# REPORT DOCUMENTATION PAGE

Form Approved OMB NO. 0704-0188



| 1. REPORT DATE (DD-MM-YYYY) | 2. REPORT TYPE | 3. DATES COVERED (From - To) |
|---|---|---|
| 11-12-2018 | Final Report | 15-Aug-2014 - 14-Aug-2015 |

**4. TITLE AND SUBTITLE**
Final Report: Electrochemical Workstation for Research on Chemical Surface Modifications and Characterization of Novel Conductive Polymers

**5a. CONTRACT NUMBER**
W911NF-14-1-0464

**5b. GRANT NUMBER**

**5c. PROGRAM ELEMENT NUMBER**
611103

**6. AUTHORS**
Dr. Myron Coolbaugh

**5d. PROJECT NUMBER**

**5e. TASK NUMBER**

**5f. WORK UNIT NUMBER**

**7. PERFORMING ORGANIZATION NAMES AND ADDRESSES**
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**8. PERFORMING ORGANIZATION REPORT NUMBER**

**9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS (ES)**
U.S. Army Research Office
P.O. Box 12211
Research Triangle Park, NC 27709-2211

**10. SPONSOR/MONITOR'S ACRONYM(S)**
ARO

**11. SPONSOR/MONITOR'S REPORT NUMBER(S)**
65079-CH-RIP.1

**12. DISTRIBUTION AVAILIBILITY STATEMENT**
Approved for public release; distribution is unlimited.

**13. SUPPLEMENTARY NOTES**
The views, opinions and/or findings contained in this report are those of the author(s) and should not contrued as an official Department of the Army position, policy or decision, unless so designated by other documentation.

**14. ABSTRACT**
This DURIP Grant was used to purchase the components of an Electrochemical Workstation (ECW,) including eight potentiostats, electrochemical cells for standard electrochemical techniques (e.g. cyclic voltammetry) as well as cells for studying corrosion. A rotating disk electrode was also purchased. The workstation software will permit a very large range of electrochemical experiments including electrochemical impedance spectroscopy (EIS). Additional capabilities include a spectroelectrochemisty setup and an electrochemical quartz crystal microbalance (eQCM). The EIS system is capable of characterizing batteries and fuel cells. Implementation of the ECW has just

**15. SUBJECT TERMS**
Electrochemistry, corrosion, aluminum, batteries, fuel cells, surface chemistry

| 16. SECURITY CLASSIFICATION OF: | | | 17. LIMITATION OF ABSTRACT | 15. NUMBER OF PAGES | 19a. NAME OF RESPONSIBLE PERSON |
|---|---|---|---|---|---|
| a. REPORT | b. ABSTRACT | c. THIS PAGE | | | Myron Coolbaugh |
| UU | UU | UU | UU | | 19b. TELEPHONE NUMBER 704-330-1429 |

# RPPR Final Report
as of 26-Dec-2018

Agency Code:

Proposal Number: 65079CHRIP **Agreement Number: W911NF-14-1-0464**
**INVESTIGATOR(S):**


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DUNS Number: 071057806 EIN: 250983069
**Report Date:** 14-Nov-2015 Date Received: 11-Dec-2018
**Final Report** for Period Beginning 15-Aug-2014 and Ending 14-Aug-2015
**Title:** Electrochemical Workstation for Research on Chemical Surface Modifications and Characterization of Novel Conductive Polymers
**Begin Performance Period:** 15-Aug-2014 **End Performance Period:** 14-Aug-2015
**Report Term:** 0-Other

Submitted By: Ramon Fernandez Email: rfernandez@jcsu.edu
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**Distribution Statement:** 1-Approved for public release; distribution is unlimited.

**STEM Degrees:** **STEM Participants:**

**Major Goals:** 1) Characterization of Light-metal Alloy Surface Treatments based on Fluoromettalates

2) Electrochemical Measurements of Molecularly Imprinted Polymer- Modified Electrodes.

3) Electrochemical Characterization of Novel Conductive Polymers.

In addition to the research applications noted above, the ECW will be integrated into the existing Analytical Chemistry, Instrumental Analysis and Physical Chemistry courses. The ECW will also be utilized in a number of courses under development to be offered with the Center for Renewable Energy and Sustainability (CRES) which will offer minors in both Renewable Energy and Sustainability.

