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Simple, aqueous-based amination of polycarbonate surfaces

Virginia VanDelinder[a], David R. Wheeler[b], Leo J. Small[c], Erik D. Spoerke[c], Ian Henderson[a], George D. Bachand[a]

[a] Center for Integrated Nanotechnologies, Sandia National Laboratories
[b] Biosensors and Nanomaterials, Sandia National Laboratories
[c] Electronic, Optical, and Nanomaterials, Sandia National Laboratories

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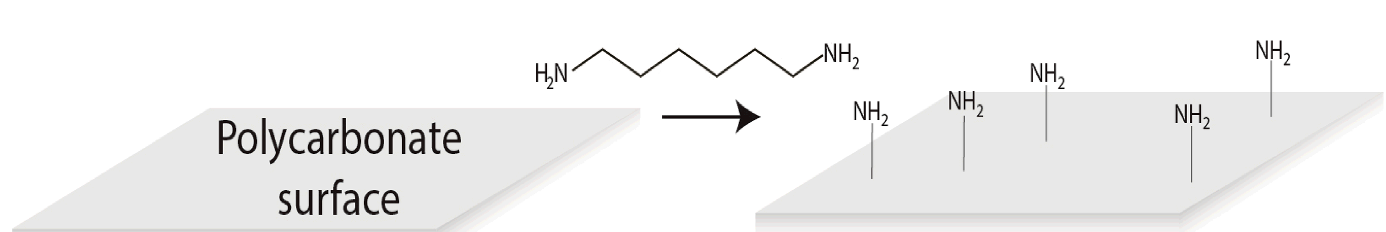
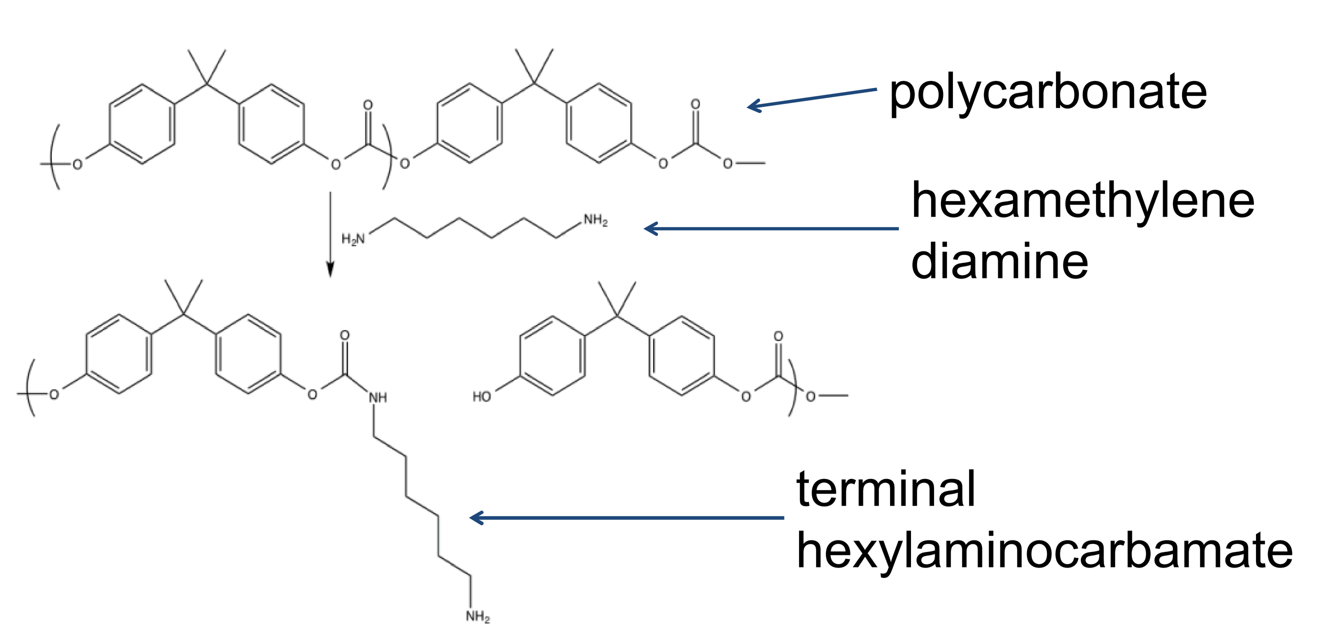
Introduction

