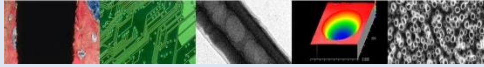
Tribolayer Formation
NSF Grant

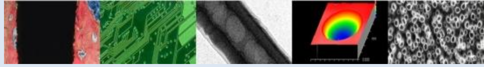
Shelley Kerwell

PI: Dr. Mathew and Dr. Shull



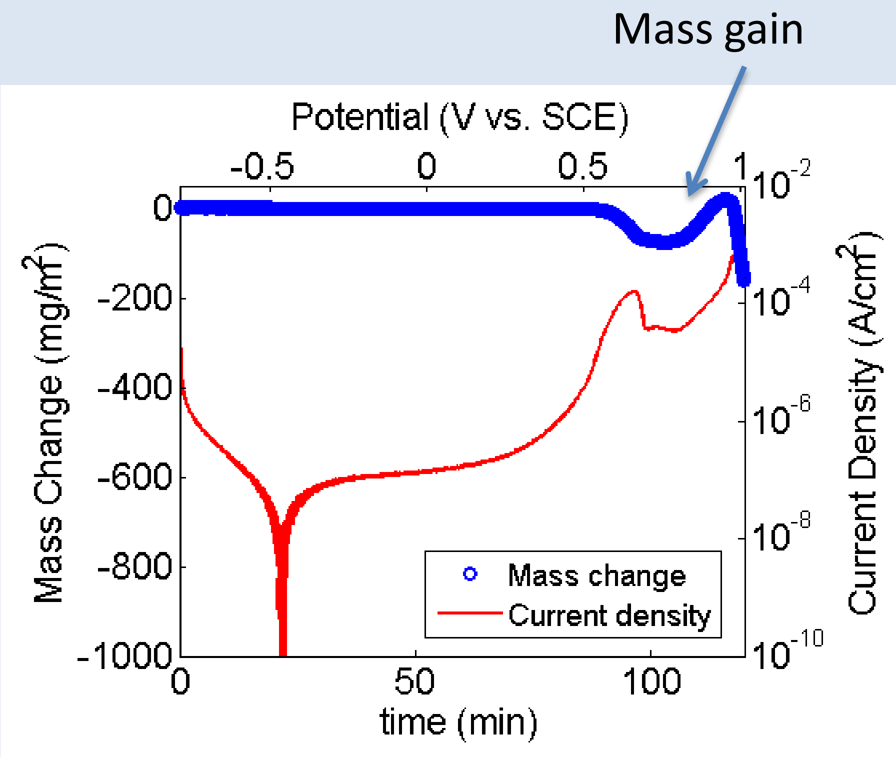
Introduction

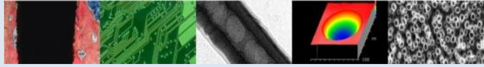
- It has been investigated that surrounding protein concentration impacts implant corrosion kinetics [1].
- Proteins are capable of improving metal-on-metal (MoM) implant performance [2,3].
- Oxide layer formation provides a barrier on the surface of the implant, serving to protect the implant [4].



Introduction

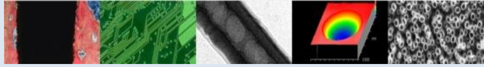
- 2012, Martin et al.
- Used CoCrMo in BCS
- Initial mass loss from corrosion
- Mass gain from protein deposition at +0.77V
- Test voltages: +0.6V, +0.7V and +0.8V





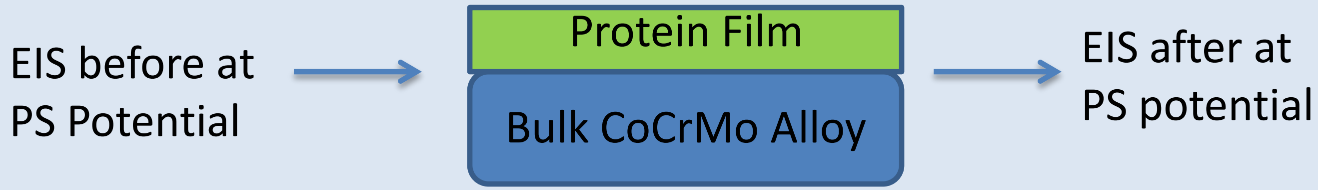
Objectives/hypothesis

- The purpose of this study is to generate oxide films in a proteinaceous environment through electrochemical treatment and evaluate the film effectiveness through Electrochemical Impedance Spectroscopy (EIS).
- Ultimately, formed electrochemical film can be used as a pre-surgical treatment on implants.



