Digital Polymers: Emergence of a New Class of Synthetic Macromolecules

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It has been shown in recent years that information can be stored at the molecular level in synthetic polymers.[1, 2] To achieve such a property, different comonomers are used as a molecular alphabet and assembled together into a defined information sequence. For instance, an alphabet based on two different monomers allows writing of binary information in a linear polymer chain.[3] But of course such digital polymers cannot be synthesized using a standard chain-growth or step-growth polymerization mechanisms because these approaches lead to polydisperse samples containing pronounced sequence defects. Instead, so-called multi-step growth strategies have to be employed.[4] For instance, solid-phase iterative chemistry allows synthesis of a wide variety of uniform sequence-defined digital polymers.[3, 4] This approach is not restricted to oligomers and long digital chains containing more than 100 coded residues have been prepared.[5] Moreover, the information stored in these chains can be easily decoded by tandem mass spectrometry. As shown very recently, not only short but also long digital sequences can be deciphered using this analytical technique.[6] Furthermore, a sequencing software allows decryption in some milliseconds.[7]

Since multi-byte digital encryption and decryption of a synthetic polymer chain has now been clearly demonstrated, the next important challenge in this emerging field of research will be the application of such digital polymers in technological areas; for example for the development of molecular memories. However, such applications are quite demanding and imply to move from simple proofs-of-concept at the single-chain level to complex multi-chain libraries allowing storage and manipulation of larger amounts of information. In this lecture, I will highlight new directions that are currently under investigation in my laboratory for the development of such complex “coded matter”. In particular, I will describe simple strategies for the preparation of polymer materials allowing high-density information storage. Specific emphasis will be put on the development of planar digital micro-arrays as well as on the three-dimensional organization of digital polymers.[8]

References

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