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Editorial: Nanocomposites with interfaces controlled by grafted or adsorbed polymers

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Editorial on the Research Topic
Nanocomposites with interfaces controlled by grafted or adsorbed polymers

Polymer nanocomposites represent an innovative class of materials used for a great variety of applications. They are formed by dispersions of typically hard inorganic filler nanoparticles in soft polymer matrices. A large range of polymer nanocomposites, based on particles of different size, shape and chemistry can be generated using various fabrication processes. A striking feature of nanocomposites is their large interfacial area that is determined, e.g., by nanofiller size and concentration, polymer-nanoparticle interaction, and the resulting dispersion of particles in the polymer matrix. The design of the nanofiller surface by grafting or adsorbing polymer molecules can modify both the interfacial physics and the filler structure, giving access to improved macroscopic (mechanical, electrical, or optical) material properties.

It is the aim of the present topical Research Topic to focus on some aspects of recent research in this highly active and evolving area. We review and summarize state-of-the-art investigations of polymer nanocomposite materials which promote at a better understanding and control of the complex behavior of nanocomposites. Two articles with original experimental approaches have been contributed, one presenting an innovative application of microgel-nanoparticle composites in solvent, the other an in-depth study of the structure and dynamics of a bulk polymer nanocomposite. In parallel, we have reviewed the general field of particle and polymer structure and dynamics using scattering techniques, in particular neutron scattering, and highlighted the role of interfacial polymer layers in the specific case of polymer-grafted nanoparticles in a second review.

Nanocomposites can have many faces and may serve for fundamental studies as well as applications. Figure 1 illustrates the typical morphology of polymer nanocomposites, where possible length scales are set by the size of the primary particle, which is most often in the 20 nm range. Appropriate techniques for probing different aspects are mentioned in the legend. An original application oriented nanocomposite is described by Sabadasch et al. Catalytically active palladium nanoparticles are incorporated into the core of a polymer microgel, which is thus itself a nanocomposite made of two different polymers with a core-shell structure. A combination of light scattering to study the temperature-dependent size of the particles, and electron microscopy to localize the NPs, is proposed. The core-shell