Polycarbonate (PC) is a desirable material in many applications due to its high impact strength, toughness, heat resistance, and optical transparency. PC has widespread industrial applications ranging from lab-on-a-chip diagnostic devices to compact discs. In many of these applications, particularly those related to biomedical devices, the ability to functionalize PC is central to its utility. To that end, a number of methods have been developed to modify the surface chemistry of PC for specific applications. All previous methods, however, require either expensive, specialized equipment or create extremely toxic products. Even worse, the harsh chemicals employed in these methods can damage microscale surface features or create macroscale inhomogeneities.

We propose an aqueous treatment of PC that provides a simple route to aminated surfaces. We demonstrate the ability of this facile method to serve as a foundation upon which other functionalities may be attached, including anti-fouling coatings and oriented membrane proteins.



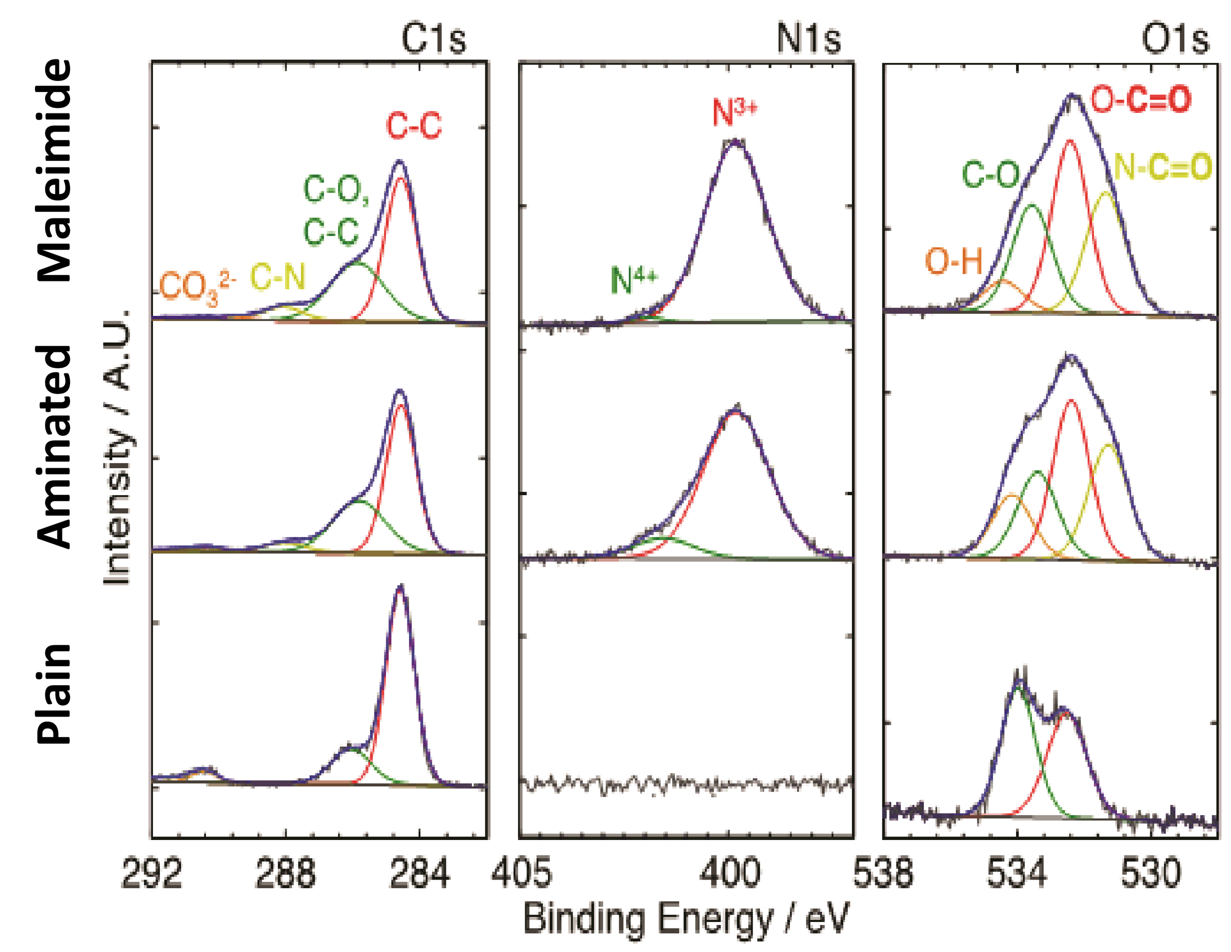
Functionalization scheme



Upon addition of the aqueous hexamethylene diamine solution to the PC surface, the carbonyl group undergoes nucleophilic addition by the diamine. This reaction results in scission of the polymer chain and the formation of a terminal hexylaminocarbamate.

