Warren J. Baker Endowment
for Excellence in Project-Based Learning
Robert D. Koob Endowment *for Student Success*

FINAL REPORT

I. Project Title

Surface Modification of Polyurethane-Urea Elastomers with Colloidal Gold Nanoparticles

II. Project Completion Date

June 15th, 2018.

III. Student(s), Department(s), and Major(s)

(1) Kyle Aidukas, Chemistry and Biochemistry, B.S Biomedical Engineering and Chemistry
(2) David Bilger, Chemistry and Biochemistry, M.S Chemistry

IV. Faculty Advisor and Department

Dr. Shanju Zhang, Chemistry and Biochemistry

V. Cooperating Industry, Agency, Non-Profit, or University Organization(s)

Western Coatings Technology Center

VI. Executive Summary

Six variations of disulfide containing poly(ester urethane) ureas (PEUU-SS) were synthesized, five of which have not yet been reported in the literature. The project successfully produced a high molecular weight polycaprolactone (HW) and 4-carbon diisocyanate (BDI) elastomer. The elastomers identity was confirmed using differential scanning calorimetry (DSC) and Fourier transform infred spectroscopy (FTIR). The HW-BDI-PEUU-SS was submerged in a colloidal gold solution and the attachment of gold nanoparticles to the polymer was demonstrated. This was apparent by both a visible color change of the elastomer and four-point probe conductivity measurements. Due to the distance between disulfide linkages being above the percolation threshold of the nanoparticles, a water bridge was necessary for conduction to occur. In the future, gold nanowires or further loading of colloidal gold nanoparticles may be attached to the seeded surface. It was possible to attach gold nanoparticles to both a purified sample and an unpurified one with minimal change to the glass transition temperature, indicating thermal properties are not affected by surface modification.

One major roadblock this project faced was film creation after purification in isopropanol, which led to solubility testing on the HW-BDI-PEUU-SS. It was found that there was minimal solubility of the dried polymer in any readily available solvents (Octanol, Hexanol, Isobutanol, Isopropanol, THF,

DMSO, DMF). These solvents were chosen due to their similar Hansen solubility parameters to the reported hexafluoroisopropanol used in the literature. Since there was minimal solubility of the purified polymer, fibers were drawn in a water bath for tensile testing and thin films were drop cast directly from the reaction mixture without purification. At this time the DMA actuator broke and mechanical testing could not be performed. Contact AFM was executed on control samples and gold modified films of HW-BDI-PEUU-SS and conductive AFM was performed on only gold modified samples. A major limitation on the clarity of the images was that the films were not conductive without a bridge. In future work this should be fixed by including nanowires or attaching more colloids as mentioned above. FTIR studies were done to determine the reaction kinetics of the prepolymer synthesis. DSC and FTIR studies were also done for a low molecular weight (LW) 4-carbon diisocyanate, LW 6-carbon diisocyante, HW 6-carbon diisocyanate, LW 8-carbon diisocyante, LW 12-carbon diisocyanate. All samples showed visible color changes when immersed in colloidal gold solution. The results from this project were presented at the 2018 Materials Research Symposium in Phoenix, Arizona, and at the California Polytechnic State University College of Science and Math Student Research Conference.

VII. Major Accomplishments

(1) Synthesized novel poly(ester urethane) urea elastomers containing disulfides (PEUU-SS) using 4, 6, 8, 10, and 12 carbon linear diisocyantes, 530 MW and 2000 MW polycaprolactone, trans-4,5-dihydroxy-1,2-dithiane (O-DTT) and putrescene.

(2) Characterized synthesized PEUU-SS using FTIR, DSC, and TGA.

(3) Successfully attached synthesized gold nanoparticles to PEUU-SS.

(4) Observed surface characteristics using AFM and SEM

(5) Determined resistance using four-point probe.

VIII. Expenditure of Funds

Expense	**Cost**
Chemicals and lab supplies	$3675
Travel	$1265
Total	$4940

IX. Impact on Student Learning

This project was a profound experience for Kyle Aidukas, as it was a branch into the more synthetically heavy side of polymers. This project called for anhydrous and air-free synthetic methods that were more difficult than synthetic methods taught in the Polymers and Coatings concentration. It also was a large lesson in managing a project, and guiding the research towards a workable end. Thanks to this, Kyle was better able to lead in his biomedical engineering senior project, as he already had experience thinking about and developing ways to overcome foreseen and unforeseen obstacles. This project once again reinforced how valuable it is to be in a team. And lastly, it was a learning experience to find out how difficult the adaption of literature methods to a reproducible method in our lab was. There were intricacies that were not expressly stated in the literature, but

that became evident through multiple failures.

David Bilger is currently completing his Ph.D. at the University of Massachusetts Amherst, which focuses on applications of semi-conducting polymers in organic electronics. Writing proposals is a common occurrence in graduate level science programs, and this project has exposed David to this process in full, from writing the proposal to disseminating the final results. In addition, collaborative efforts between research groups are becoming more common within scientific fields. This project has exposed David to participating in such an effort, including the organization and communication necessary to complete a project in a timely and effective manner, and the creativity necessary to move a project forward when road-blocks occur.