A Review on the Technologies for Micro-Patterning Self-Assembled Monolayers to Understand Interactions of Biomaterials with Surfaces

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Statement of Purpose: The ability to engineer surface properties (e.g. wettability, adhesion) at microscopic scale is the key in the emerging technologically important areas such as bio-sensors, tissue engineering, microelectromechanical systems (MEMS), and controlled delivery of liquids in microfluidics. The ability to control/define surface properties is also important to fundamental studies in surface sciences and physics (e.g. wetting). Alkanethiols (HS(CH2)nX) provide a means to engineer surface properties. Alkanethiols chemisorb on some metallic surfaces, e.g. gold, silver and copper, through metal-sulfur bonds, spontaneously, through the following reversible chemical reaction:

M + HS(CH2)nX = M- S(CH2)nX + ½ H2
M= Au, Ag, Cu, etc.

The alkanethiols make a very stable well-packed one-molecular layer called self-assembled monolayer (SAM) on gold, and based on their end groups (X) can show various surface characteristics. For example, a methyl end group (X=CH3) shows hydrophobic properties and a carboxylic acid end group (X=COOH) shows hydrophilic properties. The packed and crystalline structure of SAMs can mask certain properties of the substrate, e.g. biocompatibility, wettability and adhesion. Thus, the SAMs provide a means to systematically modify surface properties. The objective of this research is, therefore, to summarize to what extent these well-defined surfaces has been used to understand interactions of biomaterials with surfaces.

Often for technological reasons a surface is required to have different properties at neighboring regions, e.g. wettability, adhesion and different chemical functionalities. Such a surface is called a patterned surface. Using patterned SAM surfaces a broad range of surface properties can be modulated.

Methods: The properties of SAM coated surfaces that can be systematically altered and the ways for "patterning" a SAM surface are competitively discussed based on literature reports. The review also covers manipulation of biomaterials and living cells at interfaces. Spatial control of biomaterial-surface interactions is possible through controlling biomaterial attachment to the surface. Advantages with these systems include the optical transparency of SAMs when supported on thin films of gold, the electrical conductivity of the underlying gold, the compatibility of these substrates with a range of analytical methodologies, the stability of these substrates during storage and in contact with biological media, and the range of surfaces, including curved and nonplanar substrates, that can be used.

Down stream technologies such as development of advanced devices (e.g. biosensors, bioelectronic components, smart biomaterials and microarrays) have received particular attention. Extension of patterning methodologies to SAMs on silicon substrate is covered as well.

Results: The SAM patterning technologies have extensively used to understand interactions of biomaterials with surfaces:

- Interactions of cells and proteins with man-made surfaces.
- Neuronal growth

Beyond understanding, on the application level several SAM patterning technologies have been used for bioscience and medical techniques:

- Separation of cells
- Regeneration/guidance of neurons
- Directed growth of bone cells
- DNA manipulation

Conclusions: Among the tools nowadays available, professionals can find reliable techniques that have been developed for manipulation of DNA, proteins and other biomolecules, as well as cells, spatially and temporally at surfaces with high precision. Spatial control of biometerials on surfaces can be achieved by the production of patterned surface chemistries using modern high-resolution patterning technologies and temporal control is accessible through the application of switchable surfaces and application of electric/magnetic and electromagnetic fields, e.g. laser based methodologies [1]. The features of SAMs described in this review make them well-suited model surfaces for studies in biology that require substrates with tailored properties.

References:

1. Shadnam, M.R., Amirfazli, A.A. (2008) *J. Comput. Theor. Nanosci.* 5, 2054–2059.