Betty A. and Donald J. Baumann Family Scholarship Fund Application Form

1. **Name and NetID**

Patrick Herchenbach, pjh70872

2. **Chemistry faculty research director**

Dr. Erin Gross

3. **Proposal title**

Optimization of Portable Electrochemiluminescent Detection of Biogenic Amines with Mobile Phones and 3D Printed Materials

4. **Proposal description. Please limit the proposal to about 500 words and include figures as appropriate. Your proposal should briefly outline the overall project and its goal(s). If you have previous results related to your proposed project, concisely summarize those results and describe what you expect to accomplish during the time frame of the scholarship.**

Introduction

Biogenic amines are primarily produced by the decarboxylation of amino acids by bacteria. Therefore, they are a good indication of bacterial life[1]. The overall goal of my project is to optimize and modernize a system to detect the presence of bacteria in food.

Electrogenerated chemiluminescence (ECL) is a common analytical method to detect unknown analyte concentrations[2]. ECL utilizes a luminophore and a coreactant analyte undergoing a redox reaction that emits light (shown in figure 1). At relatively high concentrations of luminophore, the analyte is the limiting reagent and the intensity of the light emitted by the reaction can be used to measure the coreactant concentration. The luminophore used in our lab is tris(2,2'-bipryidly)ruthenium (II) ($Ru(bpy)_3^{2+}$). 2-(dibutyalamino)ethanol (DBAE) is used in place of a biogenic amine due to its well-studied redox reaction mechanism. A small potential (1.1 V) is run through the electrode so that $Ru(bpy)_3^{2+}$ and DBAE are both oxidized. After being oxidized, DBAE forms a free radical and donates an electron to $Ru(bpy)_3^{3+}$. $Ru(bpy)_3^{3+}$ enters an electronically excited state and as $*Ru(bpy)_3^{2+}$ relaxes back to its ground state, a photon is released[3] as shown in Figure 2. The amount of photons released corresponds with the concentration of the limiting reagent.

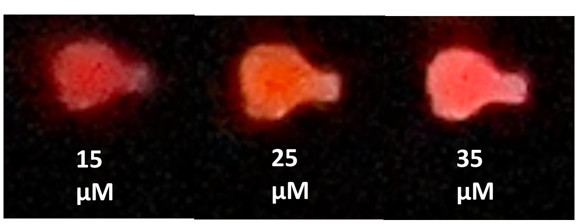

Figure 1. Long exposure images of the oxidation of 5mM $Ru(bpy)_3^{2+}$ with increasing concentrations of DBAE

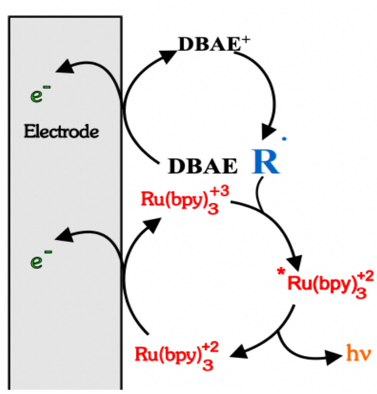

Figure 2. Oxidation-reduction mechanism of $Ru(bpy)_3^{2+}$ and DBAE at the surface of an electrode, emitting light.

ECL detection requires an electrode, a camera, and a light tight case. Lab cameras, such as charge coupled devices, are often used to capture ECL, however, mobile phone cameras have been shown to be effective[3-4]. Previous work in our lab has developed a method using stencil printed carbon electrodes on thin plastic transparencies. My goal is to use 3D printed parts to update and increase the durability of our system. I designed and 3D printed a light-tight case (shown in figure 3) for the reaction to be photographed and modernized our electrodes by fabricating them on a 3D printed polylactic acid substrate. Red/orange light (≈620 nm) is emitted and the average red pixel intensity on the surface of the electrode is analyzed with the free software ImageJ. This red pixel intensity increases linearly with an increase in analyte as shown in figure 4. The flexibility to use an available camera and the lightweight 3D printed parts allow for a compact, portable detection system.

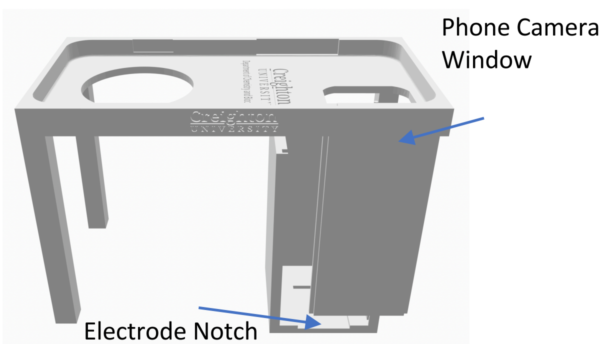

Figure 3. Light-tight case for iPhone 12 Pro Max

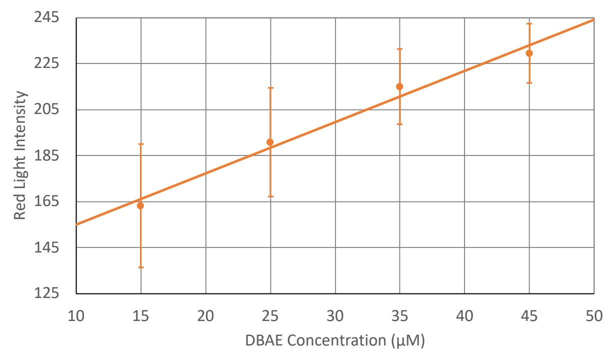

Figure 4. Red light intensity Vs. concentration of DBAE in 5 mM $Ru(bpy)_3^{2+}$ at a potential of 1.1 V.

