of the gold sol were mixed with the requisite amount of soap solution and enough water added to make the volume up to 15 cc. After 3-4 minutes 1 cc. of the 10 per cent NaCl solution was added and the whole well mixed. The colour of the sol was observed after 15 minutes.

TABLE I

Sodium Oleate. Temp. 17°-18°

Concentration of soap solution in grams per 100 cc.	Gold Numbers Sol A	Sol B	Sol C
1.0	1.0	1.0	0.5
0.1	1.4	1.2	1.0
0.01	—	—	1.5

Sol C was a relatively coarse-grained sol prepared by the formaldehyde method without nucleus. Sols A and B have the same gold content and were prepared by the nucleus method, but Sol A contains smaller particles than Sol B. The results in this table show that increase in the concentration of the soap increases its protective action to a certain degree. To secure comparable results the soap solutions used in the following measurements possessed concentrations varying from 0.1 to 0.2 grm. of soap per 100 cc. of solution. The effect of the size of particle in the gold sol on the gold number for a definite soap solution is shown in Table II. In the sols D, E, F, A the size of particle increases regularly from D to A whilst all the sols have the same gold content. The graded sizes were prepared by varying the amount of nucleus solution added to the gold solutions before their reduction. Sol A was prepared by the formaldehyde method. The concentration of the sodium oleate was 0.1 grm per 100 cc.

TABLE II

Temp. 17°-18°C

Sol	D	E	F	A
Gold number for sodium oleate	0.4-0.5	0.7	1.1-1.2	1.0-1.4

Table II shows that the gold number increases with increasing size of particle of the gold sol. During periods of time up to at least 13 days, the soap solutions (preserved at room temperature, 17°-18°C) gave the same gold numbers towards a particular gold sol, as shown by Table III.

TABLE III

No. of Days	1	2	4	6	13
Gold number for sodium oleate	1.0	1.0	0.9-1.0	1-1.1	1.1
Gold number for sodium stearate	2.5	2.5	2.5	2.6	2.5

The concentration of the soap solutions were 0.1 grm. per 100 cc. of solution

Table IV shows the gold numbers towards a given gold sol for a number of different soaps at a series of temperatures.

TABLE IV

Soap	0	14°C	40°C	60°C	75°C	100°C
Sodium and potassium laurates (slightly acid solution)	—	12-14	—	10	—	—
Sodium myristate	—	10-12	—	7.5-8.5	—	1-0.9
Potassium myristate	—	12	—	8.5	—	1.2-0.9
Sodium palmitate	—	1.8-2	—	0.3	—	0.2
Potassium palmitate	—	2-2.2	—	0.3	—	0.3
Sodium stearate	—	3.0	—	0.6	0.5	0.4-0.3
Potassium stearate	—	3.8	0.4	0.3	—	0.2-0.1
Sodium oleate	1.25-1.3	1.0	0.5	—	0.3	0.2
Potassium oleate	1.4	1.2	—	—	1.0	0.9
Sodium linoleate	—	1.0	1.4	—	—	3.0
Potassium linoleate	—	0.82	—	—	0.9	1.8-1.6

Slightly alkaline solutions of the alkali salts of lauric acid do not show any marked protective action but a very slight one is observed in neutral or acid solution. It is of great importance to note in connection with these results that if a comparison is to be made between different soaps it is necessary to prepare them all in a neutral condition, the slightest excess of acid or alkali having a very great influence on the results.

The variation of the "gold numbers" with the concentration of the electrolyte has been determined for two soaps. As is to be expected, the number of milligrams of soap required to protect the sol increases with increase in the concentration of the electrolyte, the increase being at first rapid and then becoming slower. These results are shown in Table V. The numbers indicate the milligrams of the soap required for protection.

TABLE V

Temperature 17°-18°C. Total volume in all cases, 15 cc.

cc. of 10 per cent NaCl solution added to 10 cc. of gold sol	0.5	1.0	1.5	2.0	2.5	3.0	3.5
Potassium linoleate	0.35	0.8	1.8	2.7	3.9	5.4	7.5
Sodium oleate	1.0	1.2	1.3	1.5	—	Solution turbid	

General Discussion of Results

With the exception of the linoleates, all the soaps used exert a greater protective action at higher temperatures as is shown by the marked diminution in the gold number with rising temperature. McBain and his co-workers, from a study of the lowering in vapour-pressure and the electrical conductivity, have concluded that the ionic micelles of the soap decrease in size with rise in temperature. The increase in mobility (and possibly in number) of the ionic micelles with rise of temperature together with the increase in thermal agitation of the soap micelles and the gold particles may therefore be connected with the increase in protective action (viewed from a kinetic standpoint). The results in Table IV show that there is no very marked and general regularity between the protective actions of the sodium and potassium salts of the same acid. Potassium linoleate, however, seems to have a higher protective action than the corresponding sodium salt.

The gold numbers of the soaps show that on the whole they can be arranged as follows as regards their protective action at room temperature:—linoleate > oleate > palmitate > stearate > myristate > laurate. There is a variation, however, with temperature, and the nature of the alkali cation also exert an influence. It was found that the addition of alkali increases the gold number (and therefore lowers the protective action of the soaps.) This was found to be very marked in the case of the laurates, which in neutral or slightly acid solution show only a relatively small protective action.

If we adopt the theory of Spring, that the washing power of a soap is related to its power of forming "adsorptive compounds" with the dirt particles, it is probable that the relative washing powers of soaps will be connected with their relative protective actions toward a gold sol.

The thanks of the author are due to Professor F. G. Donnan for having suggested this work and for his kind interest and advice.

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