Synthetic Biology for Engineering Programmable Soft Materials

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Abstract

Hydrogels based materials have drawn much attention within the past decade. Potentials for engineering their properties have broadened their applications from therapeutic devices to tough materials for use in robotics. These developments have coincided with the rise of synthetic biology that has led to new methods for artificial regulation of gene expression, engineering nano- and micro-scale modules within living systems, and interfacing living systems with inorganic materials. As such the past few years has seen the extensive integration of synthetic biology modules into hydrogels to impart sense and response functionalities. These novel biomaterials should be superior to traditional materials that suffer from 1) centralised, top-down and resource intensive manufacturing processes, and 2) a limited ability to sense and respond to their environments. Nonetheless hydrogels as the first generation of smart biomaterials still suffer from a limited signal bandwidth and sense/response abilities that are coupled with their bulk properties, where an output of the system is often reflected by a gel-sol phase transition. Recent efforts have tried to overcome these limitations with a view to creating materials with higher order intelligence and Boolean functionality, where the signal output is independent of the material properties. The fulfillment of this goal has been made possible due to the emergence of cell free transcription/translation, providing strategies for engineering structurally independent, programmable and orthogonal multi sense and response systems. Moreover, the convergent bottom-up approaches in the field of artificial life for the construction of minimal cells, is also expected to have unprecedented impact on smart material sciences in the years to come.

***Keywords**:* Synthetic Biology, Hydrogel, Soft Materials, Cell-Free, Artificial Life

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