

352a Chitosan-Mediated Biofabrication: Interfacing Devices and Biology

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Recent advances in two distinct areas have made unprecedented development of technology in the fields of science, engineering and medicine. The first area is microfabrication that has significantly changed the dimensions and scale for performing sciences. The second area is biological sciences that continue to provide tools in connecting and manipulating genetic information to complex biological functions. Integrating these two areas offer tremendous opportunities that will enable even greater advancements for both areas. New fields such as nanobiotechnology and implantable BioMEMS are already emerging and making significant impacts. Indispensable to this integration is the assembly of biomolecules onto inorganic surfaces that will provide vitalization of “lifeless” platforms with the “bio-reagents” that give recognition and/or biofunctional capabilities. Despite recent efforts, simple and robust biomolecule assembly strategy that allows spatial, temporal and orientational control remains highly needed. We have developed chitosan-mediated biofabrication concept to harness biochemical properties of various biopolymers for such facile biomolecule assembly onto inorganic devices.

Chitosan is an aminopolysaccharide with a primary amine group at each glucosamine monomer unit. As shown in Figure 1, the low pKa value (6.5) of this amine group makes chitosan soluble at low pH and insoluble at high pH. This pH-responsive property allows deposition of chitosan onto conductive surfaces by applying an electric signal to generate a localized pH gradient. By exploiting microfabrication to program this directed assembly of chitosan we were able to construct biopolymeric scaffolds which then can be readily biofunctionalized in a spatially selective manner.

Specifically, the amine group's nucleophilicity enables facile covalent conjugation of biomolecules such as nucleic acids, proteins and even virus particles. First, single-stranded DNA can be covalently coupled to chitosan by chemical conjugation to generate readily addressable probe sites for nucleic hybridization assays. Further, this “nucleation site” can function as the capture surfaces for self-assembled nanostructures such as tobacco mosaic viruses, as shown in Figure 2.

Second, proteins can be assembled onto inorganic surfaces by chemical or biochemical means. Protein assembly (a red fluorescent protein DsRed) can be achieved by covalently coupling the proteins onto electrodeposited chitosan, as shown in the upper panel of Figure 3. In addition, proteins can gain the ability to be electrodeposited by forming a conjugate with chitosan, as illustrated in the lower panel of Figure 3. We use an enzyme tyrosinase to anchor proteins (in this case GFP) to chitosan and electrodeposit this protein-chitosan conjugate onto surfaces by applying an electric signal. This flexibility allows sequential assembly of multiple proteins onto different addresses, as shown in Figure 3.

We have also recently shown that our chitosan-mediated assembly strategy is readily applicable to BioMEMS devices for post-fabrication biomolecule assembly in three dimensional structures. In conclusion, we believe that our strategy offers several advantages such as spatial and temporal control, simplicity, user-friendly and flexible assembly for the integration of microfabrication and biology. In this presentation, our recent advances in virus assembly as well as the newest implementation to biophotonic devices will be highlighted.

