PLASMA APPLICATIONS:
Surface Activation and Modification

For references citing the use of our plasma cleaners for surface activation and modification, see the Surface Modification and Surface Wettability categories in the References: Technical Articles page.

Benefits of Plasma Treatment

- Modify surfaces by attachment or adsorption of functional groups to tailor surface properties for specific applications
- Restructure polymer surfaces through crosslinking
- Deposit polymer layers by plasma polymerization
- Graft functional polymers or end groups onto plasma-activated surfaces [Figure 1]
- Prepare surfaces for subsequent processing, e.g. film deposition or adsorption of molecules
- Improve surface coverage and spreading of coatings and enhance adhesion between two surfaces (See Surface Adhesion and Wettability)
- Modify wettability to render a surface hydrophilic [Figure 2] or hydrophobic [Figure 3] with the appropriate process gas(es)
- Change surface properties without affecting the bulk material

Applications

- Self assembly studies with patterned hydrophilic and hydrophobic surfaces
- Dental research of periodontal cell adhesion
- Promote adhesion of microorganisms on plasma-modified surfaces
- Promote adhesion of cells and cell proliferation on plasma-modified biomaterials or tissue scaffolds
- Modify surface to act as protective or barrier layer to the bulk material
- Crosslink polymer surfaces to reduce permeability of specific molecules
- Render surfaces hydrophilic by oxidation and formation of hydroxyl (OH) groups
- Render surfaces hydrophobic with deposition of fluorine-containing groups (CF, CF_2, CF_3)

Processing Methods

- Oxygen or air plasma
  - Removes organic contaminants by chemical reaction with highly reactive oxygen radicals and through ablation by energetic oxygen ions
  - Promotes surface oxidation and hydroxylation (OH groups); increase surface wettability
  - Oxidation may be undesirable for some materials (e.g. gold) and can affect surface properties
- Argon plasma
  - Cleans by ion bombardment and physical ablation of contaminants off the surface
  - Does not react with the surface or alter surface chemistry
- Carbon tetrafluoride (CF_4) plasma
  - Forms hydrophobic coating of fluorine-containing groups (CF, CF_2, CF_3)
  - Decreases number of hydrophilic polar end groups on surface; decreases surface wettability
- Surfaces should be used immediately after plasma treatment; plasma-treated surfaces may recover their untreated surface characteristics with prolonged exposure to air
- Suggested process parameters values for plasma treatment using a Harrick Plasma cleaner (some experimentation may be required to determine optimal process conditions)
  - Pressure: 100 mTorr to 1 Torr
  - RF power: Medium or High
  - Process time: 1-3 minutes

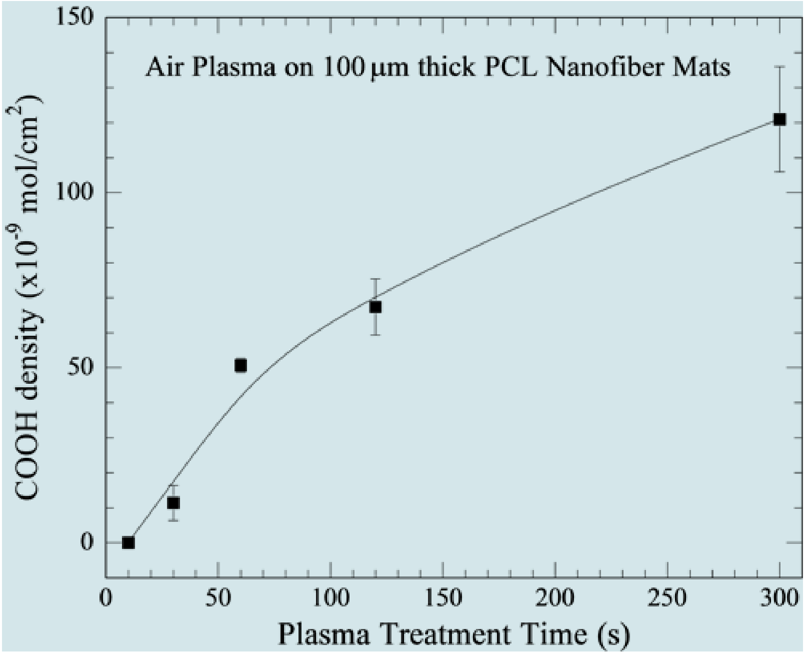

Figure 1. Surface density of carboxyl (COOH) groups as a function of air plasma treatment time, using a Harrick Plasma cleaner, on 100 μm thick poly (caprolactone) (PCL) nanofiber mats. The COOH layer facilitates subsequent grafting of gelatin molecules onto the PCL nanofiber mats for potential use as tissue-engineering scaffolds. Data from Ma, Z., W. He, T. Yong, S. Ramakrishna. "Grafting of Gelatin on Electrospun Poly(caprolactone) Nanofibers to Improve Endothelial Cell Spreading and Proliferation and to Control Cell Orientation." Tissue Eng. (2005) 11: 1149-1158.

