Foreword

In a liquid crystal watch, the molecules contained within a thin film of the screen are reorientated each second by extremely weak electrical signals. Here is a fine example of soft matter: molecular systems giving a strong response to a very weak command signal.

They can be found almost everywhere. Soft magnetic materials used in transformers exhibit a strong magnetic moment under the action of a weak magnetic field. Take a completely different domain: gelatin, formed from collagen fibres dissolved in hot water. When we cool below 37°C, gelation occurs, the chains joining up at various points to form a loose and highly deformable network. This is a natural example of soft matter.

Going further, rather than consider a whole network, we could take a single chain of flexible polymer, such as polyoxyethylene [POE = $(CH_2\ CH_2\ O)_N$, where $N \sim 10^5$], for example, in water. Such a chain is fragile and may break under flow. Even though hydrodynamic forces are very weak on the molecular scale, their cumulated effect may be significant. Think of a rope pulled from both ends by two groups of children. Even if each girl and boy cannot pull very hard, the rope can be broken when there are enough children pulling.

POE, added to water at homeopathic dose levels, completely transforms its hydrodynamic properties (take, for example, the experiment devised by James in Toronto). We see here another aspect of soft matter: the fact that an additive, in very small quantities, can change everything. A whole practical area of science, called formulation, is based on the study of such additives, whether it be an ink, a paint, a medicine, or a product for treating vines. In this sense, soft matter physics is directly concerned with industrial problems.

But it also touches upon some quite fundamental questions, as we see from the history of long-chain molecules. It took a very long time just to realise that such things existed, a step taken by Staudinger in 1920; and then to establish that they are usually flexible, the fundamental idea put forward by Kuhn in 1940. Following this, their statistical conformations were described, the great triumph of Flory in the 1950s. And finally, the deep connection between chain conformations and the trajectories of quantum particles was the superb idea, developed by Edwards in the 1960s, which meant that fifty years of theoretical knowledge acquired in atomic and nuclear physics could be transposed to polymers.

A quite analogous story could be told about detergents or, as they are rather pompously called, surfactants. Soap bubbles fascinated Gibbs a hundred years ago, inspiring him to construct a thermodynamic theory of interfaces. In our own time, the discovery of vesicles, curious and flaccid objects, has opened up a whole new chapter in the science of surfactants. Extremely rich statistical problems are raised by these soft surfaces, and their analysis is a distant cousin of the string theories at present under development in elementary particle physics.

The aim of the present book is not to enter into the labyrinth of theory, but rather to show, using relatively simple examples, how concept and experiment relate today, with regard to everyday subjects, such as soaps, rubber, emulsions, plastic, grains in suspension, and so on. Thanks to all those who have taken part in this project, and especially to M. Daoud and C. Williams, patient shepherds for a capricious flock of researchers.

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