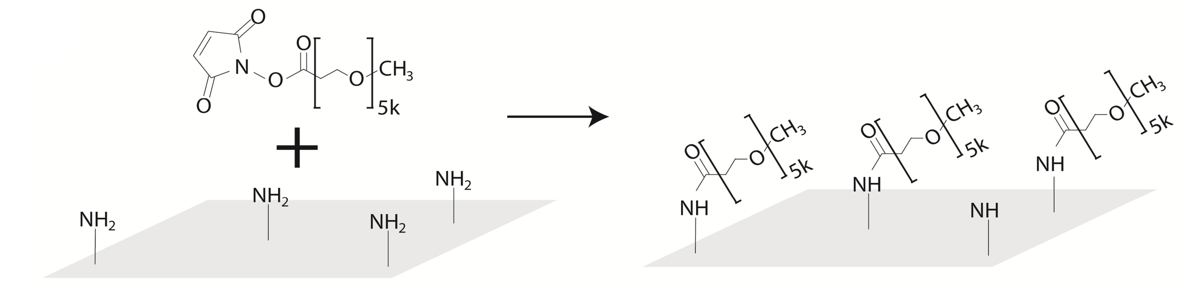
Surface characterization - XPS

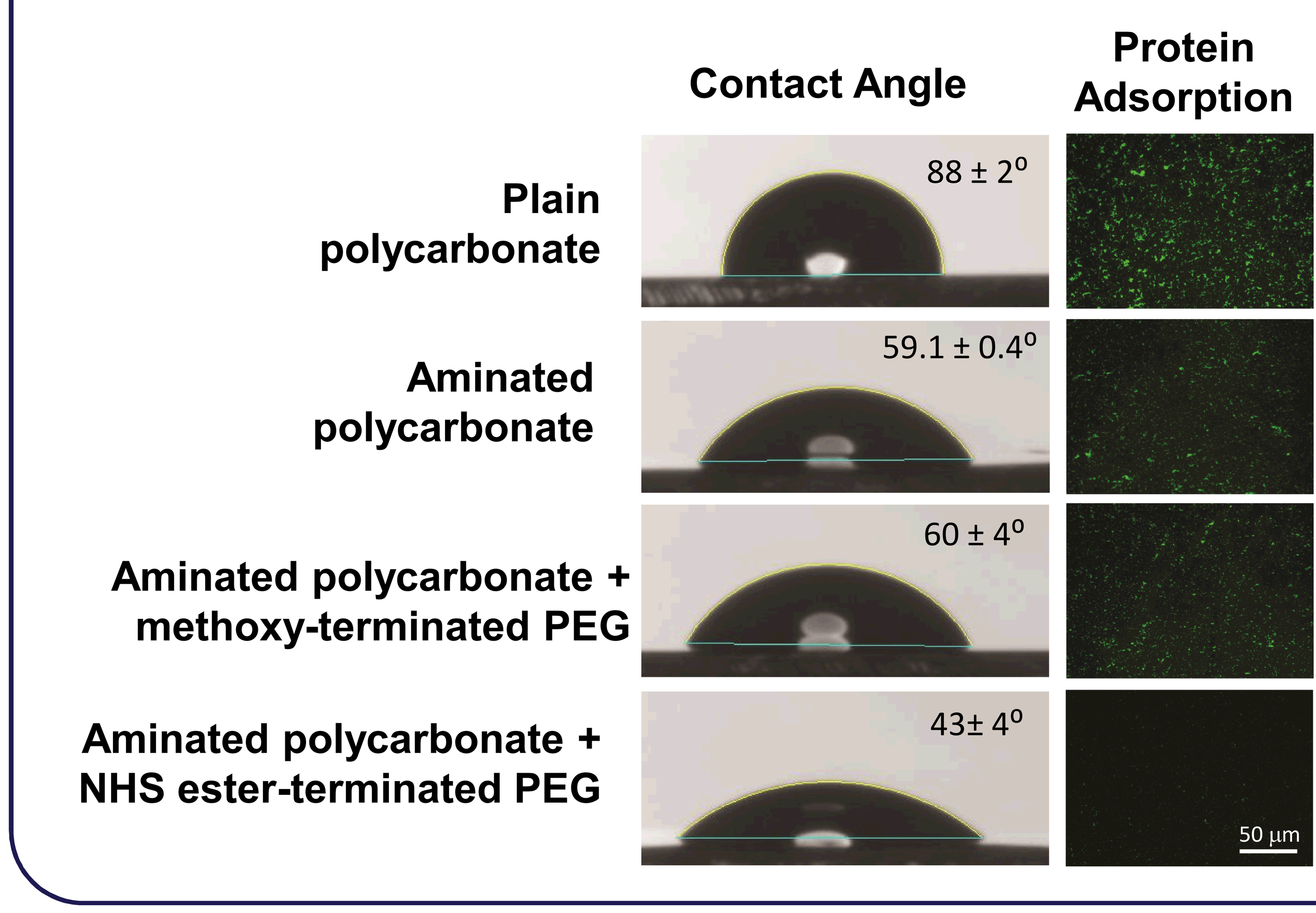
X-ray photoelectron spectroscopy (XPS) was used to confirm the effective amination of the PC surface. The spectra of the plain unfunctionalized polycarbonate appear consistent with literature reports. Upon amination, the XPS spectra assert the addition of nitrogen to form a hexylaminocarbamate: a C1s peak at 288.2±0.2 eV appears, characteristic of C-N bonding. Upon