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ELECTRON MICROSCOPY OF POLYMERS

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ABSTRACT

Electron microscopy (EM) is, of course, only one of the many tools for polymer characterization that are of importance for the elucidation (and, therefore, also control) of micro- and nanostructures that determine the properties of polymeric materials. Nevertheless, there are some striking advantages that give electron microscopy some special attention. ***Firstly***, the images can be interpreted even by an eye that is not too deep in the theoretical models: EM, in a literal sense, helps to get *an image* of the situation, lifted from micro- and nanoworld straight to your desktop. ***Secondly***, EM pictures can precisely reproduce local morphological details, heterogeneities and faults down to the nanometer range, and morphological parameters, as there are lamellar thickness distribution, length, long period, orientation and superstructures can be measured directly and in discrete values (that, *in summa*, should match with values generated by methods like WAXS etc. that take an average from the volume under investigation). ***Thirdly***, the investigator has the added value of analytical tools that can be applied at the region of interest, as there are EDX (elemental mapping in the nano-range), EELS (chemical analyses with nanospot accuracy), and electron diffraction techniques.

The lecture provides an overview over standard EM techniques that are considered to constitute the basic tool-box with respect to the ability to select suitable analytical approaches as well as to the ability to read EM images. Transmission (TEM) and scanning electron beam (SEM) image formation principles are briefly recapitulated. These general considerations are followed by a short round-up of recent developments and their impact on advanced EM-based polymer characterization.

The generation of electron beam transparent samples of appropriate thickness (30 … 120 nm for most of the TEM observations on polymers and biological samples) or of suitable surfaces (e.g. block faces for SEM and AFM) from bulk material requires the selection and application of suitable techniques. Since the success of EM and AFM imaging is, to a great extent, depending on proper preparation, the focus is put on the procedures of sample-taking, mechanical preparation, chemical fixation and staining and the use of etching techniques. Sample preparation by means of (cryo-)ultramicrotomy as one of the main procedures for EM preparation of soft matter is discussed in more detail. Finally, recent experiences in the application of ion beam based (FIB) methods and laser-assisted preparation techniques are summarized.

The presentation is illustrated by a number of examples originating from recent work on semicrystalline polymers, nanocomposites, block copolymers, and hybrid biological/biomedical materials.

References

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