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Steele 006

“Programmable DNA-Nanomaterials for Sensing, Regulating, and Enhancing Enzyme Function”

Abstract: Approximately 10^{20} chemical reactions occur in our bodies every second, most of which are facilitated by enzymes – nature's biocatalysts. Detecting enzymes in their active form, therefore, offers significant potential for early disease detection. Furthermore, by modulating the functional state of enzymes, new therapeutic strategies can be developed. Nanomaterials are uniquely positioned to interact with enzymes. Their comparable size enables extensive surface interactions, providing advantages over small molecules. Additionally, nanomaterials can be synthetically engineered to exhibit specific multifunctional properties that are often difficult to achieve with traditional proteins or small-molecule drugs. Our laboratory focuses on the development of DNA-based molecular tools and nanomaterial interfaces to establish programmable strategies for sensing, controlling, and enhancing enzyme function. Specifically, we are designing tools to detect proteases – a class of enzymes frequently dysregulated in diseases such as cancer, neurodegenerative disorders, and infectious diseases. Our goal is to create minimally invasive detection platforms that enable early diagnosis of these conditions. In addition to detection, we are focused on regulating enzyme behavior to develop next-generation precision therapeutics that minimize side effects. To achieve this, we are developing DNA-based molecular devices that bind to enzymes but can unbind in response to specific molecular cues, providing a programmable means of switching enzyme activity on or off. A third arm of our research focuses on enhancing catalytic activity of enzymes using nanomaterials, without making any changes to the enzymes' amino acid sequences. Together, our work establishes a unified strategy for sensing, regulating, and enhancing enzymes, leveraging DNA nanotechnology and nanomaterial interfaces. These advances provide powerful new approaches for precision diagnostics, synthetic biology, and biocatalysis, with far-reaching applications in medicine, biotechnology, and industrial catalysis.

Bio: Devleena Samanta is the William H. Tonn Endowed Assistant Professor of Chemistry at The University of Texas at Austin (UT Austin). Her research focuses on developing protein and DNA-based nanostructures for chemical sensing and therapeutic applications. Her achievements in the field have also been recognized with numerous honors, including the prestigious Packard fellowship, a Scialog Fellowship, the Outstanding Researcher Award from the International Institute for Nanotechnology (IIN), and selection as a Hanna Gray Fellow Finalist by the Howard Hughes Medical Institute. She is a recipient of the College of Natural Sciences Teaching Excellence Award and the Natural Sciences Foundation Teaching Excellence Award at UT Austin, as well as the Outstanding Mentor Award from the IIN. Devleena earned her Ph.D. in Chemistry from Stanford University in 2017 under the mentorship of Professor [Richard N. Zare](#). She then trained with Professor [Chad A. Mirkin](#) at Northwestern University as an IIN Postdoctoral Fellow.