**Accomplishments:** Assembly of the ECW was considerably delayed by completion of the New Science Center at Johnson C. Smith University. The projected move-in date was March 2015 when the equipment was purchased; actual move in was August 2015. As a result the ECW has not been extensively used in either research or instruction at the time of this report.

**Training Opportunities:** Nothing to Report

**Results Dissemination:** Nothing to Report

**Honors and Awards:** Nothing to Report

**Protocol Activity Status:**

**Technology Transfer:** Nothing to Report

**RPPR Final Report**
as of 26-Dec-2018

"Electrochemical Workstation for Research on Chemical Surface Modifications and Characterization of Novel Conductive Polymers"

Table 1 provides a comprehensive listing of all the equipment purchased as components of the Electrochemical Workstation (ECW) along with vendors and pricing. Assembly of the ECW was considerably delayed by completion of the New Science Center at Johnson C. Smith University. The projected move-in date was March 2015 when the equipment was purchased; actual move in was August 2015. As a result the ECW has not been extensively used in either research or instruction at the time of this report.

Several research projects are expected to use the ECW in the near future. These are briefly described below.

1) Characterization of Light-metal Alloy Surface Treatments based on Fluoromettalates

This project will be pursued by the Program PI, Dr. Coolbaugh. This work will use techniques including dynamic polarization and electrochemical impedance to study the effects of surface modifications of light metal alloys (e,g, AA2024 T3) on corrosion. The study will seek to gain insight into these surface modifications (or conversion coatings) by studying the electrochemistry of the coatings as a function of the composition of the surface modifying solutions. Dr. Coolbaugh currently has a student engaged in reproducing the results of previous work at American Research Corporation of Virginia (ARCOVA) that led to the development of a NAVARC trivalent chromium pretreatment which was shown to be an effective replacement for chromate conversion coatings.

2) Electrochemical Measurements of Molecularly Imprinted Polymer- Modified Electrodes.

This research by the program PI will focus on using electrochemical techniques to study and in some cases prepare molecularly imprinted polymer-modified electrodes. Techniques including cyclic voltammetry and electrochemical impedance spectroscopy will be used to characterize the behavior of these systems as they interact with both target and non-target molecules. One goal of such research is to develop effective transduction mechanisms that would allow these systems to be used for chemical/biological sensing. Such work may also utilize the electrochemical quartz crystal microbalance.

3) Electrochemical Characterization of Novel Conductive Polymers.

This research project which is an extension of work conducted by Dr. Mbah of the Department of Natural Sciences and Mathematics at JCSU and Dr. Schmedake of the University of North Carolina, Charlotte (UNCC) to synthesize and characterize novel conducting polymers (CP) based on bipyridines. One class of such compounds were observed to have interesting electrochromic behaviors and some potential as sensing materials. The spectroelectrochemistry setup may be used in this research.

In addition to the research applications noted above, the ECW will be integrated into the existing Analytical Chemistry, Instrumental Analysis and Physical Chemistry courses. The ECW will also be utilized in a number of courses under development to be offered with the Center for Renewable Energy and Sustainability (CRES) which will offer minors in both Renewable Energy and Sustainability.

