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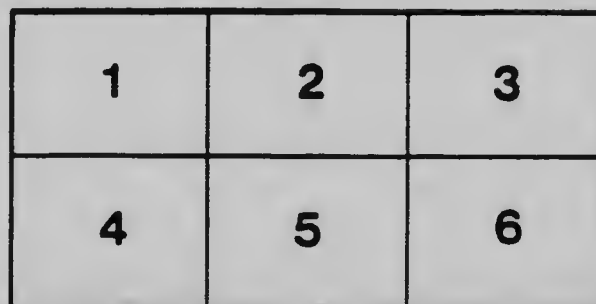
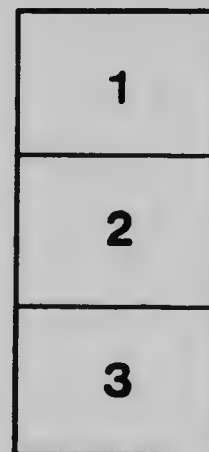
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No. 59: PERIODIC PRECIPITATION, BY MISS A. W. FOSTER

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Periodic Precipitation

By MISS A. W. FOSTER, M.A.

University of Toronto

Presented by PROFESSOR E. F. BURTON, Ph.D., F.R.S.C.

(Read May Meeting, 1918.)

One of the most interesting physical properties of colloidal particles in hydrosols (aqueous colloidal solutions) is the possession of an electrical charge. When an emulsoid such as gelatine is added to the hydrosol the particles still retain their peculiar charges, as is shown by their motion in an electric field. On addition of electrolytes to the hydrosol (without added gelatine), the charge on the particles is lessened and coagulation of the particles takes place. This discharge of the particles is thought to be due to the absorption by the charged colloidal particles of the added ions, which bear a charge opposite in sign to that on the colloidal particle.

The purpose in undertaking the experiments detailed herewith was to find whether colloidal particles in a matrix of solid gelatine still absorbed ions in the same way. The phenomenon of Liesegang rings was chosen in order to demonstrate the results.

The Liesegang phenomenon is the name given to periodic precipitates in some sort of gel produced by the diffusion of some reagent placed upon the gel. The first mention of the phenomenon has been attributed to Runge and also to Boehm, but it is due to Liesegang that the subject has come into prominence. Chemical precipitates of many different substances possessing a certain periodicity have been obtained by the diffusion of different reagents in gels containing various solutes.

In the present experiments the Liesegang rings were formed by the action of silver nitrate on a thin sheet of solid gelatine, which has been impregnated with a small quantity of potassium chromate. To a 4% gelatine solution was added potassium chromate to make up 1/200 gram molecular weight per litre. Two ccs. of this solution was poured on a glass plate (3¼" x 4¼") kept perfectly level and after the gel had set, that is, at the expiration of an hour or more, a drop of 10 gram molecular weight per litre of silver nitrate solution was dropped on the centre of the gelatine film. The resulting ring

formation is shown in Fig. 1, with magnification $1\frac{1}{2}$ times, and in Fig. II (mag. 25).

The colloidal solution chosen for these experiments was a Bredig copper hydrosol formed by making an arc under pure water with two copper wires in series with a resistance in a 110 volt circuit. As these copper particles bear a positive charge they would absorb from a solution of potassium chromate some of the chromate (negatively charged) ions.

Any theory explanatory of the Liesegang rings presupposes that the potassium chromate is originally equally distributed through the gelatine. The addition of copper colloidal solution to the gelatine containing traces of potassium chromate would alter the continuity of this distribution, if the copper particles strongly absorb the chromate ions. One would expect under these circumstances that the rings would not form.

Gelatine solutions were made up similar to those used to produce the rings shown in Figs. I and II, with the exception that a quantity of copper colloidal solution was used in place of water. If the gelatine solution was poured out as soon as the copper colloidal solution was added, concentric rings like those shown in Figs. I and II were produced in films made from both these preparations, but if the films were made several hours after the addition of the colloidal copper, the precipitate was in the form of microscopic quantities scattered over the plate around the central portion, some being gathered into piles, so that the whole area presented a blotchy appearance under the low power microscope. (Fig. III.)