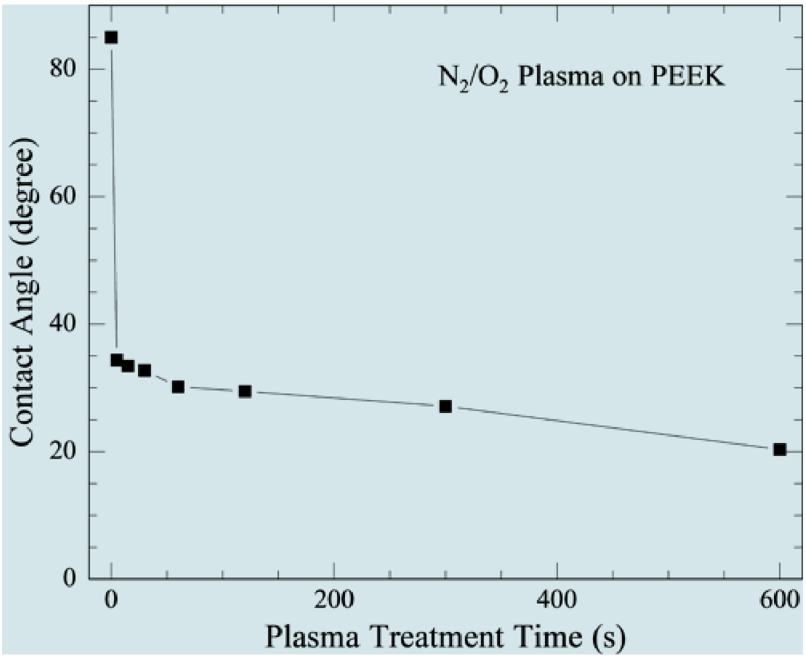

Figure 2. Water droplet contact angle as a function of N_2/O_2 plasma treatment time, using a Harrick Plasma cleaner, on polyetheretherketone (PEEK). The PEEK surface is rendered hydrophilic after 20 seconds of plasma treatment. Data from Ha, S.-W., M. Kirch, F. Birchler, K.-L. Eckert, J. Mayer, E. Wintermantel, C. Sittig, I . Pfund-Klingenfuss, M. Textor, N. D. Spencer, M. Guecheva, H. Vonmont. "Surface Activation of Polyetheretherketone (PEEK) and Formation of Calcium Phosphate Coatings by Precipitation." J. Mater. Sci.- Mater. Med. (1997) 8: 683-690.

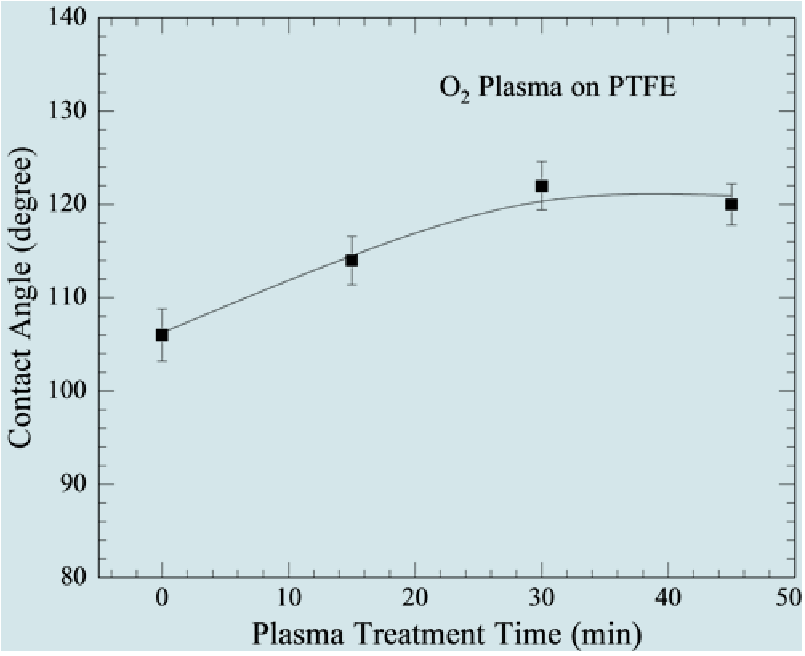

Figure 3. Water droplet contact angle as a function of O_2 plasma treatment time, using a Harrick Plasma cleaner, on poly(tetrafluoroethylene) (PTFE), indicating increased hydrophobicity. Plasma treatment produces nanoscale roughness that increases hydrophobicity. Data from Lee, S.-J., B.-G. Paik, G.-B. Kim, Y.-G. Jang. "Self-Cleaning Features of Plasma-Treated Surfaces with Self-Assembled Monolayer Coating." Jpn. J. Appl. Phys. (2006) 45: 912-918.