Beaded Silica Films.

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Suctorial Organs of the Blow-fly.

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I.—On certain Beaded Silica Films Artificially Formed.

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PLATE LXIII., AND UPPER PART OF LXIV.

ON a former occasion the writer called the attention of the Society to the large number and variety of beaded patterns that could be obtained by making the artificial diatoms of Max Schultze. In forming these objects silicic fluoride gas is allowed to come into contact in its nascent state, with cotton filaments moistened with water. The result is a deposition of silica in the shape of irregular vesicles, the walls of which exhibit beaded structures in definite patterns; the beads in different, and in similar patterns, varying greatly in size; and many of the patterns being composed of two or more sized beads, usually symmetrically arranged.

When the silica in this gaseous state comes into contact with water, in a mass instead of being distributed in finely divided portions adhering to absorbent filaments, it is deposited in amorphous particles, which, when magnified, exhibit numerous flaws, but no regular structure. It seems as if the passage from the gaseous to the solid state was too sudden and violent for any definite pattern to be formed. In like manner when silica is precipitated from its alkaline salts, or "water glasses," dissolved in water, only angular amorphous particles are obtained, and a similar result follows the gradual drying up of a dialyzed solution of silica in water, as the

DESCRIPTION OF PLATE LXIII., AND UPPER HALF OF PLATE LXIV.

FIGS. 1 and 2.—Cellular aspects of films $\times$ with Powell and Lealand's $\frac{1}{3}$ th objective.

FIGS. 3, 4, 5.—Organic forms in some films—the framework of the cells probably composed of minute coalescing beads. They were most favourably situated for resolution.

FIG. 6.—Upper figure, branching fungoid-looking threads common on films; lower figure, similar threads resolved into beads.

FIG. 7.—Forms like 6 frequently found on thin films as if sprouting from them, highly magnified with Powell and Lealand's $\frac{1}{3}$ th.

FIG. 8.—Remarkable specimen of the same.

The above figures are copied from drawings of the objects made by Dr. Anthony, F.R.M.S., and kindly presented to the author.

films, or nodules, thus obtained easily separate by friction into the same sort of particles.

To obtain any silica deposition of a structural character, it was thought necessary to place some retarding influence in the way of the precipitation of the mineral from the gaseous combination above mentioned, and for this purpose a mixture of glycerine and water was tried and found to answer. The materials for making the gas, powdered glass, or flint, powdered fluor spar and sulphuric acid, were shaken up in a small flask supplied with a glass exit-pipe about $\frac{3}{16}$ " in diameter. This apparatus was placed upon a retort stand, so that it was easy to hold an evaporating dish in the right hand and immerse the end of the exit-pipe in the glycerine and water it contained, while the left hand was at liberty to regulate the heat and rate of formation of the gas by approximating or withdrawing a spirit lamp from beneath the flask, as the case required. A little mercury was placed at the bottom of the evaporating dish in order that the end of the exit-pipe might be dipped under its surface, if at any time the deposition of silica became so rapid as to threaten to stop it up. By allowing the gas to come over at a moderate rate, and letting the tip of the exit-pipe dip just under the surface of the water and glycerine, a number of thin films were quickly formed, some of great tenuity, and others thicker, but all avoiding anything like aggregation into lumps.

These films were easily taken up by a small sable brush, placed on a glass slide and washed to remove the glycerine, with successive drops and small streams of water. In doing this, care is necessary not to let the water-stream float them away, or create confusion by carrying one film on the top of another. When freed from glycerine the films can be examined in clean water under glass, or allowed to dry perfectly and then mounted in balsam, the latter being the most convenient. A slide thus prepared will probably contain films of different thicknesses, some perhaps consisting of a single or double layer of beads evenly and closely arranged, and others having more bead layers, and the upper ones either in confused groups or in approximately regular patterns. If the films are in either of the last conditions, transparent illumination with oblique light often exhibits nothing but confusion, and with small pencils of direct light, obtained with the smaller stops of a condenser, an organic aspect is frequently noticeable, as if a number of dingy bacteria-like, fungoid, or small bodies were growing upon some base. Pl. LXIII., Fig. 1, gives a good idea of this appearance in the case of a film tending towards a cellular structure. In Fig. 2 the cellular structure is more distinct, as shown in other films. Figs. 3, 4, 5, exhibit simulations of organic cell forms, and might be taken for veritable results of secretions and depositions occurring in the processes of organic life, but the cell hollows are referable to the bursting of minute gas-

bubbles. A little gentle violence will displace some of the bacteria and fungoid-like bead groups. Fig. 6 group shows a spurious fungoid portion, only partially resolved into beads; another portion perfectly resolved. Figs. 7 and 8, remarkable forms seen with $\frac{1}{16}$ th.

I am indebted for the beautiful drawings of these objects illustrating this paper to Dr. Anthony, whose skill both as an observer and artist is well known to and highly appreciated by his brother Fellows of this Society.

The size of the silica spherules forming the films varies, but less so than might at first be supposed, as only those that are favourably situated and carefully illuminated can be distinctly resolved and separated from their neighbours. In two slides Dr. Anthony found most to be about $\frac{1}{1000000}$ " in diameter, and some close upon $\frac{1}{1000000}$ ". In a slide sent to Dr. Pigott, he found them to vary from between $\frac{1}{1000000}$ " to $\frac{1}{1000000}$ ", and "had no doubt many by proper illumination can be seen much less than this." The real size of the beads probably varies according to the rate at which the gas is evolved and decomposed by contact with the glycerine and water, and it is the writer's opinion that the smallest beads are considerably less than $\frac{1}{1000000}$ ".