converting the surface from amine to maleimide, no new peaks appeared in the XPS spectra, as expected, but the relative peak intensities changed in a manner consistent with maleimide termination.



Applications – PEG grafting for antifouling

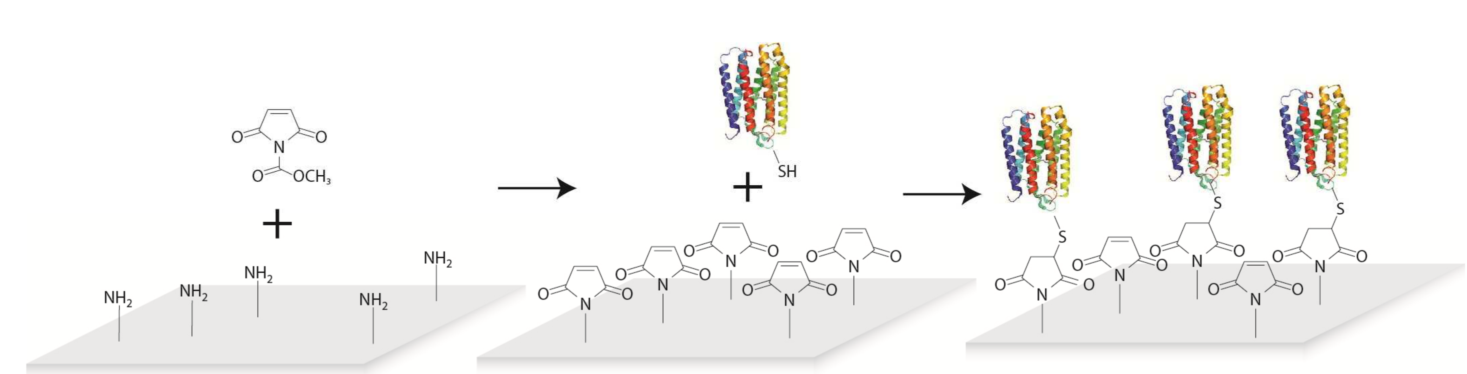
The aminated surface can be used to covalently tether secondary functional molecules to the PC surface. We bound polyethylene glycol (5k mPEG-NHS ester) to introduce anti-fouling properties to the PC.

