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# The current state of colloid science

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**The time is now opportune to develop a determined attack, both experimental and theoretical, on some of the more important problems relating to the formation, stability and properties of colloidal dispersions. Thus says the report[1] of an SRC panel looking into the case for special support of research in colloid science. Here Professor Overbeek reviews the current state of *knowledge in the field, and some of the problems waiting to be* tackled.**

Even if one regards colloid science in a restricted sense as the science of colloidal dispersions, a number of scientific disciplines is so intimately interwoven with it that a somewhat wider definition of colloid science has to include surface and interface science, micellar aggregates in solution, membrane phenomena, and at least part of polymer science. In all these fields colloid science puts strong emphasis on physical and physicochemical aspects of the systems.

As a pure science, colloid science is attractive because it offers many extreme examples of phenomena which also occur with mixtures of small molecules, and it helps in understanding these phenomena just as a good caricature may give a better insight into a personality than a smooth portrait. For example, Brownian motion of individual colloid particles can be seen and is of great help in understanding thermal motion in general. Membrane permeability can be more easily adapted to the colloidal size range than to that of small molecules. Light scattering is more obvious and more easily measured with colloids than with micromolecular systems. Many other similar examples can be given.

As an applied science, colloid science is important because of its great variety of industrial, environmental, biochemical and biophysical applications.

In spite of this, colloid science is relatively neglected in academic teaching and research. There are very few centres in the Western academic world (in the USSR the situation is better) in which it is vigorously pursued; and, what is perhaps worse, in many chemistry curricula, colloid and surface science are completely neglected. As a result, too few students are incited to specialize in this field and there is a deplorable lack of trained personnel. This is the more regrettable since the multidisciplinary nature of colloid science and its applications makes it an ideal training ground for students who should learn to communicate with people specialized in other fields and who should be able themselves to combine a variety of methods and knowledge in solving their problems.

One of the reasons why colloid science has not attracted many students —apart from the spectacular recent developments in biochemistry and in theoretical chemistry—may well be that colloid science could be described as the application of fairly straightforward classical thermodynamics, statistics and kinetics to complicated systems; and people, certainly students, prefer to keep things simple. To convert this drawback into an asset, the multidisciplinary nature and the very widespread applicability of colloid science

## Recommended areas of study

Topics that the SRC panel on the science of colloidal dispersions considered to be particularly worthy of special study, either for their intrinsic scientific merit alone, or because in addition they are areas of study which can be foreseen as having an immediate or long-term influence on industrial processes or products.[1]

**Surface chemistry:** surface energy of solids (*e.g.* effects of wetting and adsorption), study of adsorbed layers by spectroscopic and optical methods.

**Theoretical studies:** thermodynamics of colloids, further development of double layer theory, theory of interfacial layers, especially of steric stabilizers.

**Interparticle forces:** direct measurement of forces between surfaces, effects of adsorbed layers, relevant theoretical studies on systems of simple specification.

**Colloid stability:** effects of hydrodynamic factors on stability, stability of emulsions, heterocoagulation, stability of foams and the effect of polymeric stabilizers.

**Colloid properties:** development of optical and spectroscopic techniques, rheological properties of model systems.

**Chemical reactions:** chemical and biochemical reactions in or catalyzed by colloids.

**Lyophilic colloids:** liquid crystals, association colloids.

**Aerosols:** chemical formation and stabilization.

**Biocolloids:** membranes, cell and particle adhesion.

*Professor Overbeek, an eminent colloid scientist who was one of the originators of the DLVO theory of colloids, works in the van't Hoff Laboratory, University of Utrecht, The Netherlands.*

should be pointed out to students. One might mention, for example, aerosols and the filtration of dirty gases; clearing of turbid waters; membranes with such obvious applications as the artificial kidney, the artificial lung and water desalination; magnetic tapes; reinforced plastics; the whole field of inks, paints and lacquers; heterogeneous catalysts; laundering; and finally breaking or stabilizing emulsions for fighting oil pollution or for use in pharmaceutical, cosmetic and agricultural applications.

