

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

1. Name

Monika Satkauskas

2. Chemistry Faculty Research Director

Dr. Stephen Gross

3. Research proposed (Please copy proposal into the box below this section. It will expand to include all text. The proposal is not to exceed 500 words and is not to exceed 2 pages. A summary of work already completed should also be included, if appropriate.)

While oral healthcare has improved over the past 50 years, dental caries still plagues the majority of the population.¹ Dental caries occurs due to the accumulation of dental plaque, a biofilm composed of bacteria to cover the entire tooth. Streptococcus mutans and lactobacilli, found in the biofilm, feed on sucrose and cause a drop in pH, which lead to decay.² Since nearly half of new restorations replace previous restorations, improvements in restorative dental materials are key.³ Composites should be bacteriostatic when considering the effects of bacteria. Dental amalgam is a metallic, cost-effective, bacteriostatic composite. However, consumers are increasingly demanding a tooth-colored restorative material for esthetics.⁴ Dentists are installing light polymer composite resins instead of dark-colored amalgam.⁵ Unfortunately, polymerized composites shrink, forming pockets that allow bacteria to proliferate and continue decaying the tooth under composites. Over time, trapped bacteria can flourish, creating diseased tissue underneath restorations. These hidden sites of decay are painful and costly to the patient, requiring additional restorations.⁶

My project aims to reduce the recurrent decay associated with dental polymer composites. Previous work in Dr. Gross' research group has demonstrated the potential for release of microencapsulated aqueous solutions of calcium, phosphate, and fluoride salts to help fight demineralization and promote remineralization in the oral environment.^{4,7,8} The current goal is to create an antimicrobial dental composite utilizing microencapsulated water-soluble antimicrobial agents as new fillers for dental materials. By simple passive diffusion due to a concentration gradient, the controlled, steady-state rate of release may allow for an effective long-term antimicrobial dental material.

Preliminary studies have demonstrated the efficacy of microencapsulating three antimicrobial agents. Benzalkonium chloride (BAC) and cetyl pyridinium chloride (CPC) are commonly found in over-the-counter dental products, and such as toothpastes and mouthwashes. Silver diammine fluoride (SDF) is the up-and-coming addition to dental medicine, having been recently approved by the FDA for use in the mouth. I was able to use an interfacial polymerization technique in a reverse emulsion to accomplish these syntheses. Past work has demonstrated the efficacy of controlled release of BAC and CPC from microcapsules directly into water for long-term release. Both the chemical structure of the microcapsule and the initial concentration of the antimicrobial agent were found to profoundly affect release rates.

In the proposed work for the Baumann Scholarship, I will study the release of antimicrobial agents from microcapsules suspended in a bacterial environment. The CLSI Broth Microdilution method, against *E. coli* (gram negative bacteria) and *B. Subtilis* (gram positive bacteria), will be used to confirm the antimicrobial properties of the microencapsulated therapeutic agents.⁹ The initial concentrations in the microcapsules and the bacterial pose a major kinetics hurdle. By varying the concentration of antimicrobial (1, 2, and 3 w/w %), and the concentration of bacteria (3.1×10^3 , 6.3×10^3 , 1.3×10^4 , 2.5×10^5 , and 5×10^5 Colony Forming Units), I can determine when the rate of release of therapeutic agent overcomes the rate at which the bacteria grow.

Additionally, I will also determine the bioactivity of the dental composites containing the microencapsulated antimicrobial agents. Dental composites consist of monomers that comprise the continuous phase and have glass fillers to add strength and reduce the polymerization shrinkage that leads to the gaps and defects that bacteria occupy to cause decay. The monomer ratios of urethane dimethacrylate (UDMA) to triethylene glycol dimethacrylate (TEGDMA) assessed will be 50:50, 65:35, and 80:20 w%:w%. Glass filler, a mechanical toughening agent, will be varied from 20 to 50%. Initial concentrations in the microcapsules and initial bacterial concentrations will be varied as in the CLSI Microbroth dilution test with the microcapsules. A direct contact test utilizing UV-Vis methods will be used to determine cell growth or death.

References:

1. US Department of Health and Human Services. Oral Health in America: A Report of the Surgeon General. Rockville MD: US Department of Health and Human Services, National Institute of Dental and Craniofacial Research, National Institutes of Health, 2000.

2. Loesche WJ. Microbiology of Dental Decay and Periodontal Disease. In: Baron S, editor. Medical Microbiology. 4th edition. Galveston (TX): University of Texas Medical Branch at Galveston; 1996. Chapter 99.
 3. Burke FJT, Cheung SW, Mjör IA, Wilson NH F. "Influence of Patient Factors on Age of Restorations at Failure and Reasons for Placement and Replacement of Restorations by a Group of General Dental Practitioners". Journal of Dentistry, 2001; 29: 317–324.
 4. Davidson MT, Greving TA, McHale WA, Latta MA, Gross SM. "Ion Permeable Microcapsules for Remineralization", Journal of Biomedical Materials Research Part A, 2012, 100A, 665-672.
 5. Mjör IA, Moorhead JE, Dahl JE. "Reasons for Replacement of Restorations in Permanent Teeth in General Dental Practice." International Dental Journal, 2000, 50(6), 361-366.
 6. Bürgers R, Eidt A, Frankenberger R, Rosentritt M, Schweikl H, Handel G, & Hahnel S. "The Anti-Adherence Activity and Bactericidal Effect of Microparticulate Silver Additives in Composite Resin Materials". Archives of Oral Biology, 2009, 54(6), 595-601.
 7. Falbo M, Ellassal P, Greving TA, McHale WA, Latta MA, Gross SM. "The Control of Phosphate Ion Release from Ion Permeable Microcapsules Formulated in to Rosin Varnish and Resin Glaze." Dental Materials. 2013, 29, 804-813.
 8. Falbo M, Greving TA, Schmidt MQ, Davidson MT, McHale WA, Latta MA, Gross SM. "Ion Permeable Microcapsules: The Effect of Counterions, Temperature and Concentration." ACS Symposium Book Series: Polymer for Personal Care Products. 2013.
 9. CLSI. Methods for Dilution Antimicrobial Susceptibility Tests for Bacteria That Grow Aerobically; Approved Standard—Ninth Edition. CLSI document M07-A9. Wayne, PA: Clinical and Laboratory Standards Institute; 2012.
4. Plans for presentation of research results (conference, publication, seminar, etc.)
- I plan to present my research at the International Association for Dental Research Annual Meeting in San Francisco in March 2017.
5. Post-graduate plans (job market, graduate school, medical school, etc.)

I intend to pursue a PhD in Chemistry, specifically bioanalytical chemistry. After completing this degree, I want to conduct research and teach at the university level.

For the paper copy only – In addition to above, please include:

Social security number

Applicant signature

Chemistry research director's signature