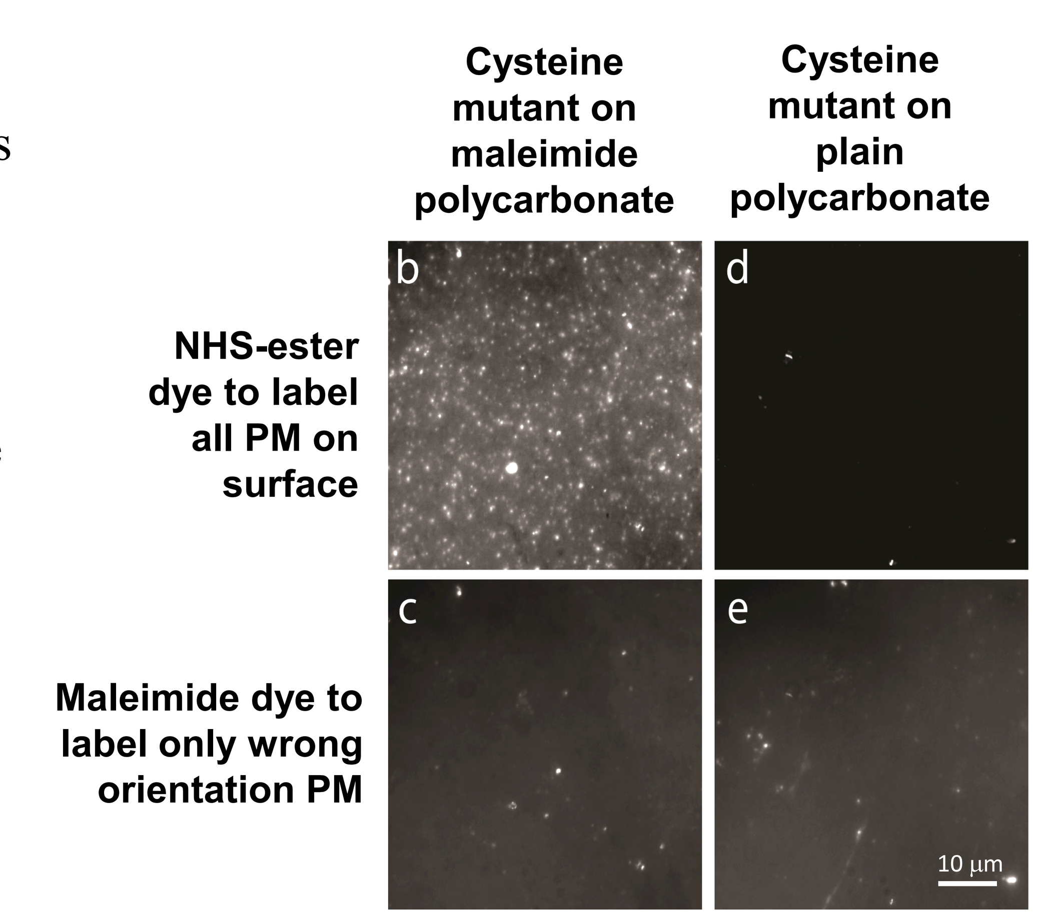




Applications – Oriented protein attachment

The maleimide-functionalized PC was used to orient the attachment of mutated bacteriorhodopsin, a 7 α-helix transmembrane protein that functions as a directional, light-driven proton pump that is purified from a *H. salinarum* in large (~1 µm) membrane patches called purple membrane (PM). Directing the orientation of these pumps is central to their potential utility *in vitro*. These particular proteins were modified by site-directed mutagenesis to contain a single cysteine residue on the cytoplasmic side. When PM membrane composed of the cysteine mutant was exposed to the maleimide-functionalized PC surface, membrane patches oriented with cysteines against the surface (cytoplasmic side down) covalently attach to the surface. Patches with the opposite orientation, on the other hand, were not bound and could be washed off.





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