Plasma Treatment for Catheter Functional Bio-coatings

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Catheters are inserted into the body to perform functions such as fluid drainage, duct dilation and drug/nutrient delivery. As an invasive device however, both the catheter function and the host's health and comfort can be compromised due to biocompatibility issues. Tissue trauma during insertion, introduced pathogens, blood-borne pathogen adsorption and propagation, thrombus (vascular), and encrustation (urological) are problems associated with catheter use. Plasma surface modification is at the forefront of technologies used to minimize the harmful side effects associated with catheter insertion and indwelling. For example, properties such as lubricity, anti-fouling, anti-microbial, anti-thrombogenic etc. can be introduced. This can be achieved by direct use of plasma produced surfaces. Alternately plasma can be used to tailor surface chemistries with specific functional groups that are used to chemically bind the functional biocompatible coating.

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 change the properties of surfaces without affecting the bulk material. Plasma is a powerful tool in solving surface preparation problems such as precision cleaning and decontamination, increasing surface wettability and adhesion promotion of functional bio-molecules and coatings. Plasma can also be used to polymerize coatings onto surfaces through a techniques called Plasma Enhanced Chemical Vapor Deposition (PECVD).

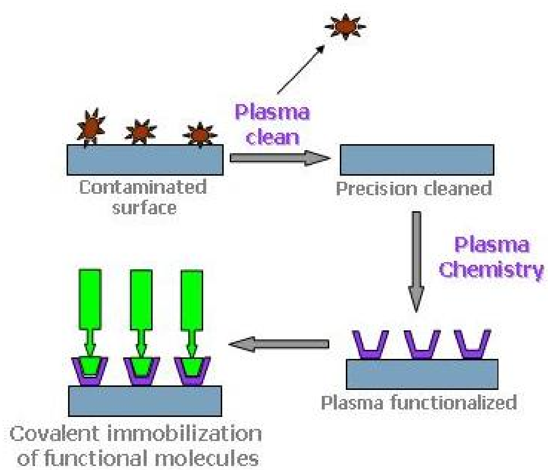
The main advantage of plasma as an enabling technology is that it is a dry process. As such there are none of the liabilities of wet chemistry, such as leaching solvents.

Surface chemistries for urological catheters

To minimize tissue trauma upon insertion and extraction of urinary catheters, a lubricious coating is applied. Plasma activation is critical to increase the surface energy of the catheter material prior to the grafting step of hydrophilic lubricious polymers such as Polyvinylpyrrolidine (PVP), polyethylene glycol or hydroxyethylmethacrylate. Insertion forces are significantly reduced with these "slippery when wet" coatings. Plasma is also used to initiate partial crosslinking of perfluoropolyether (PFPE), a low friction hydrophobic polymer.

Anti-biofouling coatings are usually variations of long hydrophilic chains such as polyethylene glycol (PEG) or PVP. Catheter surfaces can be chemically functionalized by plasma prior to wet chemically immobilizing these polymers. Attaining high surface concentration of chemical functionality (e.g. primary amines) is critical to the performance of the antifouling properties of the coating. This ensures high concentration of adjacent chains that can entangle during hydration creating a hydrophilic barrier to protein adsorption.

Antimicrobial agents can either be tethered to anti-fouling polymer chains or incorporated in to the coating where they are released over time.



Plasma prepares the surface by molecular cleaning. Specific chemical groups are then grafted by a second plasma step. The surface is then exposed to the functional molecules that chemically bind to the plasma grafted moieties

Surface chemistries for intravascular catheters and anti-thrombogenic coatings

Protein binding to materials in contact with blood initiates the process of clot formation. To combat this process, anti-thrombogenic coatings are applied. Such coatings often fail to bind to the polymer surface, shedding particles that can create emboli. Plasma treatment ensures high binding affinities of these coatings. The treatment process is unique for specific base materials, composition of the anti-thrombin, and expected product lifetime. When catheters are implanted into the body, blood clots develop and lead to premature catheter replacement. Animal test results on polyurethane catheters that were surface modified by plasma and then heparin coated revealed no protein attachment after 30 days indwelling. Simultaneous testing of polyurethane catheters treated but left uncoated, revealed only slight protein attachment while the untreated and uncoated control catheters displayed severe thrombus formation.

ePTFE

Expanded polytetrafluoroethylene (ePTFE) is a commonly used material for prosthetic implant applications. It's mechanical strength, impermeability to blood and inertness to bio fouling make ePTFE ideal for such *in-vivo* applications. Its flexibility aids in healing, and catheter tubing doesn't kink very easily and generally has good compression resistance. For biomedical applications the ability to modify PTFE surfaces is important to promote interfacial biocompatibility. For example, the adhesion of anti-thrombogenic enzymes such as thrombomodulin, urokinase and heparin requires the PTFE surface to be first modified with chemical "anchors" such as carboxylic groups that provide covalent immobilization of these enzymes. Retention of hydrophobic properties are important for surfaces that have intimate contact with blood since they are non-activating to platelet adsorption (leading to the adsorption of fibrin). It is possible to graft polar functional groups to PTFE by plasma activation with only a modest loss in hydrophobicity.

What does PVA TePla America offer?

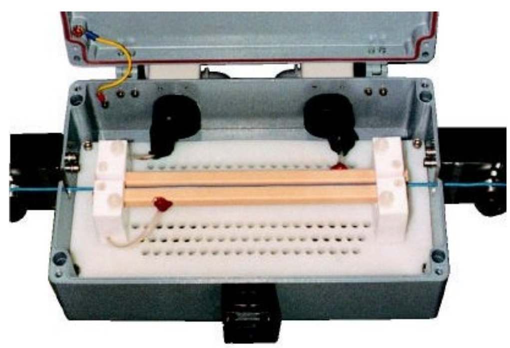
At PVA TePla America we offer a full line of vacuum and atmospheric gas plasma systems. Our reliable, easy-to-operate products deliver some of the most advanced and innovative solutions for a wide variety of industrial applications. We also offer clean area contract processing services with ISO 9001:2008 certification. This allows you to access gas plasma technology without up front capital expenditure on labor and/or facilities. Additionally, we offer free proof of process as an incentive to evaluate our plasma technology.

IoN 300

The **IoN 300** meets the high volume production requirements of our customers, emphasizing versatility and control. Its advanced features provide state of the art process control, fail-safe system alarms and data capturing software. This enables the equipment to meet the stringent control programs in the Life Science industries. The **IoN 300** uses radio frequency (RF) generated plasma in a fully integrated package. One very unique feature of the **IoN 300** is the ability to quickly and easily alternate electrodes between vertical configuration (for hanging catheters up to 66" long) to multiple horizontal shelves (up to 30).

Inline Catheter Treatment Station SKD 2.5

The SKD2.5 was designed for the inline plasma treatment of tubes, cables and wires up to 4mm in diameter. The unit treats the full 360° in one pass and is effective for PTFE and silicones.



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