Plasma surface modification of DNA and Protein Microarrays

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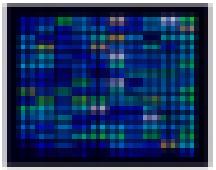


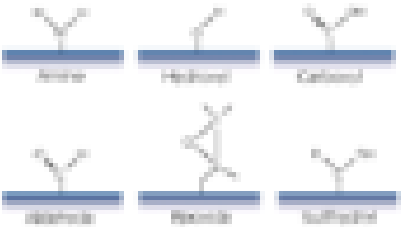
Microarray technology has accelerated the rate of biomolecular research by enabling an enormous number of experiments to be conducted in parallel. This is achieved by immobilizing arrays of probe biomolecules, such as oligonucleotides or proteins, in picomole quantities onto a substrate. The attachment of these probes requires chemically functionalizing the surface. This is a critical step in microarray fabrication and plays a significant role in their functional performance. Plasma surface functionalization reduces the complexity of wet chemical treatments, controlling surface cleanliness, functional chemistry and hydrophilicity in a single, automated process step.

What is plasma?

Plasma is a gas energized to a state of electrical conductivity. Chemically it is a highly reactive environment that is used to control properties of surfaces without affecting the bulk material. This is accomplished by first cleaning the surface at the molecular level. It then activates both the surface and the chemical precursor that is fed into the plasma. Chemical grafting of the precursor to the surface takes place at low temperature in a reliable, consistent, and environmentally friendly manner.

Microarray operating principle

DNA and protein microarrays have fast become essential tools in genetic sequencing, genetic variation analysis, and gene expression. They are used in research fields such as gene discovery, elucidation of bio-pathways, disease biomarker detection, prediction of drug responsiveness, etc. Hybridization/binding of the surface immobilized probe molecule with a labeled target molecule is the principle behind their operation. In DNA microarrays the higher the number of complementary base pairs between nucleotide strands of the probe and target the better the bonding. After washing only the strongest paired strands remain hybridized. Probe/target bonding is usually quantified photonically via labeled targets.



Above are the functional groups that plasma can readily microarray platforms with. The functional groups are deposited onto surface via a PECVD-like process producing plasma polymers with the desired chemical functionality.

Amine and epoxy functionalities

Amine functionality provides positively charged binding sites for the electrostatic attachment of oligonucleotides via their negatively charged phosphate groups. If steric hindrance interferes with direct binding of these large biomolecules, linkers provide space for the biomolecule to attach in the right configuration. Linker molecules themselves are anchored to the substrate via plasma chemical grafting e.g. amine groups.

Amine groups increase surface energies rendering them hydrophilic. Overly hydrophilic surfaces may not be desirable when depositing e.g. gel drop arrays onto a microarray platform, because the micro droplets may wet in a malformed manner. Again, gas plasma can solve this problem and preserve the morphology of the droplets by controlling the surface energy, even in the presence of the amine groups.

Epoxy plasma functionalization has proved a successful surface treatment, particularly for protein microarrays. The surface is more hydrophobic compared with other chemical functionalities, facilitating fabrication by reducing spot spreading, and most importantly showing more resistance to non specific adsorption. Non specific adsorption of DNA strands on the screen surface will increase the background and reduce the selectivity of the screen.

What are the benefits of plasma surface modification of microarray platforms?

The chemical functionalization of microarray platforms using wet chemistry has observed the