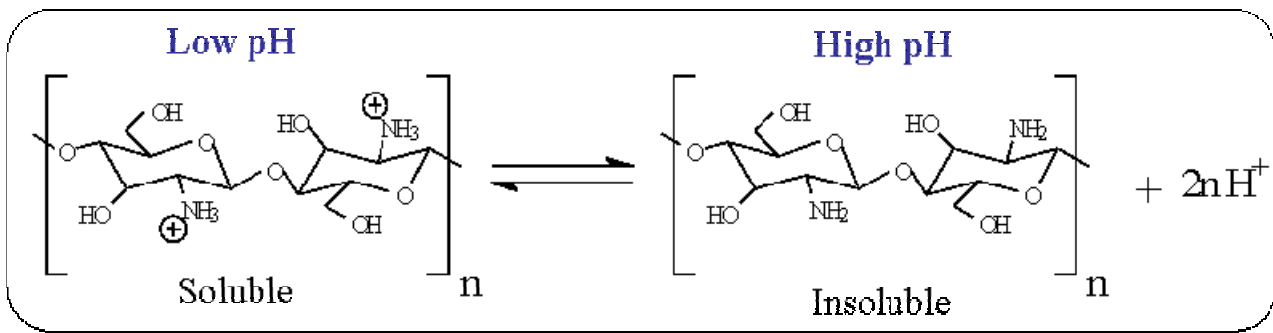


Figure 1. Structure and pH Responsive Property of Chitosan

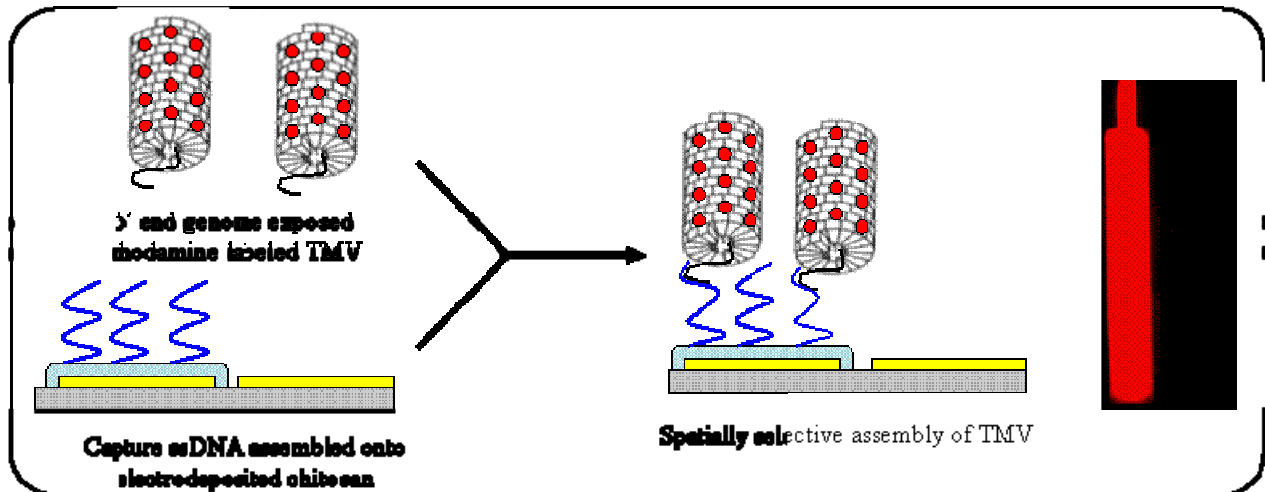


Figure 2. Virus Assembly onto Electrodeposited Chitosan

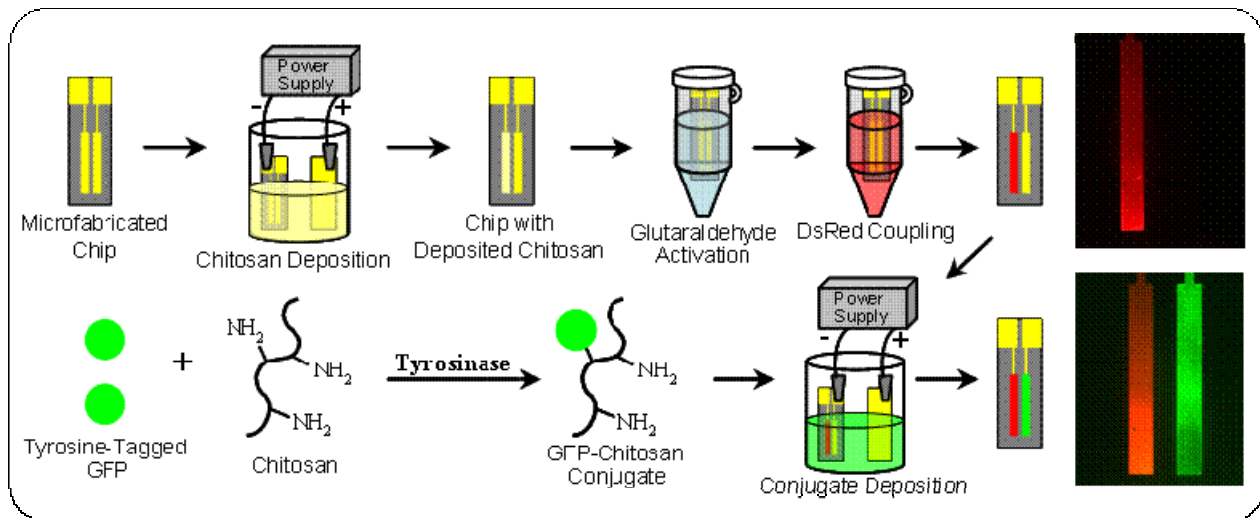


Figure 3. Sequential Assembly of Proteins