

engineering science to provide the material and shape it. But lead and direction are required of theory by preliminary calculation to show how to make use of our resources to the best advantage. As Bacon said: "Experiment not directed by Theory is blind. And Theory unsupported by Experiment is uncertain and misleading."

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COLLOIDS AND CHEMICAL INDUSTRY.¹

COLLOID chemistry, in its widest sense, deals with chemical processes which occur in the immediate neighbourhood of surfaces—that is, chemical effects which are brought about as a result of capillary and electrocapillary forces. Such effects are necessarily limited to a small range, the thickness of the capillary layer being of the order 10^{-6} to 10^{-7} cm. It is obvious that these effects can become of importance only if the surface area itself is very large. Under ordinary conditions, in which two fluid masses in bulk are separated by a definite surface—as in distribution phenomena—the capillary effects are too small to be observed. To magnify the effect it is usually necessary to realise a state of affairs in which one phase is distributed in a state of fine subdivision or "dispersed" through the other phase or medium. In these circumstances the total interfacial area is enormously great. We find such conditions in the case of fine suspensions (diameter of particle 10^{-4} cm. approx.), emulsions (diameter of particle 10^{-5} cm.), and colloid solutions (diameter of particle 10^{-6} cm. approx.). Colloidal solutions are systems in which the solute individuals or *sols*, though apparently soluble, have not broken down to the molecular limit, but consist instead of aggregates, composed roughly of several hundred molecules or atoms. Such soluble aggregates or *sols* will not diffuse through membranes (as Graham showed in his original work on the colloidal state), and thus differ markedly from the behaviour of dissolved crystalloids, e.g. salts.

The most fundamental problem in connection with such disperse systems is the problem of their stability. It is evident that uniformity in size of the particles plays an important part in this connection, as do also the electric charge and the Brownian movement which each particle possesses. The methods whereby the equilibrium is disturbed are equally remarkable and characteristic. A very minute amount of electrolyte added to a stable colloidal solution may bring about complete precipitation or flocculation of the *sol*, the *sol* separating out in a gelatinous form known as a *gel*. In some cases, and possibly in all—though this is a disputed point—such precipitation may be reversed. A closely allied phenomenon is that known as "peptisation," in which a substance, normally insoluble in a solvent, may be made to dissolve by the addition of a peptiser. This is illustrated

by the stabilising or protective effect produced by a small quantity of gelatine (itself a colloid) upon solutions of colloidal metals, and also by the well-known phenomenon met with in the case of the hydroxides of zinc and aluminium which "dissolve" in excess alkali. Experiment has shown that the alkali may be dialysed away and the peptised colloidal hydroxide reprecipitated. Such phenomena depend essentially upon selective adsorption or surface condensation of certain parts of the peptiser (usually the hydroxyl ion) upon the suspension or colloid. Gibbs showed, many years ago, that, as a thermodynamic necessity, any substance (solute) which lowers the surface tension of the solvent is positively adsorbed at the surface—that is, the concentration of the solute is greater in the surface layer than it is in the bulk of the solution. This phenomenon lies at the basis of many technical operations, such as dyeing and tanning, though, of course, other effects of an irreversible character enter later.

Another important surface phenomenon is that known as electrical endosmose. If a liquid be divided into two parts by means of a porous partition or membrane, and an electromotive force be applied across the partition, the liquid will be found to pass through the membrane, the direction of motion depending upon the electrical state of the partition in relation to the liquid and its constituents. By a suitable choice of membrane and solution certain constituents may be separated from others, e.g. crystalloids from colloids, or certain colloids may be precipitated and others left in solution.

Surface effects, the realisation of colloid equilibrium, electrical neutralisation, preferential adsorption, peptisation, colloid precipitation, imbibition or swelling of *gels*, electrical endosmose, and other phenomena of a similar nature might at first sight appear to have little significance for industrial operations and processes, although their importance has already been recognised to a certain extent in other directions, e.g. in agricultural processes (quality of soils, retention of salts, emulsions for crop spraying, etc.), in geological formations, and in biological problems (cell contents, nature and permeability of cell-walls, distribution of electrolytes, blood serum, coagulation of proteins, enzyme action, etc.). That colloidal phenomena enter into numerous technical processes may be demonstrated by a brief enumeration of some industrial operations which depend fundamentally upon what we may call the principles of colloid chemistry.