Background (Previously at RUSH)

- Summer 2012 (Ros K.)-The effects of protein on the behavior of CoCrMo alloy
- Summer 2013 (David B.)- Best treatment was 15g/L with +0.7V (R_p was 1000% higher)



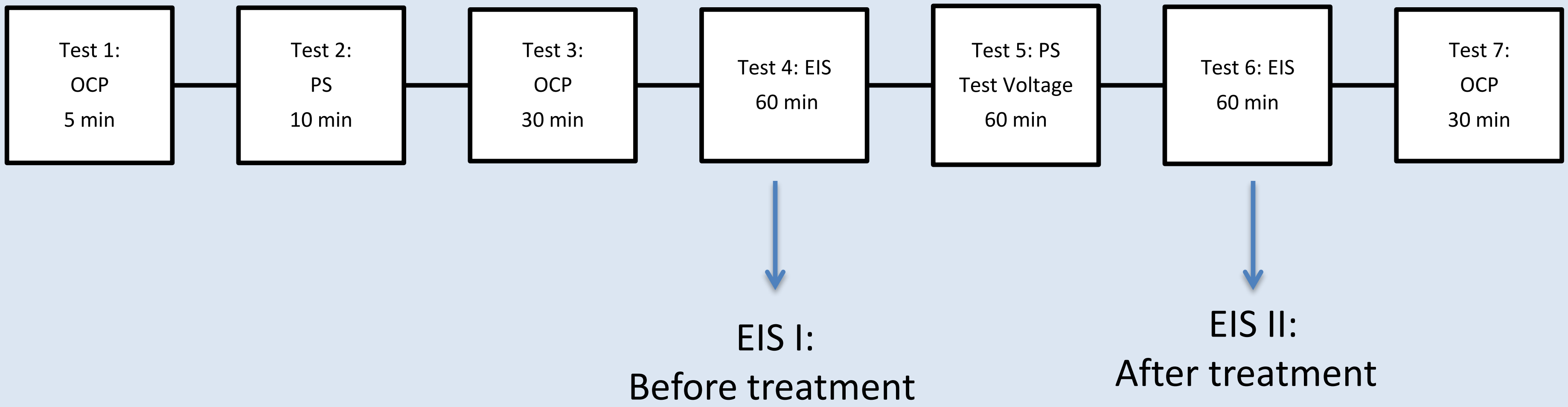
Film formation: Potentiostatic exposure at -0.4V (Control), +0.6V, +0.7V, +0.8V vs. SCE

Background (Currently at RUSH)

Film formation: Potentiostatic exposure at -0.4V (Control), +0.6V, +0.7V, +0.8V vs. SCE

