Scanning Probe Microscopy Insights into Supramolecular π-Conjugated Nanostructures for Optoelectronic Applications

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Well-defined conjugated materials play an important role in organic electronics because of their precise chemical structure and architecture. This give rise to well-defined functional properties and facilitate control over their supramolecular organization. The solid-state properties of organic electronic materials are determined not only by those of individual molecules but also by those of ensembles of molecules. This ability to control the building of nanoscopic and mesoscopic architectures represents a starting point for the construction of (supra)molecular electronic devices or even circuits (through surface patterning) with nanometer-sized semiconducting objects.

The role of self-assembling processes in these systems is demonstrated here for thiophene-, phenylene-, phenylenevinylene-, and fluorene-based conjugated oligomer (and polymer) linear and branched systems [1]. It appears that the presence of bulky side chains, or chiral centers, or hydrogen bonding groups is drastically affecting the final morphology. During these processes, the interplay between the conjugated molecules, the solvent, the substrate surface, or an external templating structure, such a single strand DNA [2], is the main key-parameter governing the formation of these supramolecular assemblies. Depending on these interactions, one-dimensional (nanowires) or two-dimensional (platelets) objects can be generated. Atomic Force Microscopy (AFM) operating in Amplitude Modulation or Frequency Modulation are used to investigate the morphologies of self assembled conjugated systems starting from molecularly dissolved solutions or from aggregates already formed in solution [3]. Moreover, molecular modelling calculations are essential in this field of research for a better understanding on how the molecules are organized within these nanostructures and therefore rationalize the experimental data.

By using AFM-derived techniques (such as Conducting AFM, Kelvin Probe Force Microscopy), electrical properties can be measured at the local scale (together with the morphological characterization of the samples) helping the optimization of the device performances. Some practical examples such as photovoltaic devices, field effect transistors and white-light emitting diodes [4] will be discussed.

References:

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