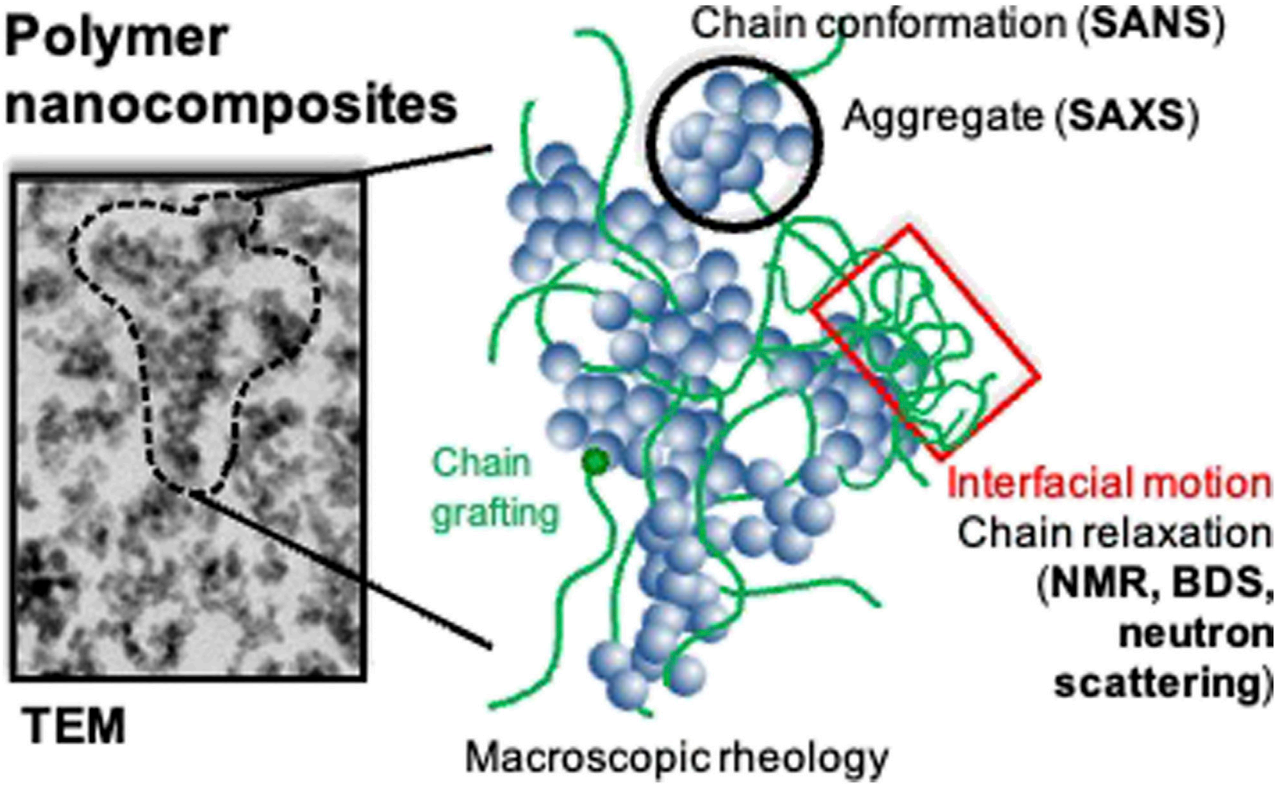

FIGURE 1
Illustration of a polymer nanocomposite with a spectrum of techniques used to characterize the structure and dynamics of nanoparticles and polymer, with a particular focus on the interfacial (possibly grafted) polymer layer.

structure is shown to provide superior properties by protecting the palladium catalyst, avoiding NP aggregation and loss, and making the system reuseable.

The power of scattering techniques for the investigation of soft matter systems such as polymer nanocomposites is reviewed in the contribution of Kruteva et al. Contrast variation in neutron scattering allows highlighting different parts of nanoscopic objects, and spectroscopic scattering techniques such as neutron spin echo or backscattering spectroscopy match perfectly the length- and time-scales of molecular dynamics. Such measurements can be complemented by NMR and broadband dielectric spectroscopy, highlighting the contribution of chains at the nanoparticle interface. The full picture of nanoparticle arrangement within the polymer matrix, and the way the particles and the chains contribute to the dynamics and thus to macroscopic properties like flow can thus be assessed and possibly optimized.

Nanocomposites consisting of polymer chains and nanofillers inspired by tire rubber materials are presented in the contribution of Philippe et al. Rheological properties are put into relationship with the relaxation spectra from dielectric spectroscopy and on molecular length scales to the relaxation times in neutron spin echo spectroscopy. The impact of filler concentration and temperature as two crucial parameters for rubber in application could be studied in this way, finding an unexpectedly high slow-down of segmental relaxation with the presence of NP interfaces. This molecular relaxation mechanisms could be related to macroscopic properties observed by rheology. Moreover, using a sophisticated deuteration scheme, these authors succeeded in measuring the single-chain structure factor in the bound polymer layer by small-angle neutron scattering.

Finally, hairy nanoparticles are introduced in the mini review by Sharma et al., and discussed in terms of their potential for designing materials with superior properties compared to simpler procedures such as simple mixing of components. Due to the possibility of having self-suspended nanocomposites where the grafted polymer is also the matrix (so-called one component nanocomposite—OCNC), the traditional formulation problems are automatically avoided, and the flow properties can be tuned. Grafting density, molecular weight and grafting chemistry are some adjustable screws for novel materials with advanced mechanical properties.

We hope to provide a small but useful Research Topic of reviews and new research on different types of nanocomposite materials, with various applications such as catalysis or rubber technology, and with a Research Topic of thought-stimulating literature on scattering approaches and other experimental techniques to the study and analysis of polymer-based nanocomposite materials.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Conflict of interest

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