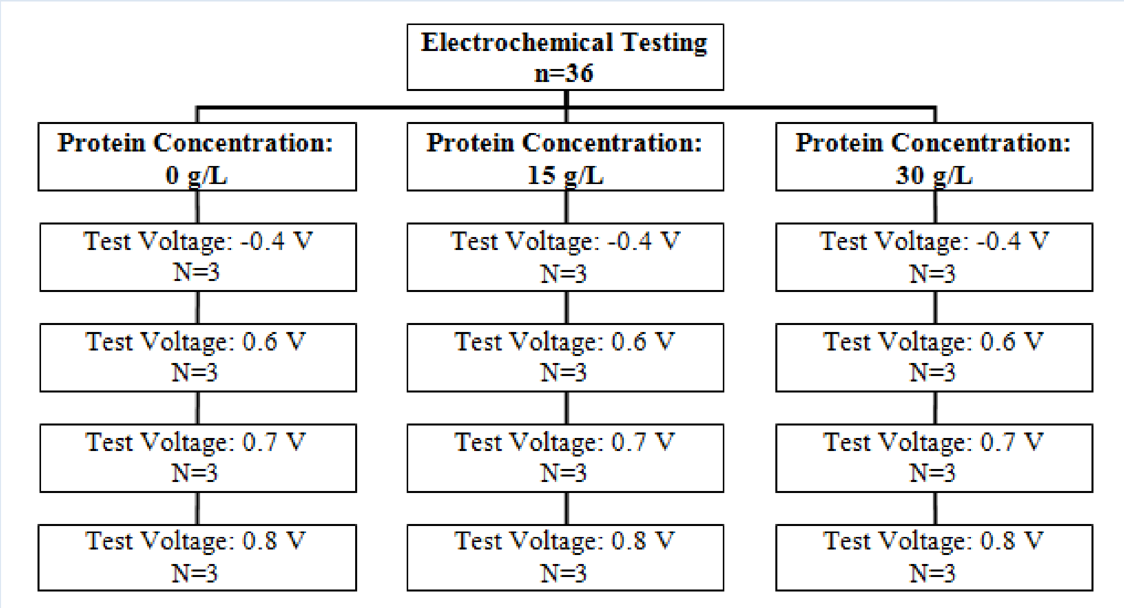
Experimental design

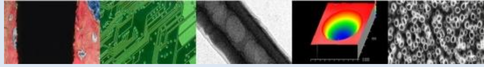
- EIS testing (Step 4 and 6, at Eoc, potential amplitude ± 10mV, frequency range 100 K-0.005 Hz).



Materials and methods

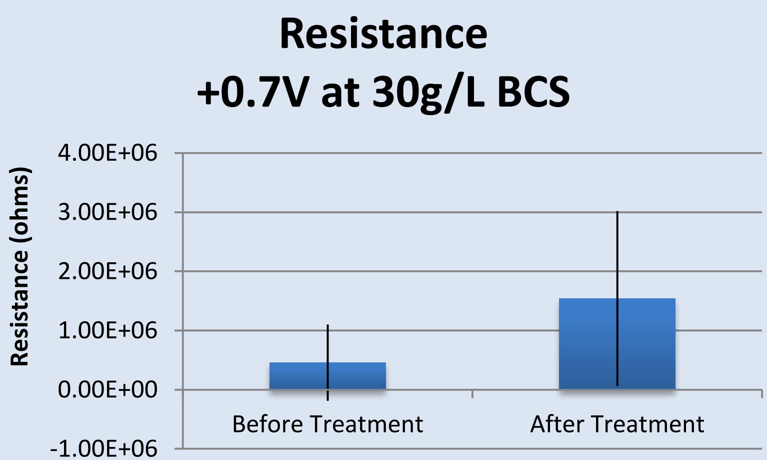
- 36 polished CoCrMo alloy disks (Ra < 17.0nm).
- BCS (15 and 30g/L protein content) as the electrolyte.
- Standard 3-electrode corrosion cell.

