CCCXXXVI.—*Scattering of Light by Stannic Oxide Sols.*

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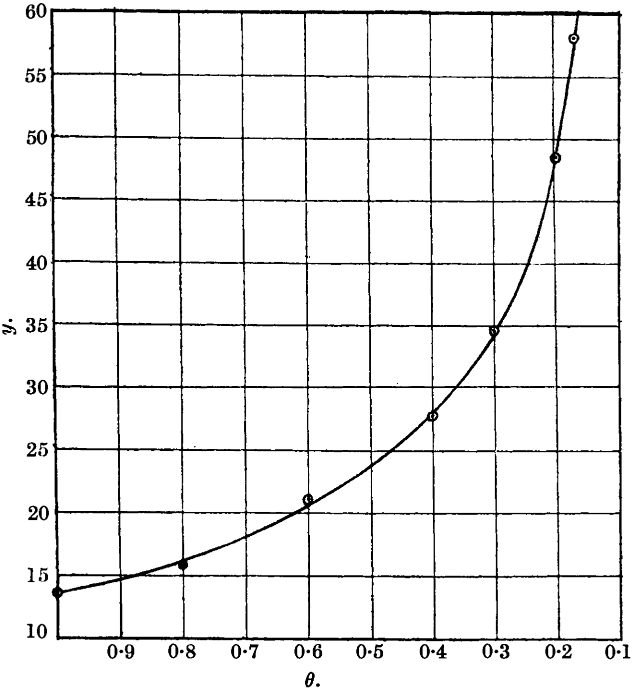
THE author recently found (this vol., p. 2296) that as increasing amounts of alkali are added to a stannic oxide sol, its turbidity diminishes at first and then increases, although the amount of diffusible stannic oxide increases continuously. It was therefore thought desirable to investigate the relation between turbidity and the ratio $SnO_2 : Na_2O$.

For non-conducting particles having a small coefficient of absorption of light, the intensity of scattered light is given by Lord Rayleigh's expression $I = K_0nr^6/\lambda^4$, where K_0 is a constant depending on the intensity of the incident beam, the refractive indices of the liquid and of the disperse phase, and the angle of observation of the scattered light, n is the number of particles per unit volume, r their radius, and λ the wave-length of the incident light. If C be the concentration (mass per unit volume) and ρ the density of the particles of the disperse phase, then $C = 4\pi r^3 n\rho/3$, and therefore $I = KCV/\rho\lambda^4$, where K is another constant and V is the volume of a particle. Mecklenburg (*Kolloid-Z.*, 1915, **16**, 97), using Odén's sulphur sol, found that Rayleigh's formula was only valid for particles having diameters within the limits 5—95 μμ. More recently, Bechhold and Hebler (*ibid.*, 1922, **31**, 70) examined the light scattered from barium sulphate particles, and found the equation to hold for particles of diameter up to 800 μμ but not above.

FIG. 1.



In the experiments now described, a Klett colorimeter nephelometer was used to compare the intensities of the light scattered by the different sols. The light from a 100-watt lamp, after passing through a cover-glass and condenser lens, fell on two cups, one containing the standard and the other the sol. The plungers were blackened on the outside, and the cups at the bottom. By keeping the position of the standard fixed and raising or lowering the other cup, the depth of the illuminated layer of sol, and hence the intensity of light scattered by it, can be matched with the standard.

For the calibration of the apparatus a stock stannic oxide sol, prepared 5 months previously and having $SnO_2 : Na_2O = 16 : 1$, was diluted to definite fractions of its original concentration and used immediately after dilution. It is assumed that dilution does not affect V, but only the value of C, for when the calibration was checked by using a sol having $SnO_2 : Na_2O = 2$, the results were the same. The data are plotted in Fig. 1, in which y represents the depth of the illuminated layer of the sol and θ the concentration referred to the standard as unity. From this curve the relative concentration of an unknown sol can be found.