**Table 1. Equipment Purchased Including Vendor and Pricing**

| Vendor | Part # | Descriptive Name | Unit Price | Quantity | Cost |
|---|---|---|---|---|---|
| Gamry Instruments | 990-00286 | Interface 1000 Potentiostat/Galvanostat/ZRA | $6,515.00 | 7 | $45,605.00 |
| Gamry Instruments | 990-00227 | Reference 3000 Potentiostat/Galvanostat/ZRA w/Auxiliary Electrometer | $15,180.00 | 1 | $15,180.00 |
| Gamry Instruments | 987-00048 | Global Software License | $6,615.00 | 2 | $13,230.00 |
| | 985-00091 | Reference 600/Interface 1000 Cell Cable, 1.5-m | $220.00 | 7 | $1,540.00 |
| Gamry Instruments | 985-00071 | Reference 600/ Interface 1000 Cell Cable, 60 cm | $210.00 | -7 | ($1,470.00) |
| Gamry Instruments | 992-00085 | Reference 30K Booster (120V) | $7,980.00 | 1 | $7,980.00 |
| Gamry Instruments | 992-00083 | eQCM 10M Quartz Crystal Microbalance | $4,820.00 | 1 | $4,820.00 |
| Gamry Instruments | 992-00096 | Spectro-115U (200-850nm) Spectroscopy with light source | $6,120.00 | 1 | $6,120.00 |
| Gamry Instruments | 990-00320 | SpectroElectrochemistry Cell Kit | $825.00 | 1 | $825.00 |
| Gamry Instruments | 932-00018 | Silver/Silver Chloride Skinny Reference Electrode(4mm dia.) | $195.00 | 1 | $195.00 |
| Gamry Instruments | 930-00003 | Saturated Calomel Reference Electrode | $285.00 | 8 | $2,280.00 |
| Gamry Instruments | 990-00200 | Dr. Bob's Electrochemical Cell Kit, Jacketed | $960.00 | 4 | $3,840.00 |
| Gamry Instruments | 990-00203 | Jacketed EuroCell Kit | $1,125.00 | 4 | $4,500.00 |
| Gamry Instruments | 932-00001 | Glassy Carbon Working Electrode, 3mm, Kel-F Body | $855.00 | 1 | $855.00 |
| Gamry Instruments | 932-00002 | Gold Working Electrode, 3 mm, Kel-F body | $690.00 | 1 | $690.00 |
| Gamry Instruments | 932-00003 | Platinum Working Electrode, 3 mm, Kel-F body | $605.00 | 1 | $605.00 |
| Gamry Instruments | 990-00197 | PTC1-Paint Test Cell (w/o Reference Electrode) | $125.00 | 8 | $1,000.00 |
| Gamry Instruments | 970-00007 | Shaft for Disk/ Quick Change Tip/Cylinder Electrodes | $545.00 | 1 | $545.00 |
| Gamry Instruments | 970-00008 | Platinum Rotating Disk Electrode Tip | $825.00 | 1 | $825.00 |
| Gamry Instruments | 970-00020 | Glassy Carbon Rotating Disk Electrode Tip | $740.00 | 1 | $740.00 |
| Gamry Instruments | 990-00211 | VistaShield Faraday Cage | $995.00 | 2 | $1,990.00 |
| | | | | | $111,895.00 |
| Gamry Instruments | | Quantity Discount | | | ($13,221.40) |
| Gamry Instruments | | Academic Discount | | | ($15,197.25) |
| | | **Gamry Subtotal** | | | **$83,476.35** |
| | | | | | |
| Pine Instruments | RRPE1001C-50 | Patterned Electrode (50 pack), carbon working (2 mm OD) and counter, AgCl ref | $106.47 | 1 | $106.47 |
| Pine Instruments | RRPE1002C-50 | Patterned Electrode (50 pack), carbon working (4x5 mm) and counter, AgCl ref | $106.47 | 1 | $106.47 |
| Pine Instruments | RRPE2001AU-6 | Patterned Electrode (6 pack), gold working (2 mm OD) and counter, AgCl ref | $170.00 | 1 | $170.00 |
| Pine Instruments | AKPOLISH | Electrode Polishing Kit | $360.58 | 1 | $360.58 |
| Pine Instruments | AKSPEKIT | [CVC-EDU] Compact Voltammetry Cell - Educational Starter Kit | $378.47 | 1 | $378.47 |
| Pine Instruments | AFASR | Heavy Duty Electrode Rotator | $1,848.00 | 1 | $1,848.00 |
| Pine Instruments | AFE3A | Rotator Shaft | $671.16 | 1 | $671.16 |
| Pine Instruments | AFE3T050GC | Glassy Carbon Rotating Electrode Tip | $590.31 | 1 | $590.31 |
| Pine Instruments | AFE3T050PT | Platinum Rotating Electrode Tip | $658.53 | 1 | $658.53 |
| | | **Pine Instruments Subtotal** | | | **$4,889.99** |
| | | | | | |
| | | | | | |
| | | **Grand Total** | | | **$88,366.34** |