By gently rubbing the films with water in a small agate mortar, avoiding any force likely to pulverize the surface of the mortar itself, they may be separated into myriads of beads, and these with a little washing and subsiding on a slide, may be obtained in nebulous clouds, or more widely scattered. Multitudes of beads in this condition appear excessively minute, and so do those in the thinnest and most transparent films. If such beads are examined with a series of fine objectives, the observer will consider them smaller pretty nearly as it is the theoretical duty of his objective to make them bigger. Thus operating with $\frac{1}{16}$ th of Beck, $\frac{1}{16}$ th of Powell and Lealand (estimated somewhat too low), and $\frac{1}{24}$ th of Nobert (estimated too high), the beads were far from increasing in proportionate apparent size as the magnification passed from between 200 and 300 to between 2000 and 3000, according to the objectives and eye-pieces employed, and the strongest conviction of their real minuteness was obtained with the highest power. No glass can give the real size of minute highly-refractive lenses, but experiments with these beads led to the belief that with glasses of fine construction those of the highest power have least proportionate error, contrary to what might have been supposed, and yet quite in accordance with the experience of those who employ objectives up to $\frac{1}{16}$ th for very minute researches, instead of relying upon a dictum once current that $\frac{1}{12}$ of extreme aperture would suffice for any magnification required.

These results appear to be in accordance with calculations made by Mr. Lister, showing that certain proportions ought to exist

between the focal length and angular aperture of objectives for their best performance. Thus the best performance is not gained by giving an $\frac{1}{3}$ th or $\frac{1}{2}$ th as much aperture as works well with $\frac{1}{15}$ ths, $\frac{1}{25}$ ths, and $\frac{1}{50}$ ths; and glasses with excessive angles may be found to exaggerate the size of refractive spherules to a considerable extent. When spherules do not absolutely touch, the best glasses magnify the interspaces more than the diameters of the spheres.

The best way of commencing the study of these films is by viewing them with dark-ground illumination, say with a fine $\frac{1}{2}$ inch of moderate angle (or if of large angle reduced by a stop) and a good achromatic condenser of considerable angle and largest central stop. Some films composed of a plurality of bead layers will then look like fine specimens of point lace, and opaque white. The bacteria-like and fungoid simulating formations that appear dingy brown, with transparent illumination come out like porcelain beads. Formations as in Fig. 2 look somewhat like portions of the moon's surface, and clouds of detached beads give quite astronomical effects, like nebulae, or portions of the Milky Way.

When a high power is employed on thin films having beads on more than one plane, the colours long since recognized by Mr. Wenham and others as indicating resolution by the best glasses will be observed. Some of these effects are extremely beautiful and polychromatic. Upon these appearances in the slide Dr. Pigott remarks in a letter to the writer, "At the best correction, when the focal point of some beads is brightest and whitest, several coloured beads appear, all on the same plane being of the same colour. The colours vary from red, orange red, yellow, to blue on different planes. If the glass is over-corrected by opening the screw-collar, so as to throw the diffraction rings above, then the colours disappear, and the beading appears of a dull black; but when under-corrected in colour, as the phrase is, the blackness disappears. It is only when the glass is over-corrected spherically that the colours vanish."

With Mr. Wenham's apparatus for dark-ground illumination with high powers these beautiful effects may be obtained. Carefully used, this apparatus gives a valuable light-ground illumination with such a glass as Nobert's $\frac{1}{24}$ th, resolving the thin films beautifully and making the beads look very small in proportion to the power. With a fine $\frac{1}{3}$ th and C or D eye-piece the illumination becomes dark ground in character, and by focussing just above isolated beads numerous brilliant chromatic diffraction rings may be obtained, each pair of coloured rings being separated by a black ring.

It would be interesting to inquire how far a regulated deposit in minute beads is an approximation towards a crystalline formation, as it is *in form* an approximation towards organic structure. Modern physicists recognize gradations instead of abrupt transitions between

the various states of matter, such as gaseous fluid, viscous and solid, of various degrees of density. When the silica passes from the gaseous to the amorphous solid state, it may be that the rushing and clashing together of molecules is too confused for crystallization, or for the regularity required in organic patterns. A certain measured and rhythmical retardation may be necessary for the formation of crystals, or organic patterns; and in the case of these silica films the violent reaction between the silicic fluoride and water is moderated by the glycerine. No one supposes he is making diatoms by Schultze's process, nor organic cells by the method now described; but some light may be thrown upon processes that do belong to organic life, by noticing how the presence of certain retarding elements may cause crystalline or other forces of aggregation to deposit matter in the shape and quantity required for the structure of living beings.

In some of the slides minute crystals have been found, mostly isolated prismatic needles, or radiating groups of them; also some rhomboid tables, differing little from square forms. In one case a small octohedral column with a flat top was seen. All the thicker films act slightly on polarized light, and so do most of the crystals, but not all, probably from some not being in the right position. These crystals are most likely silicates of minute portions of alkalis accidentally present. Their fewness and extreme smallness would render chemical analysis impracticable. In viewing them with polarized light it is advisable to place the polarizer underneath the achromatic condenser, and observe them with $\frac{1}{2}$ th and higher powers.