Polymerization From the Individual Molecule's Point of View

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Plastics are becoming more and more important and are an indispensable part of modern life. Scientists are thus interested in clearing up the details of polymerization processes, in which individual molecular building blocks are linked into long polymer chains or three-dimensional networks.

A Belgian and German team from the University of Leuwen and the Max Planck Institute for Polymer Research in Mainz has now been able to follow polymerizations from the point of view of individual molecules.

As they report in the journal *Angewandte Chemie*, Johan Hofkens and his team used the techniques of fluorescence correlation spectroscopy and far-field microscopy to observe fluorescing sample molecules throughout the entire process of the radical polymerization of styrene.

Previous methods applied to this problem provided interesting insights into the reaction pathways of polymerizations; however, most are not capable of monitoring the entire reaction process. In addition, they only provide a picture of the reaction that is averaged over all of the molecules. Irregularities that occur during the polymerization cannot be recorded at the molecular level, although such heterogeneities have a large influence on the properties of the final polymer. Knowledge of such details can help to make polymerization processes easier to control and to improve the properties of the products.

Single-molecule spectroscopy does not average out differences between individual molecules; instead it highlights them. The researchers followed the polymerization by using fluorescing probes.

During the reaction, which converts a solution of monomers into an ever-denser polymer matrix, the freedom of movement of the probe molecules is constantly decreasing. Fluorescence correlation spectroscopy makes it possible to measure the time during which individual probe molecules stay within a tiny defined space. This then enables the registration of the rapid molecular motions occurring in the barely reacted solution.

Far-field microscopy directly displays the positions of the fluorescing probes and is well suited for following slow and immobilized molecules. The two methods are complementary and together they provide a picture of the translational motions throughout the entire polymerization process. Additional information is provided by probe molecules built in to the growing polymer.

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