Experimental Plan

DBAE is the analyte that has been studied in my project so far. The next step is to expand our ECL detection system to other analytes. ECL detection with $Ru(bpy)_3^{2+}$ is capable of detecting many compounds with amines. Various biogenic amines including spermidine, histamine, and putrescine will be analyzed. The optimal potentials to oxidize each metabolite will be determined by conducting multiple oxidation trials at differing potentials. I will then investigate the relationship between amine concentration and signal intensity to determine the limit of detection for each analyte with our detection system. My project also seeks to use batteries and a laptop to provide the potential to reduce the need for laboratory electrochemical workstations.

Conclusion

My project will get one step closer to testing real world samples by analyzing spermidine, histamine, and putrescine. My system that has been optimized with the model reaction of

Ru(bpy) and DBAE will use ECL to detect the concentrations of these amines. I will also investigate the use a battery pack and a laptop to supply the potential for the ECL.

References

1. Onal, A. A review: Current analytical methods for the determination of biogenic amines in foods. *Food Chemistry* **2007**, *103,* 1475-1486.

2. Li, L. et al. Recent Advances in Electrochemiluminescence Analysis. *Anal. Chem.* **2017**, *89,* 358-371.

3. Heckenlaible, N. et al. Comparison of Mobile Phone and CCD Cameras for Electrochemiluminescent Detection of Biogenic Amines *Sensors* **2022**, *22*, 7008.

4. Delaney, J. L. et al. Electrogenerated chemiluminescence detection in paper-based microfluidic sensors. *Anal. Chem.* **2011**, *83*, 1300-1306.

5. Elgrishi, N. et al. A Practical Beginners Guide to Cyclic Voltammetry. *J Chem. Educ.* **2018,** *95,* 197-206.

5. **Presentation of research results (past and future conferences, publications, seminars, etc.)**

Publications:

Nic Heckenlaible; Sarah Snyder; **Patrick Herchenbach**; Alyssa Kava; Charles S Henry; Erin M Gross "Comparison of Mobile Phone and CCD Cameras for Electrochemiluminescent Detection of Biogenic Amines" *Sensors* **2022**, *22*, 7008. https://doi.org/10.3390/s22187008

Presentations:
Presenter is underlined

1. Patrick Herchenbach, Charles S. Henry and Erin M. Gross "Optimization of portable electrochemiluminescent detection system with mobile phones and 3D printed materials" poster presented at the 2022 Ferlic Fellows Poster Presentations, Creighton University, October 26, 2022.

2. Patrick Herchenbach, Charles S. Henry and Erin M. Gross "Optimization of portable electrochemiluminescent detection system with mobile phones and 3D printed materials" poster presented at the American Chemical Society fall meeting, Chicago, IL August 24, 2022.

3. Patrick Herchenbach, Charles S. Henry and Erin M. Gross “Optimization of portable electrochemiluminescent detection system with mobile phones and 3D printed materials” presented at the American Chemical Society fall meeting Sci-Mix, Chicago, IL August 22, 2022.

4. Patrick Herchenbach, Erin M. Gross, Charles S. Henry, Alyssa Kava “Use of 3D printed materials for the fabrication of electrochemiluminescent sensors” presented at the NE-INBRE Annual Conference, Nebraska City, NE August 7, 2022.

5. Patrick Herchenbach, Erin M. Gross, Charles S. Henry, Alyssa Kava “Use of 3D printed materials for the fabrication of electrochemiluminescent sensors” Summer Research Poster Showcase, Creighton University, August 5, 2022.

6. Patrick Herchenbach, Erin M. Gross, Charles S. Henry, Alyssa Kava “Use of 3D printed materials for the fabrication of electrochemiluminescent sensors” Creighton University Research Day, April 20, 2022.

7. Patrick Herchenbach, Erin M. Gross, Charles S. Henry, Alyssa Kava “Use of 3D printed materials for the fabrication of electrochemiluminescent sensors” Creighton University Honors Day, April 13, 2022.

8. Patrick Herchenbach, Erin M. Gross, Charles Henry, Alyssa Kava “Use of 3D printed materials for the fabrication of electrochemiluminescent sensors” American Chemical Society spring meeting, virtual and Sci-Mix poster session, March 23, 2022.

9. Angelle M. Le, Patrick J. Herchenbach, Charles S. Henry and Erin M. Gross “Optimization of electrochemistry and electrochemiluminescence of stencil-printed carbon ink electrodes” presented at University Research Week, virtual, Creighton University April 20, 2021.

10. Angelle M. Le, Patrick J. Herchenbach, Charles S. Henry and Erin M. Gross “Optimization of electrochemistry and electrochemiluminescence of stencil-printed carbon ink electrodes” presented at the American Chemical Society Spring meeting, virtual, April 10, 2021.

6. Post-graduate plans (job market, graduate school, medical school, etc.)

I plan on attending graduate school working towards a PhD in analytical chemistry.

7. Number of semesters involved in research, including current semester (summers count as two semesters)

10 semesters.

8. Anticipated graduation date

May 13, 2023