It is evident from these results that the positively charged copper particles, as would be expected, do combine with the negatively charged chromate ions, for the nature of the precipitate is entirely changed when they are present. These results would also indicate that a certain interval of time is necessary for the diffusion of the copper particles through the gelatine solution and the formation of the copper-chromate aggregates.

The same idea was carried out with agar solutions. The agar was prepared by washing and boiling and straining, and the solutions were made up as were those containing gelatine. The phenomena observed are shown by micrographs. Fig. IV shows the outer boundary of the precipitates formed by the diffusion of a drop of a solution of ten gram molecular weight of silver nitrate per litre in a 1% agar solution containing one one-hundredth gram molecular weight potassium chromate per litre, and Fig. V shows the formation when copper colloidal particles are present in the same chromate-bearing agar solution. Some films containing only chromate showed

a slight border, but the corresponding films containing copper gave a much more marked effect. It may be that the agar solution reaches, on account of its increased rate of solidifying, a state in which further diffusion is prevented more quickly than the simple chromate agar solution, thus causing a concentration of the silver chromate precipitate at the diffusion boundary. It would appear that the protective action of the agar on the chromate is such that the presence of the positively charged copper particle does not change the character of the precipitate as it does in the gelatine.

References: Liesegang: *Zs. phys. chem.* 88, 1914.

Ostwald: *Zs. phys. chem.* 32, 1897.

Morse and Pierce: *Zs. phys. chem.* 45, 1903.

Stansfield: "Retarded Diffusion and Rhythmic Precipitation," *Am. Jour. Sci.*, Vol. XLIII, Jan. 1917, pp. 1-26.



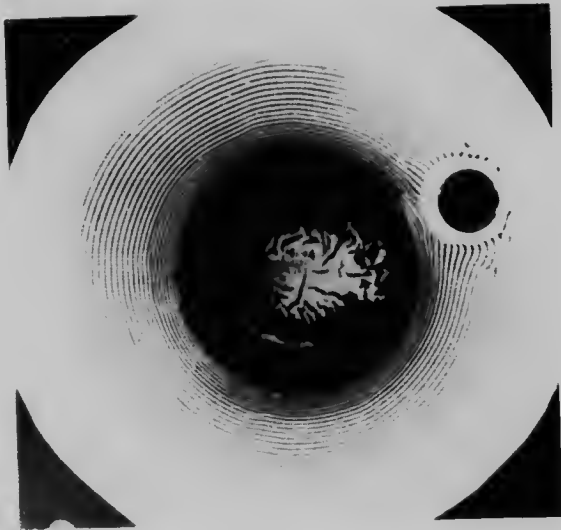


Figure 1. Rings formed by Silver Nitrate diffusing into gelatine containing Potassium Chromate.



Figure 2. Part of figure 1 with higher magnification.

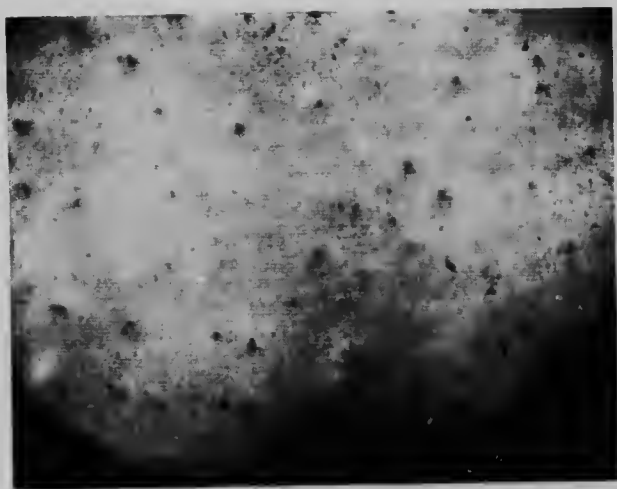


Figure 3. Precipitate formed in gelatine which had been impregnated with Copper colloidal solution.





Figure 4. Precipitate formed by same chemicals as above in agar-agar.



Figure 5. Same as figure 4 except that the agar-agar had been impregnated with copper colloidal solution.



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