Effective Method to Functionalize a Metal Surface with Minimal Coating Material

Jeffrey J. Weimer  
*University of Alabama in Huntsville*

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RCEU 2023 Project Proposal

Title

Effective Method to Functionalize a Metal Surface with Minimal Coating Material

Faculty Information

Name: Jeffrey J Weimer
Status: Associate Professor
Department/Program: Chemistry
College: College of Science
Phone: x6954
UAH Email: Jeffrey.Weimer@UAH.edu

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I. Project Description

The goal is to develop an easy, robust method to make a metal surface water repellent (hydrophobic) with a minimal amount of coating. Because Teflon is strongly hydrophobic, we imagine coating metals with a molecular agent that has a comparable chemistry. One candidate is 1H, 1H, 2H, 2H per-fluoro-octyl-trimethoxysilane (PFTMS). Its large molecular size, its abundance of fluorine groups, and its ability to form strongly adherent chemical bonds should make PFTMS a good candidate, even when coating a monolayer (single molecular layer).

Two methods are proposed for coating, vapor deposition and wet chemistry solution. The parameters that can be varied include solution concentration and deposition time. The hydrophobicity of the functionalized surfaces will be evaluated using contact angle goniometry. This technique measures the angle that a water drop makes on a surface. The functionalized surfaces can also be examined using Fourier transform infrared spectroscopy. This may quantify the relative amount of PFTMS on the surface as well as how the PFTMS bonds to the metal.

II. Student Duties, Contributions, and Outcomes

a. Specific Student Duties

Your first duty is to learn how to use the contact angle system proficiently. You will analyze a range of liquids on a range of surfaces. You will validate your results against the literature. This duty should be completed to full satisfaction in the first two weeks.

Your second duty is to create solutions of a chosen solute that mimics PFTMS in a chosen solvent at well-defined, micro- or milli-molar concentrations. You will create these solutions with well-known concentrations. This duty should be completed in one or two weeks and can start while the first duty is being completed.

Your third duty is to define the experimental protocols that you will use and to set up the equipment to perform the wet chemistry and/or vapor driven coating processes. You will assemble glassware and chemicals, establish one or both deposition methods in a series of dry-runs, and write viable protocols for each method. Your protocol report will be reviewed for approval by the project mentor. This duty should be completed in two weeks and can start in parallel with the second duty.

Your fourth duty is to carry out the approved depositions and measurements as a function of solution concentration and/or deposition time. This duty should be completed in three weeks.

Your fifth duty is to analyze the measured data to determine a characteristic for deposition efficiency, primarily as hydrophobicity versus solution concentration or deposition time. You will apply spreadsheet analysis to graph the measured data and, as appropriate, perform additional regression or curve-fitting analysis. This duty should start in parallel to the fourth duty and be completed within one week before the project ends.
Your final duty is to create a written report and a poster to document your work. This duty will start throughout the project and must be completed in the final week of the project.

b. **Tangible Contributions by the Student to the Project**

You will expand the state of our research work to functionalize surfaces. We have an ongoing thesis project in Chemistry to functionalize the surfaces of silicon wafers and mica with hydrophobic coatings. You will benefit significantly from achievements in this thesis work. Your work will compare the results obtained on silicon wafer and mica surfaces to metals.

c. **Specific Outcomes Provided by the Project to the Student**

The outcome from the first duty is an improvement in your skill at using contact angle goniometry to measure the wettability of solid surfaces.

A primary outcome from the second duty is an improvement in your skills to create chemical solutions with well-defined concentrations at the small (micro- or milli-molar) range. An additional outcome is an improvement in your ability to evaluate the precision on measured values from such work.

The outcome from the third duty is an improvement in your ability to create and document a viable protocol to carry out an a laboratory experiment in chemistry. The outcome from the fourth duty is an improvement in your skills at completing such a protocol. The outcome from the fifth duty is an improvement in your ability to evaluate data from an experiment in chemistry.

The final outcome is an improvement in your ability to document the objectives, experimental approach, data, and results from a laboratory experiment in chemistry.

### III. Student Selection Criteria

Students should have at least a 200 level experience in a chemistry-related laboratory. With otherwise comparable qualifications for students who apply to this project, preference will be given to students who have taken CH 224, the analytical chemistry course and laboratory.

### IV. Project Mentorship

You will be mentored by the project advisor and by an MS graduate student in Chemistry (Elizabeth Cantrell). The graduate student will teach you how to use the contact angle system and how to create solutions at small concentrations in a consistent, reliable manner. The graduate student will also oversee your day-to-day work in the laboratory. The project mentor will review your progress on at least a weekly basis in one-on-one meetings with you and the graduate student. He will also train you on how to keep certifiable laboratory notebooks, how to write properly structured technical reports for protocols and experimental methods, how to display images and results from the contact angle and FTIR analysis, how to analyze data quantitatively, and how to complete a properly structured technical report about the work done and the results obtained during the project.