## POSTER SESSION 1

**Balcony, Easel 90**

*11:00 AM to 1:00 PM*

### Peptide-Enabled Directed Immobilization of Kinetically Matched Enzymes in Flow Bioreactors

*Amanda Hong (Amanda) Tran, Junior, Electrical Engineering*
*Allegra Joyce (Allegra) Branch, Junior, Mechanical Engineering*
*Mentor: Mehmet Sarikaya, Materials Science & Engineering*
*Mentor: Deniz Tanil Yucesoy, Materials Science and Engineering*

Enzymatic pathways comprising multi-step biochemical reactions in biological cells constitute a key part of life. Biomimetic reconstruction of these metabolic pathways holds tremendous promise for developing sustainably powered devices. In biological cells, enzymatic components are kept in strict compartments or in serial networks. To mimic this complex hierarchical assembly of enzymes found in nature, a common approach is immobilizing these enzymes on the surface of porous substrates i.e., anodic aluminum oxide (AAO) membrane. However, one common limitation has been immobilization of multiple enzymes with a single type surface chemistry. As a result, these approaches have failed to provide enough capability to control spatial localizations of enzymes on AAO surfaces. Solid-binding peptides (SBPs) offer a novel solution to circumvent these problems with their exquisite recognition and long range solid-coverage properties. The ease of genetic conjugation of these short peptides with large proteins makes them an ideal candidate in utilization as molecular linkers in designing new multi-enzymatic devices. In this study, the utilization of a gold binding peptide (AuBP) as a molecular linker in combination with histidine-tag to immobilize Lactate Dehydrogenase (LDH) and Formate Dehydrogenase (FDH) enzymes on AAO based flow bioreactor was demonstrated. The efficacy of the described approach was tested by monitoring the sequential lactate and formate break down by LDH and FDH enzymes spectrophotometrically. The overall sequential catalytic conversion with greater than 90% yield was observed. Furthermore, the surface selectivity of the SBP conjugated enzymes were tested by visualizing their localization on Ni-NTA patterned gold surface using fluorescence microscopy. Cumulatively, this study highlights the utility of solid binding peptides as a molecular linker for addressable immobilization of multiple enzymes in the AAO based devices.

## POSTER SESSION 3

**Commons East, Easel 80**

*2:30 PM to 4:00 PM*

### Tooth Whitening Lozenge: Peptide-Based Teeth Remineralization and Whitening

*Allegra Joyce (Allegra) Branch, Junior, Mechanical Engineering*
*Aashna Vivek Abrol, Senior, Materials Science & Engineering*
*Mentor: Mehmet Sarikaya, Materials Science & Engineering*
*Mentor: Deniz Tanil Yucesoy, Materials Science and Engineering*
*Mentor: Sami Dogan, Restorative Dentistry*
*Mentor: Hanson Fong*

Tooth discoloration is a common aesthetic concern for many individuals, and in response the dental profession and public expend considerable amounts of time and money to improve the appearance of stained teeth. Although many treatments are available to attempt whitening discolored teeth, these methods are typically expensive or cause more harm to the oral health of the individual due to the use of harsh chemicals, e.g. hydrogen peroxide, which often results in tooth hypersensitivity. The peptide-enabled aqueous whitening approach restores the color of teeth by forming a mineral layer on the tooth enamel and consequently masking the underlying discoloration, offering a suitable alternative to conventional bleaching methods. In this approach, peptides direct $Ca^{2}+$ and $PO_4{}^{3}-$ ions to form a new mineralized layer on the tooth surface. The aim of this study is to develop a suitable vehicle to deliver remineralization components to an oral environment, promoting enamel remineralization and built-in tooth whitening. With this aim, lozenges composed of varying concentrations of peptide, $Ca2^{+}$, $PO_4{}^{3}-$and other inactive ingredients were manufactured using a hydraulic compression machine, and a suitable formulation was selected based on disintegration times optimized in artificial saliva. The whitening lozenge was then applied to human teeth samples under conditions mimicking the oral environment. Structural and optical properties of the resulting mineral layer were characterized using scanning electron microscopy and a chromameter, respectively. Our results demonstrate that surface discoloration has been successfully masked using whitening lozenges in vitro and, therefore, the color of the teeth was aesthetically improved. The technology developed in this study offers a simple oral hygiene product that acts biogenically in water and results in an additive treatment. The whitening lozenge is expected to considerably impact the dental and cosmetic industry as an over-the-counter product.

