



DISPERSION OF POWDERS IN LIQUIDS

With Special Reference to Pigments

THIRD EDITION

Edited by

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IN LIQUIDS

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THIRD EDITION

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INTRODUCTION

Since the first edition of this book appeared in 1969 there have been some significant developments that are important for a better appreciation of the science and technology of the process of dispersing powders in liquids. Furthermore, there has been an increasing awareness of the value of understanding and applying the fundamental principles of colloid and interface science to practical systems—the gap between theory and practice has narrowed significantly. One area of scientific endeavour has made a major advance, and that concerns the stabilisation of dispersions by macromolecular substances, which is particularly relevant since many practical systems contain molecules of high molecular weight. Our understanding of the chemistry of powder surfaces has also improved, and the importance of such knowledge to the incorporation stage is now being recognised. These and other developments have been incorporated in this third edition.

The fundamentals and terminology of the dispersion process are defined in Chapter 1. It is useful to divide the overall process into three distinct stages. The first involves the wetting of the powder surface, and Chapter 2 considers those aspects of the surfaces of solids and their interactions with liquids that are relevant to this stage. Once the powder is wetted out a milling stage is usually necessary but for pigments this area of mechanical breakdown of aggregated structures is not well defined. The third stage concerns the stability of the dispersion to flocculation, and in Chapter 3 the various theories of stability are described for systems containing either charged or uncharged colloidal particles. The relevant theoretical and practical aspects of electrical

phenomena associated with charged solid/solution interfaces, including electrokinetic phenomena and the calculation and significance of zeta potential, are discussed in Chapter 3. These first three chapters contain a number of references to scientific studies of the various aspects of the dispersion process: to the casual reader they may seem too remote from the practical situation to merit further study, but succeeding chapters focus attention on the fundamentals and how they find application in practice, and endeavour to pinpoint the problem areas.

In all three stages it might be said that 'surface activity' predominates, and it is not surprising that in a variety of ways surface active agents play an important role in the process. In the large range of dispersion processes in which pigments are used, the surface active compounds employed are legion. Their types, properties and applications are reviewed in Chapter 4. The alternative technique for the formation of a dispersion of fine particles in a liquid medium, that is by precipitation from supersaturated systems, is discussed in Chapter 5. This is, of course, an important aspect of the manufacture of many inorganic and organic pigments, but the principles involved in the development of precipitate morphology are also relevant to the ageing processes that can occur in certain pigmented systems.

Chapter 6, a new addition to the book, covers the fundamental aspects of the breakdown of solid materials, both amorphous and crystalline, and identifies the parameters that are important in comminution. The techniques used for dispersion in industrial processing are surveyed in Chapter 7, illustrating how the choice of machine is related to the nature of the system involved, and how optimisation can be achieved. The degree of dispersion achieved may be difficult to assess—the ultimate experiment would clearly define the particle size distribution in the dispersed system, but in so many practical cases this experiment is still somewhat remote. Several quite reliable techniques are in regular use and some new ones are introduced; these are based on the principles discussed earlier in the book and something of a link between these principles and the practical problem of assessing the state of dispersion is created in Chapter 8. The final two chapters are concerned with the current position in the dispersion of inorganic (Chapter 9) and organic (Chapter 10) pigments in a variety of media. Where feasible the authors demonstrate the application of fundamentals while focusing attention on the areas where knowledge is limited and empiricism prevails.

The editor is grateful for the numerous constructive suggestions that he has received from readers, and hopes that this new edition goes at least some way to meet their needs.

G. D. PARFITT

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G. D. PARFITT

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CHAPTER 1

FUNDAMENTAL ASPECTS OF DISPERSION

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THE DISPERSION PROCESS

The term *dispersion* is used here to refer to the complete process of incorporating a powder into a liquid medium such that the final product consists of fine particles distributed throughout the medium. The dispersion of fine particles is normally termed *colloidal* if at least one dimension of the particles lies between 1 nm and 1 μ m and the term *sol* is used for *any* colloidal system in which the dispersion medium is liquid. Solid particles dispersed in a liquid form a *suspension*.

Sols are classified, in terms of the affinity of the colloidal particle for the medium, as *lyophobic* (possessing aversion to liquid) or *lyophilic* (possessing affinity for liquid); *hydrophobic* and *hydrophilic* respectively for aqueous media. Some difficulties may arise with the use of these terms. In the sense of the definition lyophobic implies no affinity between the colloid and the medium, e.g. an insoluble powder, but taken to its logical extreme this would suggest no wetting of the powder by the liquid and hence no dispersion could be formed. But although a metal oxide powder may be insoluble in water it is nevertheless normally wetted by water and hence the powder surface is hydrophilic, but the dispersion is classed as hydrophobic. We might also wish to consider the degree of hydrophobicity of a surface in terms of, say, the heat of wetting in water; there is no hard and fast rule when these terms are used for interfaces, but the application to dispersion is clearly defined. Solutions of macromolecules and association colloids are of the lyophilic type and form spontaneously when the components are brought into contact. They are

true solutions and are stable in the thermodynamic sense whereas lyophobic sols do not form spontaneously and hence in principle are thermodynamically unstable. The division between solutions and dispersions is without ambiguity.

Essential to an understanding of the dispersion of powders in liquids is a knowledge of the formation and properties of the solid-liquid interface. In the early stages of the process the solid-air interface is replaced by one between solid and liquid. The powder consists of aggregates/agglomerates of similar particles and to disperse these particles into a liquid mechanical work is performed, and the forces that exist at the interface determine the ease with which the process can be brought about. Once dispersed the particles are free to move in their new environment, and flocculation is prevented by various chemical and physical methods, all of which relate to the character of the solid-liquid interface.

The three stages of the dispersion process

It is useful to consider the overall process of dispersion as consisting of three stages, and take each stage separately in order to assess the importance of the various factors involved. These three stages are quite distinct in their nature, but in practice they overlap. The principles involved in each stage are fairly well established but because of the overlap it is often not easy to recognise any particular aspect in a practical dispersion system. The three stages to be considered are the following:

(a) Wetting of the powder

In many practical uses of powders the primary particle size is sufficiently small for further subdivision to be unnecessary. But in the dry state the powder usually contains some aggregates of primary particles and these are attached to other aggregates and/or primary particles forming agglomerates. Aggregates are groups of primary particles joined at their faces and having a surface area significantly less than the sum of the areas of their constituent particles. An agglomerate is a collection of primary particles and aggregates which are joined at edges and corners, and the surface area of the whole is not markedly different from the sum of the areas of the individual components.¹ The initial stage of wetting involves both the external surface of particles and the internal surfaces which exist between the particles in the clusters that make up the dry powder. The wetting process is dependent on the nature of the liquid phase, the character of the surface, the dimensions of the interstices in the