nature materials

Vol.7 No.4 April 2008 www.nature.com/naturematerials

Theory in application

It's not surprising that the work of de Gennes has already found a variety of applications — understanding soft matter brings great advantages for industry.

When asked to describe Pierre-Gilles de Gennes' lasting legacy to the polymer community, Ludwik Leibler tells us in this month's interview: "a global approach". It was this global approach, summarized perfectly in the Nobel committee's statement that de Gennes received the 1991 Prize in Physics "for discovering that methods developed for studying order phenomena in simple systems can be generalized to more complex forms of matter", that contributed so greatly to moving our understanding of soft matter firmly into the realm of the quantitative.

de Gennes did on a grand scale what many researchers do regularly to some degree: applying what is learnt from one situation to another. What amplified de Gennes' great success in this endeavour was his ability to extract the very essence of a research problem, thereby making analogies with ostensibly completely unrelated systems possible.

These analogies — such as the comparison between the alignment of magnetic moments at a magnetic phase transition and polymer chain conformations, or the use of laws developed to describe superconductivity to understand phase transitions in liquid crystals — enabled quantitative descriptions of outwardly messy problems.

Deriving quantitative models of the behaviour of soft-matter systems seems to the untrained eye to be almost a hopeless task, given that they are often characterized by their high degree of disorder. Add to that the fact that properties can be radically changed by minor alterations of structure — by arranging exactly the same number of the constituent atoms in a branched rather than a linear polymer, for example — and the degrees of understanding required become immense.

However, although this high level of flexibility in property–structure relationships can cause headaches in the initial understanding of how to make a polymer that does what you want it to do, the fact that they are highly tailorable through very minor changes brings great advantages. It is these advantages that have made polymers the materials of choice for a wide variety of industries.

PHILIPPE PLAILLY/SCIENCE PHOTO LIBRARY

Pierre-Gilles de Gennes — a doyen of soft-matter theory.

With the polymer industry now at the heart of so many consumer products, and new, specialty, applications appearing every day, the need for improved processes and tailored properties is greater than ever. By incorporating a theoretical understanding of polymer structure–property relationships into the development of any new polymer or product, the route to the best formulation can be simplified and the need for trial and error can be — if not eliminated — at least abbreviated.

The complex nature of soft matter means that, for industry, it is often better to achieve this theoretical understanding via a collaboration with academia than by pursuing in-house activities. And indeed, de Gennes himself was a firm supporter of industry–academia collaborations in this context, which isn't surprising given his global approach. As a source of unexpected research problems, industry has the capability of providing the global questions of which he was so fond.

In the reverse direction, even some of de Gennes' ideas that were, at first glance, highly academic have found useful applications. For instance, his work in the 1980s on wetting of surfaces was famously applied to wine making to enable even coverage of grape skins with fungicide.

With all these themes in mind, we look this month at the application of soft-matter theory, from fundamental modelling of simple homopolymers, to the control of block copolymers and supramolecular chemistry. Our interview with Ludwik Leibler[2] — who, like de Gennes, uses his background in theoretical physics to understand soft-matter systems — and commentary from Glenn Fredrickson[3], both examine the collaborations between industry and academia. The review by Nie and Kumacheva[4] considers the field of patterning surfaces with functional polymers, a growing area of relevance for future technologies.

Along the way we take a moment to reflect on one of the masters of the field, who died almost one year ago, and whose comprehension will inform our understanding of soft matter for a long time to come. And in the wider sense, although de Gennes' brilliance in linking diverse areas of science was certainly something special, a more global view on research could help us all find more of the answers we're looking for.

References

1. Brochard-Wyart, F. *Nature* **448,** 149 (2007).
2. *Nature Mater.* **7,** 265–266 (2008).
3. Fredrickson, G. H. *Nature Mater.* **7,** 261–263 (2008).
4. Nie, Z. & Kumacheva, E. *Nature Mater.* **7,** 277–290 (2008).