It has been shown (Ghosh, this vol., p. 2298) that even at the lowest ratio of $SnO_2 : Na_2O$ investigated, the amount of diffusible stannic oxide in a sol does not exceed 19%. Hence in these sols, when their total stannic oxide content is fixed, the amount of colloidal matter may be taken to be approximately constant, and if the sols give different values of y when their alkali content alone is altered, then the corresponding concentrations may be taken as a rough measure of the variation of the volume of the particles.

In these experiments two standards, A_1 and A_2, were used, their concentrations being in the ratio 1 : 0·31; the former was obtained by diluting 50 c.c. of the stock sol to 250 c.c. and storing it for 15 days before use. In Table I, y_s and y represent the scale readings of the standard and of the sol respectively, θ_1 (or θ_2) the corresponding concentrations referred to A_1 (or A_2), and R the ratio of $SnO_2 : Na_2O$ in the different sols, which were used 4 days after their preparation.

TABLE I.

	Standard A_1			Standard A_2	
$y_s = 20.$	($SnO_2 = 15$ g./l.).		$y_s = 20.$	($SnO_2 = 7·5$ g./l.).	
R.	y.	θ_1.	R.	y.	θ_2.
7·7	42·5	0·37	7·7	29	0·61
5·4	44·5	0·35	5·6	29·5	0·60
4·2	47·2	0·33	4·35	30·5	0·57
3·3	48·5	0·32	3·57	30·5	0·57
2·9	45·8	0·34	2·78	30·0	0·58
2·4	42·2	0·37	2·44	28·8	0·61
2·15	32·5	0·52	2·17	27·8	0·65
1·94	23·5	0·81	1·87	27·0	0·68
			1·45	17·0	1·21

Table II gives the results of some experiments in which potassium hydroxide was used instead of sodium hydroxide; R_1 represents the ratio $SnO_2 : K_2O$ in the sol.

TABLE II.

$y_s = 40$.	Standard A_2 (SnO_2 = 30 g./l.).		$y_s = 40$.	Standard A_2 (SnO_2 = 30 g./l.).	
R_1.	y.	θ_2.	R_1.	y.	θ_2.
7·7	38	1·06	1·5	40	1·00
6·1	38	1·06	1·2	40	1·00
4·0	40	1·00	1·0	40	1·00
2·7	42	0·94	0·5	30	1·47
1·9	40	1·00			

It will be seen from the above data that as the value of R diminishes, the corresponding value of θ_1 or θ_2 also diminishes, reaches a minimum, and then increases; the minimum is more pronounced in the sols of higher stannic oxide content than in those of lower, but in both cases it is reached when R lies between 4 and 3. The sols containing potassium hydroxide do not show any appreciable variation in θ_2 when R_1 is reduced from 7·7 to 1·0, but θ_2 increases with further diminution of R_1.

It is generally believed that on continued addition of alkali to the colloidal solution of an acidic oxide, such as silica or stannic oxide, the particles become more finely divided and finally tend to pass into the state of molecular solution. This has been actually observed in sodium silicate solutions by Ganguly (*J. Physical Chem.*, 1926, **30**, 706; 1927, **31**, 407) and by Harman (*ibid.*, 1925, **29**, 1155; 1926, **30**, 359, 917; 1928, **32**, 44). The above data show clearly that the colloidal particles in a stannic oxide sol begin to coalesce when the ratio $SnO_2 : Na_2O$ is below a certain value. At the same time, however, the amount of sodium stannate (simple or complex) steadily increases (compare Ghosh, *locc. cit.*). The behaviour of stannic oxide towards alkali is therefore not in accord with the general view. The increase in the concentration of the diffusible stannic oxide may be accounted for by two assumptions, either (1) that the aggregation of the colloidal particles leads to the liberation of some of the stannate ions previously adsorbed by them, or (2) that with increasing proportion of alkali the bigger colloidal particles become aggregated whilst at the same time the smaller ones become further subdivided. It is known that the bigger particles of Odén's sulphur sol coagulate more easily than the smaller. A stannic oxide sol as ordinarily prepared consists of particles of different sizes; hence the second assumption is the more probable.

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