## POSTER SESSION 4

**MGH 241, Easel 154**

*4:00 PM to 6:00 PM*

### 3D Printed Biomineralizable Hydrogels for Biogenic Dental Tissue Repair

*Nicole Georgette (Nicole) Bentzen, Senior, Materials Science & Engineering*
*Walker Jai Kasinadhuni, Junior, Pre Engineering*
*Mentor: Mehmet Sarikaya, Materials Science & Engineering*
*Mentor: Deniz Tanil Yucesoy, Materials Science and Engineering*
*Mentor: Sami Dogan, Restorative Dentistry*

3D printing of materials has been expanding from a process used solely for manufacturing of parts and prototypes in industry to the medical fields during the last decades. The 3D printing process with hydrogels has been used for biomedical applications and the process is also gaining popularity in dental industry, though mainly for model and mold creation, although it has yet to be used for dental composites. The most common dental fillers are either metals, alloys, or resin-based composites. The traditional dental composites, such as ionomers and synthetic resins in addition to metal amalgam are non-adherent to tooth and have different thermal expansion coefficients, which can lead to cracking of the fillers and additional damage to patient's tooth. Common fillers also have non-natural colors and can leach into the blood stream or oral cavity, causing allergic and harmful reactions. In this research, our aim is to develop a biogenic dental filler using micro-extrusion 3D printing process combined with biomineralizing hydrogel technology. For 3D printable tooth filler, alginate gel was used as the main molecular scaffold along with biomineralizing peptides. After optimizing the rheological characteristics of alginate gel by tuning its concentration, crosslinking properties as well as biomineralization, the efficacy has been characterized in vitro in the presence of $Ca^{+}2$ and $PO_4{}^{-}3$ precursor ions. Furthermore, nano- and microstructures of biomineralized dental filler have been tested using scanning electron microscopy and X-ray diffraction techniques. Our results so far indicate that 3D printable, biomineralizing tooth filler can successfully be developed and, when fully optimized, the technique will allow filler material to be custom-made for patient's caries. In summary, while the novel tooth filler produces internal structures mimicking the natural tooth and well interfaced with the existing tissue, the filler material is also 3D easily fabricated for clinical implementations.

## POSTER SESSION 4

**MGH 241, Easel 155**

*4:00 PM to 6:00 PM*

### Biomimetic Dental Hypersensitivity Treatment

*Kathleen Tenny (Kate) Ericksen, Junior, Materials Science & Engineering*
*Eric Linden Hall, Junior, Materials Science & Engineering*
*Mentor: Mehmet Sarikaya, Materials Science & Engineering*
*Mentor: Deniz Tanil Yucesoy, Materials Science and Engineering*
*Mentor: Sami Dogan, Restorative Dentistry*
*Mentor: Hanson Fong, Materials Science & Engineering*

Dental hypersensitivity (DS) is one of the most common diseases in the United States, affecting the majority of the adult population. DS is commonly accompanied by gingival recession and occurs at the cervical third of the crown. DS is usually triggered externally, e.g. by cold, hot, acid, or basic conditions in the saliva, and produces a sharp pain at the root of the tooth. Our objective is to develop a biomimetic treatment protocol comprising a peptide gel formulation to treat DS. Current approaches include desensitizing nerve ends by blocking the axonic action via potassium salts, limiting the permeability of dentinal tubules using synthetic adhesive sealers, e.g. NaF, bioactive glasses, oxalic acid and glass ionomer cements, or forming coagulates inside the tubules using protein cross-linker agents. Although these agents may be effective, clinical validation is still lacking and their short durability against daily tooth brushing, various foods, or drinking of acidic beverages makes their occlusion effects incomplete. We propose to form a mechanically and thermally stable mineral layer and thereby occlude exposed dentinal tubules using a peptide-remineralization approach. Working closely with the Dental School, our approach involves exposing underlying dentin by removing cement tissue at the coronal root surface by scraping away dentin on extracted human tooth to mimic hypersensitivity conditions. The samples are next treated with peptide-enabled remineralization resulting in tens of micrometer-thick new layer over the damaged dentin. The stability of the newly formed layer is then mechanically and thermally evaluated using nanomechanical testing and thermal-cycling, respectively. Our results demonstrate that exposed dentinal tubules are successfully occluded by mechanically and thermally stable mineral layer. Through a molecular biomimetic approach, the method described herein offers a unique solution to dentinal hypersensitivity, which can be used as a platform technology to develop effective in-clinic and over-the-counter hypersensitivity treatments.