Synthesis and Characterization of Nucleic Acid-functionalized Nanomaterials

Brianna S. Carroll, Purdue University and Jong Hyun Choi, Purdue University

Motor proteins such as kinesin move along microtubules in order to transport cellular cargos throughout the cell by obtaining energy from RNA hydrolysis which allows the cell to complete the tasks needed to stay alive. In this work, we developed synthetic molecular motors using DNA enzymes (DNAzyme) and fluorescent nanomaterials which mimic the functions and structures of motor proteins. A DNAzyme-capped CdS nanoparticle and a RNA-functionalized single-walled carbon nanotube (SWCNT) were used as a walker and a track in the motor platform, respectively. As a walking mechanism, the DNAzyme cleaved the RNA substrates in the presence of metal cations. The RNA molecules were functionalized with SWCNTs using pi-pi stacking. Due to their fluorescent properties under specific light excitations, they were visualized to track the position of our motor. In addition, we studied the kinetics of molecular motors in different environments. As a result, the fastest translocation velocity was found to be 1nm min^{-1} and the maximum displacement was 3μm. A turnover rate of $0.025s^{-1}$ was determined by making a kinetic model based on the density of the single motor reactions. We demonstrated that the cation concentration, type of metal cation, pH, and temperature all modify the kinetics of the molecular motor. In conclusion, we developed the bio-inspired synthetic motors using DNA nanotechnology and showed how to control their movements using design of structures and modification of chemical environments. In the future, we will develop the kinetic model to analyze their kinetics and design the optimized molecular motors on purpose.