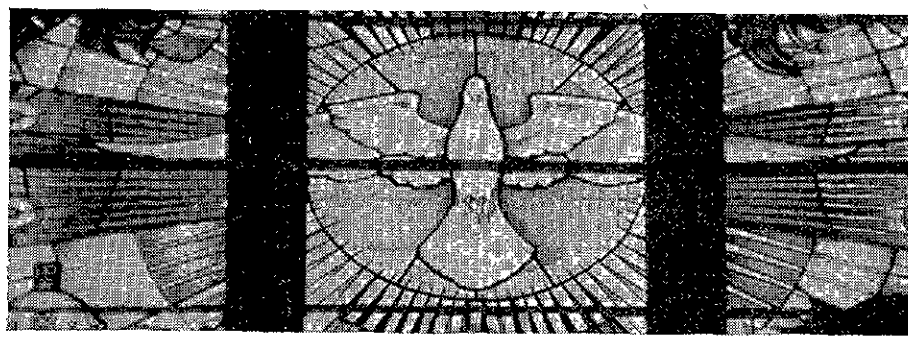
### Present knowledge

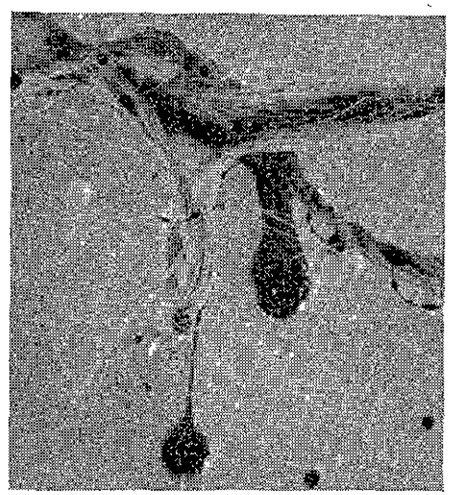
Colloid science itself is in a healthy state of development. Good progress has been made in understanding colloid stability, the electrical double layer, electrochemical aspects of membranes, and tools such as light scattering and ultracentrifugation. The understanding of thin liquid films and foams has progressed so far that these systems can be used as simple models for the interactions between suspension or emulsion particles. Similarly, micelles in ionic surfactant solutions are good models for highly-charged colloid particles. More recently isodisperse latices with controlled particle size and surface charge have been successfully used as models for colloid suspensions and emulsions.

In the earlier days of colloid science the emphasis was mainly on aqueous and 'electrocratic' systems. But with the arrival of non-ionic surfactants and a better understanding of protective action—arising from stabilization by adsorbed polymers—we are getting into a much better position to understand and control the stability of suspensions and emulsions in non-aqueous and, particularly, in non-polar media.

### Waiting problems

But there is still a wide range of problems waiting, and the time now appears ripe for solving them. No *a priori* theory exists for the breaking of emulsions, but progress in understanding spontaneous breaking of foam lamellae may well point the way to a more complete theory of emulsion stability. Even the stability of hydrophobic colloid suspensions, on which so much theoretical work has already been done, is not completely understood in the sense that further refinements are required to explain rates of coagulation. Contact angle hysteresis, so important for all wetting and dewetting phenomena, has a number of partial and qualitative explanations but not a quantitative one. Even the old arts of washing and laundering—recently so much under the attack of environmentalists—assess the efficacy of their products and methods empirically rather than on the basis of fundamental understanding of the, admittedly very complicated, processes occurring in them.





*Colloids are ubiquitous. Stained glass* (top) *is a solid suspended in a solid; emulsification of oil in detergent* (left) *forms a colloidal suspension; while egg white* (above) *is an irreversible gel.* (Photos: Unilever Films)

Biochemistry is wide open for more participation by physical chemists and particularly colloid scientists. The beautiful work on bimolecular lipid layers may give us basic understanding of the isolating and separating function of the biological membrane, but a great deal more work will have to be done before we can understand the passage of ions and other polar molecules through these membranes and the mechanisms by which their permeability is controlled. Cell contacts and cell motility are problems of surface science, and it may well be that the choice between limited and unlimited malignant proliferation of cells is determined by surface properties. Interactions between nucleic acids and basic proteins, presumably governing gene expression, must of course contain very specific elements, but there will also be a general polyanion-polycation interaction that colloid scientists are studying under the name complex-coacervation.

The use of modern spectrometric techniques has so far only scratched the surface of surface science. They may well help in gaining a better understanding of the chemical nature of surfaces and of the physical nature of liquids near surfaces.

### SRC support

The report of the Science Research Council working party on colloid science[1] expresses the state of colloid science very admirably and in much more detail than has been possible here. It also makes a number of recommendations which in my opinion have a worldwide significance, although they have, of course, been drawn up primarily with reference to the United Kingdom. In particular, I want to endorse the recommendations to set up at least one new theoretical group and to encourage further the links between academic and industrial institutions.

Of the recommended areas of support I want to emphasize foams (if only to keep in contact with current developments in the US, the USSR, and the Netherlands) and the adsorption and general role of polymeric stabilizers. Moreover, an open eye should be kept on the many possible applications of colloid science in pollution control.

Of course it is important to encourage and support work in the existing centres and to attempt to found new ones, but it is also very important to make material on colloid science available in such a form that it can be easily incorporated in undergraduate training in general and/or physical chemistry. This might result in a much larger number of students realizing the attraction of colloids and surfaces and at least some of them may choose their career in these fields.

### Reference

1. *Colloid science: report of a multidisciplinary panel on the science of colloidal dispersions.* London: SRC, 1972.