Revealing the Origins of Friction via Atomic Force Microscopy

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Synthetic biology aims to design cellular systems for a defined function. Functional genes, synthetic genetic control systems and biocomputing approaches are the key tools to develop synthetic genetic circuits for advanced functionalities. In other words synthetic biology is an engineering discipline that applies strand engineering rules to controlled hierarchical assembly of the genetic building block within a cellular framework. In our approach we designed genetic circuits to probe the bio-nano interfaces through cellular programming. We implemented synthetic genetic circuits to pattern nanomaterials, to synthetize nanomaterials and to report toxic event triggered by nanomaterials. In this context we developed cellular programming abilities through synthetic genetic circuitries. In the nanomaterial patterning and synthesis part we utilized bacterial biofilm structures. Bacterial biofilms are complex, hierarchical assemblies of the bacterial biofilm proteins, carbohydrates and other biomolecules (depending on the bacteria species these biomolecules may vary). In this study we used E. coli biofilm proteins as a tool for material synthesis and patterning through cellular programming. The cellular programming language used RNA based devices, bacterial cellular communications etc. E. coli biofilm composed of two major protein namely CsgA and CsgB proteins through engineering of these proteins nanomaterial patterning capabilities of biofilm structure are engineered. Controlling the assembly route of the CsgA and CsgB protein through cellular engineering we managed to form patterned nanoparticle assemblies covering large areas for material applications. Additionally biofilms were engineered to create a conductive interfaces for electro-genesis and electro-genetic applications. We followed two routes i) using nanoparticle growth to establish continuous nanoparticle chains enabled conductivity ii) mimicking conductive polymers and designing&fusing aromatic rings to biofilm structures and enable a bio-based conductivity. We have also programmed cellular systems to sense nanomaterial precursors and synthesize corresponding material via a simple circuitry. We managed to grow metal, metal-oxide and semiconductor material using this approach.

In addition to the nanomaterial patterning and protein nanofiber engineering approaches, another area for the utilization of synthetic biology for nanotechnology applications is to probe nanotoxicity of the nanomaterial systems. In this approach we utilized the well-characterized heat shock response regulation system. In this approach we managed to build genetic circuits those can sense and response to the nanomaterial toxicity through sensing the ions related with the corresponding nanomaterials. In conclusion synthetic biology provides many tools to probe the nano-bio interface towards synthesizing new material systems, understanding material-cell interactions and creating innovative interfaces for next generation biomedical technologies.

References

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