S-layer protein lattice as a key component in biosensor development

Bernhard Schuster

Abstract

Statement of the Problem: Combining biological with electronic components is a very challenging approach because it allows the design of ultra-small biosensors with unsurpassed specificity and sensitivity. However, many biomolecules lose their structure and/or function when randomly immobilized on inorganic surfaces. Hence, there is a strong need for robust self-assembling biomolecules, which attract great attention as surfaces and interfaces can be functionalized and patterned in a bottom-up approach. Methodology: Crystalline cell surface layer (S-layer) proteins, which constitute the outermost cell envelope structure of bacteria and archaea, are very promising and versatile components in this respect for the fabrication of biosensors. S-layer proteins show the ability to self-assemble in-vitro on many surfaces and interfaces to form a crystalline two-dimensional protein lattice. The S-layer lattice on the outside of a biosensor turns out to be a piece of the interface engineering connecting the bioreceptor to the transducer interface, which may cause signal enhancement. The S-layer lattice as ultrathin, exceptionally permeable structure with useful gatherings in a very much characterized spatial dissemination and direction and a general enemy of fouling qualities can fundamentally bring the cutoff up as far as assortment and simplicity of bioreceptor immobilization, smallness and arrangement of particle course of action, specificity, and sensitivity. In addition, emulating the supramolecular building standard of archaeal cell envelopes, containing a plasma film and an appended S-layer grid permit the creation of S-layer bolstered lipid layers. In the last mentioned, film dynamic peptides and layer proteins can be reconstituted and used as profoundly delicate bioreceptors. Biosensor-related examination has gained colossal ground in the course of recent decades, in light of the fact that the development in gadgets, nanolithography, nanobiotechnology, biomimetics, and manufactured science prompted effective courses for consolidating natural frameworks with silicon innovation. Biosensors are per definition devices, which use a biological recognition element that is retained in direct spatial contact with the transduction system or, in simplified terms, a device that changes over a physical or natural occasion into a quantifiable, for the most part electrical sign. The biosensing component or bioreceptor is every now and again an organically determined or biomimetic material, such as living cell, tissue, compound, film protein, layer dynamic peptide (e.g., ionophore), immune response, nucleic corrosive, and natural delicate components that are made by genetic engineering. The analyte, which binds in a highly specific manner to the bioreceptor may be amongst other ions, nucleic acids, and other organic molecules from cell cultures, human and food samples, and pollutants from environmental samples. One of the most testing assignments is to meet natural or biomimetic frameworks with silicon innovation so as to produce the utilitarian interface engineering. Natural particles may total or even denature on the outside of cathodes, sensors, or other generally inorganic strong backings, and thus, free their capacity. In order to prevent the loss of function, very frequently an intermediate layer is generated between the biosensing element and the inorganic surface of (ion-sensitive) field-effect transistors, microarray electrodes, metal-, polymer-, or graphene-coated sensor chips, etc. This intermediate layer comprises either of polymers, self-assembled monolayers, or a monomolecular array of self-assembled protein subunits forming surface layers. If a lipid membrane is desired as part of the biosensing element, then an incomplete layer of so-called tether molecules replace the rigid SAM. Incomplete in the sense that one wants to have only few tether molecules, which anchor the membrane to the surface. This course of action, where the tether particles are blended in with supposed spacer atoms guarantees a specific fluidity of the lipid film. The latter is very important if one wants to reconstitute integral membrane proteins and/or membrane-active peptides functionally in a tethered membrane. In general, a tether molecule is composed of a binding group to be anchored on a solid support, a hydrophilic backbone, and a hydrophobic moiety to anchor the lipid membrane. Molecules, like polymers, glyco-polymers, peptides, and proteins are used so far to build up the hydrophilic part of the tether layers. The challenge generating the intermediate layer is to combine multiple functions, including: to act as immobilization layer with a suitable binding to both, the inorganic support, and the biological molecules (e.g., bioreceptors, matrix-forming lipids; (2) to allocate a binding matrix where the immobilized molecules are arranged in a well-defined spatial and directed orientation; to provide a reservoir for water and ions; and, to provide sufficient space and stability for the biosensing elements. Furthermore, some biosensors requires an immobilization method of the bioreceptor to the sensor surface utilizing physical or built methodologies. This is in particular the case if one wants to rely on film proteins and layer dynamic peptides as biosensing component on the grounds that these biomolecules need a lipid film to embrace their practical structure and to send intensification properties. The immobilization of the biosensing component has the extra bit of leeway to be assessable with the wide arms stockpile of surface-detecting strategies. For sure, numerous biosensors depend on surface-delicate strategies, similar to surface plasmon spectroscopy (SPR), surface acoustic wave (SAW), quartz gem microbalance with dissemination checking, electrochemical impedance spectroscopy, cyclovoltammetry, or total internal reflection fluorescence microscopy transducer. Important questions in this context are how one can create an intermediate layer with all of the intrinsic properties listed above and how can the biosensing element be coupled to or integrated in this functional layer. The present paper focuses on a promising approach to generate a particular type of protein-based intermediate layer, the so-called surface layer. In the

accompanying, I present a introduction to bacterial S-layer proteins and their utilization for the immobilization of practical particles and lipid layers. In addition, I additionally present S-layer combination proteins and their usage as segments for the age of biosensors. Finally, I discuss the application of S-layer lattices for the generation of functional lipid membrane platforms in detail and possible further future directions. Conclusion & Significance: S-layer proteins bridge the biological with the inorganic world and hence, fulfill key requirements as immobilization matrices and patterning elements for the production of biosensors.. This presentation sums up models for the fruitful execution of bacterial S-layer protein lattices on biosensor surfaces so as to give a review on the application capability of these bioinspired S-layer protein-based biosensors.

Bernhard Schuster

University of Natural Resources and Life Sciences, Austria, Germany