Polymer Membranes/Biomembranes

Bearbeitet von
Wolfgang Peter Meier, Wolfgang Knoll

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Preface

The multicomponent nature of biological membranes and their intra- and extracellular interactions make direct investigations on the membrane structure and processes nearly impossible. Clearly, a better understanding of the membrane properties and the mechanisms determining membrane protein functions is crucial to the implementation of biosensors, bioreactors and novel platforms for medical therapy. For this reason, the interest in model systems suitable for the construction and study of complex lipid/protein membrane architectures has increased steadily over the years. The classical portfolio of model membranes used for biophysical and interfacial studies of lipid (bi)layers and lipid/protein composites includes Langmuir monolayers assembled at the water/air interface, (uni- and multi-lamellar) vesicles in bulk (liposomal) dispersion, bimolecular lipid membranes (BLMs), and various types of solid-supported membranes. All these have specific advantages but also suffer from serious drawbacks that limit their technical applications. Polymer membranes comprised of entirely synthetic or hybrid (synthetic polymer/biopolymer) block copolymers appeared to be an attractive alternative to the lipid-based models. Generally, the synthetic block copolymer membranes are thicker and more stable and the versatility of polymer chemistry allows the adoption of relevant properties for a wide range of applications.

This volume provides a vast overview of the physico-chemical and synthetic aspects of artificial membranes. Numerous membrane models are described, including their properties (i.e. swelling, drying, lateral mobility, stability, electrical conductivity, etc.), advantages, and drawbacks. The potential applications of these models are discussed and supported by real examples.

Chapter 1 summarizes methods for the stabilization of artificial lipid membranes. They include synthesis of new types of polymerizable lipids and polymerization of membranes. Creation and characterization of novel poly(lipid) membrane systems, as well as their functionalization for biotechnological applications, are also described. Chapter 2 addresses experimental studies on the design and characterization of lipopolymer-based monolayers at the air-water interface. Thermodynamic and structural data collected with X-ray and neutron reflectrometry, infrared reflection absorption spectroscopy, and sum frequency generation spectroscopy provide

information on how the lipopolymers organize at the air-water interface. Important insight into the viscoelastic and lateral diffusion properties of these systems is also given. The assembly and the structural and functional characterization of various types of polymer-supported lipid bilayer membranes are discussed in Chapter 3. It has been shown that the chemical nature of the polymer cushion can be diverse, ranging from polyelectrolytes to glycopolymers and cross-linked hydrogels, which makes it possible to tailor the features of the polymer supports. Additionally, important properties of the tethered membranes such as swelling in water of the polymer tethers and lateral mobility of the lipid molecules are presented. Synthetic block copolymer membranes represented mainly by vesicles are introduced in Chapter 4. Here the discussion is focused on principles of vesicle formation, membrane properties, and methods for vesicle preparation and characterization. Numerous membrane-forming copolymer systems are presented, including copolymer membranes with responsiveness to external stimuli. In addition, recent examples demonstrating the use of vesicles as therapeutic formulations, for cellular targeting and as nanoreactors, revealed their high potential for bio-applications. Chapter 5 is dedicated to biohybrid vesicles consisting of a synthetic polymer and biologically relevant polymer, e.g. peptides and sugars. The self-assembly mechanism of biohybrid amphiphilic polymers is described as a function of polymer composition (geometrical packing of chains), hydrogen bonding, secondary structure interactions and supramolecular complexation. The potential use of biohybrid membranes as drug and gene carriers, bioreactors, and composite materials, as well as for cell recognition, is accented. Finally, Chapter 6 reviews molecular models and computer simulation techniques for amphiphilic vesicles formed either by lipid or block copolymer molecules. System-specific, atomistic and coarse-grained representations of amphiphilic vesicles are considered. The discussion of the coarse-grained models is particularly focused on how their parameterization can be related to the material properties of specific systems. As these models are particle-based, their equilibrium properties are obtained from a straightforward Monte-Carlo scheme. The mechanical properties of the vesicles are established and compared with the properties of a planar bilayer. Selected results demonstrated the effect of loading on the vesicle stability and the mechanical properties of its bilayer shell.

In summary, we attempted to collect contributions from several expert groups to summarize the current state of the art of artificial membranes. There still exist many challenges and opportunities for improvement before at least some of these developments are commercialized. Certainly, this process will call for a fruitful interdisciplinary research and we hope that the current volume could be a useful source of fundamental information.

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Wolfgang Knoll

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