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Polymer Surface Modification with Atmospheric-Pressure Plasmas

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Project Summary

The goal of this research is to understand how an atmospheric-pressure plasma can modify the surfaces characteristics of polymers. Polymers such as Teflon, PVC, and polypropylene are commonly used in everyday life. They have desirable properties such as being light weight and chemically resistant. They are also inexpensive and easy to produce. However they lack natural surface properties necessary for applications in chemistry, biology, and material science. Some example surface properties include selective reactivity and bonding, high or low wettability, and high conductivity. For these reasons, surface modification of polymers to transform them from inexpensive materials into highly valuable items has become an important part of many industries. Common surface modification techniques include treatment by flame, UV light, electron beams, ion beams, chemicals, lasers, and X-rays. We seek to investigate a new method to modify polymer surfaces, high-pressure plasmas.

Plasma modification of polymers is used today, though primarily in vacuum conditions. The ability to generate a stable plasma jet at atmospheric pressures is relatively new to the field and not yet well understood. Operating at atmospheric conditions greatly simplifies the process and reduces costs. This has potential to change the current paradigm of surface processing. However we first must better understand how the plasma modifies polymer surfaces.

The objective of this RCEU project is to develop an empirical relation between the plasma conditions and the resulting polymer surface properties. The project will be experimental using the atmospheric-plasma device at the lab. By changing the power level and gas used, different plasma conditions can be produced that may produce various results on the polymer surfaces. Polymer samples such as Teflon or PVC will be exposed to the plasma jet for varying durations and offset distances. Characterization of the surface will be performed with IR and Raman spectroscopy and contact angle measurements. We seek to obtain at least an empirical relation between the power and gas type to the surface properties. The surface characterization will be carried out in partnership with Dr. Waddell in Chemistry.

The RCEU student's tasks in the project include:

A) Design of the test plan.
B) Operation of the plasma device.
C) Characterization of the surface properties.

Student Duties

The student will have primary responsibility for designing the testing plan for the materials, running the plasma device and exposing samples, and characterizing the surfaces. Any necessary materials and parts will be provided. Graduate student support as well as my support will be available for the project. The final step, analyzing the data, will be a joint effort between the RCEU student, graduate students, me, and Dr. Waddell. The RCEU student is expected to be a self-motivated and diligent professional. He or she will have significant independence on the project, though assistance and direction is always available. The student is expected to contribute

to group meetings, read necessary background material, and conduct any independent learning necessary to successfully conduct the research. A journal club meeting occurs each week in the lab where one person is asked to prepare and present and discuss an article they have read. The RCEU student is expected to participate in the journal club and prepare at least one article presentation during the summer.

This project will provide the student a chance to conduct hands-on research in the interdisciplinary field of plasma science and material chemistry. The work provides new experience that cannot be gained as part of a regular undergraduate curriculum or through internships and co-ops. This project is a great way to experience experimental research for future graduate pursuits.

The expected data from this project are surface properties such as contact angle, bond strengths, and bond types as a function of plasma power, gas, exposure time and distance. At the end of the semester the student is expected to produce a detailed report of his or her work in journal format. I encourage submission of quality work to society or national conferences and journals.

Mentor Supervision and Interaction

During the summer semester, I spend 2-3 days a week personally working at the lab alongside my students. I may assist with their projects or do work on my own. Thus I will have regular interactions with the RCEU student. The student will also have daily interactions with the graduate students who work with me and conduct research in the lab. Direct supervision, mentoring, and evaluation of the project by me will occur once a week at the regularly scheduled project meetings at the lab. In the meetings we will discuss the current status of the project, the results and difficulties, what to do next, and address any other issues that may come up. Indirect interactions and mentoring by graduate students and I will occur throughout the semester as part of the day to day activities. The student will either report to me, or Ms. Blair, the graduate student working on the atmospheric-pressure plasma research of which this project is part of.