We have already instanced dyeing and tanning. We find further that colloid chemistry plays a fundamental part in certain stages of soap manufacture; in washing and scouring processes, in connection with textile fabrics, hides, skins, and in fur dressing; in mercerisation and finishing; in the manufacture of photographic materials; in the treatment of cellulose and wood pulp in paper manufacture; in paper sizing and colouring (carbon and other copying papers); in the treatment

¹ First Report of the British Association Committee on Colloid Chemistry and its Industrial Applications. (1917.)

of gums, gelatine, albumin, starch, tragacanth, and adhesive materials generally; in the clarification of wines; in filtration processes, treatment of sewage, river sludge, and the function of charcoal purifiers; in the de-emulsification of water in steam turbines; in the preparation of medicinal emulsions; in the manufacture of margarine and other foodstuffs; in brewing and fermentation industries; in catalytic reactions, such as the hydrogenation process; in chemical analysis, electro-analysis, and electro-deposition processes; in the coagulation of rubber latex and in vulcanisation; in the manufacture of celluloid and celluloid products; in the flotation process of ore separation; in the manufacture and setting of cements, plaster, and mortar; in the preservation of building materials; in the manufacture of ruby glass, opaque glass, and enamel; and in the application of electrical endosmose to peat drying and the preparation of pure colloids for medicinal purposes.

The above rather heterogeneous list—by no means exhaustive—will give some idea of the variety and extent and consequent importance of colloid chemistry for the chemical manufacturer. It is an urgent matter that the great significance of this branch of chemistry should be recognised by all interested in the progress of chemical industry.

In the first report of the British Association Committee on Colloid Chemistry and its Industrial Applications, now before us, several of the processes mentioned above are discussed. The committee has aimed at compiling information regarding the advances which have been made in colloid chemistry itself and in its applications to industrial processes, with the object, in the first place, of making such information as widely available as possible, and, in the second, of emphasising the need for much greater attention being paid to this wide, but hitherto neglected, branch of chemistry. Each subject has been treated by an expert, so that the selection and presentation of material may be regarded as authoritative. It is evident that at the present time there is a very considerable "lag" between scientific knowledge in this field and industrial practice. The result is that the majority of working processes are largely empirical, their mechanism obscure, and the probability of improvement consequently small. This is obviously an extremely unsatisfactory state of affairs. The remedy lies, of course, in the vigorous prosecution of research over the entire range of colloid chemistry in the research laboratories of manufacturers and in the chemical departments of our universities. In this connection it is perhaps worth while to point out that there is not a single chair or independent department of colloid chemistry in any of our universities or university colleges. The time has surely come for development in this direction, in order that a subject of such present importance and possessing great possibilities may become a real source of strength to our chemical industries.

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BY the death of Dr. George Jennings Hinde on March 18 another pioneer in the modern methods of studying fossils has passed away. Dr. Hinde devoted the greater part of his long life to the investigation of the remains of the lower invertebrate animals, which need careful and often laborious preparation for the microscope before they can be examined. He thus contributed much to geology by adding to our knowledge of rock-forming organisms, and at the same time promoted the advance of zoology by his discovery and description of many kinds of calcareous and siliceous skeletons, which were either entirely new or revealed new facts in distribution.

Dr. Hinde was born at Norwich in 1839, and emigrated in early life to the Argentine Republic, where he was engaged in sheep-farming. He was always interested in natural history, and as soon as the opportunity occurred at the beginning of the 'seventies he decided to retire from business and follow more congenial pursuits. He left Argentina for Canada, and proceeded to the University of Toronto, where the late Prof. H. A. Nicholson was then starting his professorial career. Stimulated by Nicholson's lectures and personality, Hinde began to follow his teacher in studying the Silurian and Ordovician fossils of Canada. He also became interested in the remarkable glacial deposits, which are so conspicuous a feature of the region in which he dwelt. Nicholson had specially devoted attention to the microscopic structure of the corals and obscure organisms which abounded in the limestones, and it was to the microscope that Hinde naturally turned as the chief instrument for his researches. He travelled extensively and collected industriously in Canada and the United States, where he remained for seven years. Among minute fossils his most important discoveries were conodonts and jaws of annelids in the Ordovician rocks.

Returning to England, Hinde found similar jaws of annelids in the Silurian rocks of this country, and described them in the *Quarterly Journal of the Geological Society* in 1880. In 1879 he recovered and prepared a remarkable collection of sponge-spicules from a hollow in a chalk-flint at Horstead, near Norwich, and soon recognised that most of them were new. He accordingly went to study his little collection at the University of Munich, under the direction of Prof. K. A. von Zittel, who had just completed there an important revision of the fossil sponges. Hinde published his results in 1880 in the form of a thesis, for which he received the degree of Ph.D. Returning finally to England, he next prepared a descriptive illustrated catalogue of the fossil sponges in the British Museum, which was published by the trustees in 1883; and this was followed by the first volume of a monograph of the British fossil sponges, issued by the Palæontographical Society between 1887 and 1893. Several smaller papers were also the outcome of his researches, the most important being an account of the cherty sponge-