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Hydrogen Bonded Polymers

Volume Editor: Wolfgang Binder

With contributions by

W. H. Binder · L. Bouteiller · G. ten Brinke
O. Ikkala · V. M. Rotello · J. Ruokolainen
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Preface

Control of polymeric structure is among the most important endeavours of modern macromolecular science. In particular, tailoring the positioning and strength of intermolecular forces within macromolecules by synthetic methods and thus gaining structural control over the final polymeric materials has become feasible, resulting in the field of supramolecular polymer science. Besides other intermolecular forces, hydrogen bonds are unique intermolecular forces enabling the tuning of material properties via self-assembly processes over a wide range of interaction strength ranging from several kJ mol^{-1} to several tens of kJ mol^{-1}. Central for the formation of these structures are precursor molecules of small molecular weight (usually lower than 10 000), which can assemble in solid or solution to aggregates of defined geometry. Intermolecular hydrogen bonds at defined positions of these building blocks as well as their respective starting geometry and the initial size determine the mode of assembly into supramolecular polymers forming network-, rodlike-, fibrous-, disclike-, helical-, lamellar- and chainlike architectures. In all cases, weak to strong hydrogen-bonding interactions can act as the central structure-directing force for the organization of polymer chains and thus the final materials' properties.

The important contribution of hydrogen bonds to the area of supramolecular polymer chemistry is definitely outstanding, most of all since the potency of hydrogen-bonding systems has been found to be unique in relation to other supramolecular interactions. Thus the high level of structural diversity of many hydrogen-bonding systems as well as their high level of directionality and specificity in recognition-phenomena is unbeaten in supramolecular chemistry. The realization, that their stability can be tuned over a wide range of binding strength is important for tuning the resulting material properties, ranging from elastomeric to thermoplastic and even highly crosslinked duroplastic structures and networks. On the basis of the thermal reversibility, new materials with highly tunable properties can now be prepared, being able to change their mechanical and optoelectronic properties with very small changes of external stimuli. Thus the field of hydrogen-bonded polymers forms the basis for stimuli responsive and adaptable materials of the future. Moreover, the recognition that many aspects of the "bulk"-supramolecular polymer-chemistry can be transferred to binding and recognition events on surfaces is an area still in its infancy. Binding processes of polymers, nanopar-

ticles or other nanosized objects onto (polymeric, quasipolymeric) surfaces by noncovalent interactions already forms a new and strongly expanding area in nanoscience and nanotechnology.

The exploitation of the high specificity of the hydrogen-bonding systems, combined with their dynamic features has opened a new branch in polymer science: dynamic materials with self selection processes. This field, opened up by J. M. Lehn with his "dynamers" is highly prospective for the generation of new materials with properties unachievable with conventional monomers and polymeric materials, relying purely on the covalent bond, instead of the noncovalent, supramolecular interaction.

The present volume on *Hydrogen-Bonded Polymers* provides an overview on these aspects within four main chapters. Different points of view are mirrored, featuring aspects related to (a) classification of hydrogen-bonded polymers according to the nature of the connecting hydrogen bond (by W. H. Binder and R. Zirbs) (b) small-molecule self assembly into hydrogen-bonded polymers (by L. Bouteiller) (c) properties of the resulting materials, with a main focus on the interplay of dynamic properties and polymer-microphases (ten G. Brinke, J. Ruokolainen, O. Ikkala) and (d) nanocomposite materials derived from Hydrogen-bonding elements (H. Xu, S. Srivastava, V. M. Rotello). The varying titles demonstrate that hydrogen-bonded supramolecular polymer chemistry is a highly interdisciplinary research field, where structure, properties and function are closely interrelated to each other.

Still in its infancy, the field of supramolecular polymer chemistry has definitely found its own area and fixed place within the area of macromolecular and polymer chemistry. Although with a certain delay, the recognition of "designed" intermolecular forces as a tool to direct the ordering and function of macromolecules has now been widely acknowledged and respected. The transfer of principles of "organic" supramolecular chemistry is fully accomplished and used with great perfection. Many principles exploited during the past years in this field therefore have already found their application in polymeric material science, and will definitely expand in the near future.

Vienna, February 2007 Wolfgang H. Binder

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