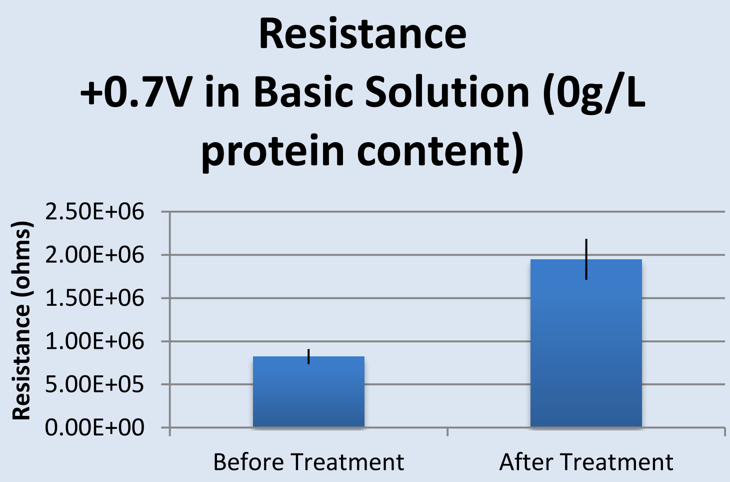




Results

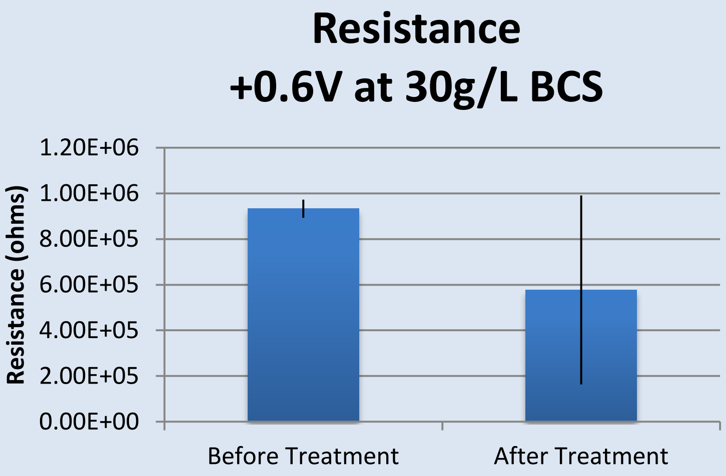
- Initial results show an increase in polarization resistance (R_p) and lower double layer capacitance after the treatment step (+0.7V at 30 g/L and 0 g/L).

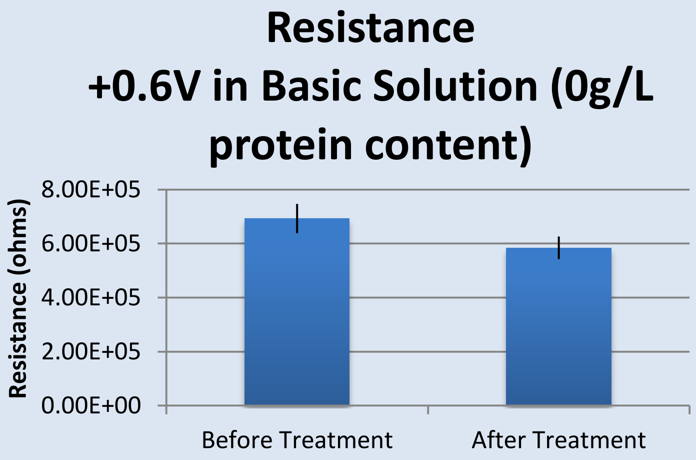


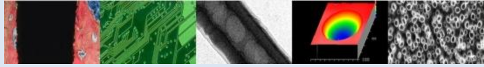


Results

At this potential, protein does not appear to have any beneficial impact on corrosion behavior.





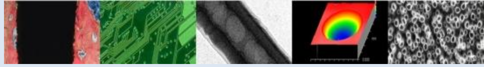


Progresses

- EIS on Mo alloy using BCS environment
- EIS on CoCrMo using a polymer chain (poly (allylamine HCL) macromolecule with protein-like structure).
- Tribocorrosion testing on samples (influence of protein film on friction).
- Raman Spectroscopy (protein film characterization).

Future work

- Cell culture study on CoCrMo disks



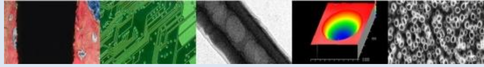
References

- [1]. Mathew MT, Jacobs JJ, Wimmer MA. Wear-corrosion synergism in a CoCrMo hip-bearing alloy is influenced by proteins. The Journal of Clinical Orthopaedics and Related Research. 2012.

- [2]. Wimmer MA, Fischer A, Buscher R, Pourzal R, Sprecher C, Hauert R, Jacobs JJ. Wear mechanisms in metal-on-metal bearings: the importance of tribochemical the importance of tribochemical reaction layers. *J Orthop Res.* 2010; 28:436–443.

- [3]. Wimmer MA, Sprecher C, Hauert R, Tager G, Fischer A. Tribochemical reaction on metal-on-metal hip joint bearings: a comparison between in-vitro and in-vivo results. *Wear.* 2003; 255:1007–1014.

- [4]. Shahgaldi B, Heatley F, Dewar A, Corrin B. “In Vivo Corrosion of Cobalt-Chromium and Titanium Wear Particle,” The Journal of Bone and Joint Surgery British Volume, vol. 77-B, no. 6. November 1995. 962-66.



Acknowledgements

- Dr. Mathew
- Robin Pourzal
- David Baer
- Elizabeth Martin
- Dmitry Royhman
- Maria Runa
- Salman Farooqui