Nanotechnology and Intelligent Response:
What Have They Done for Biomaterials Lately?

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Over the past 50 years, polymers have been approved as biomaterials in a wide range of biomedical applications and devices. Extensive studies of their biocompatibility have been reported. Especially hydrophilic polymers like hydrogels have functional groups that interact with the external environment (e.g temperature, ionic strength, and pH of the swelling agent).

In recent years, there has been considerable work in preparing *intelligent biomaterials* and finding new uses for nanoscale structures based on such biomaterials. Uses such as microchips, micropatterned devices, materials for biosensors, systems for biological recognition, and carriers for controlled and targeted drug delivery have shown the versatility of these biomaterials.

Of specific interest are applications for the formation of nanoscale three-dimensional structures. These micropatterned structures may be used for a host of applications including cell adhesion, separation processes, the so-called "factory-on-a-chip" microscale reactors, and microfluidic devices.

Why do we observe such explosion in the field now? Electronic devices have now reached a stage of dimensions comparable to those of biological macromolecules. This raises exciting possibilities for combining microelectronics and biotechnology to develop new technologies with unprecedented power and versatility. While molecular electronics use the unique self-assembly, switching, and dynamic capabilities of molecules to miniaturize electronic devices, nanoscale biosystems use the power of microelectronics to design ultrafast/ultrasmall biocompatible devices, including implants that can revolutionize the field of bioengineering.

Thus, in recent years, we have seen an explosion in the field of novel microfabricated and nanofabricated devices using intelligent hydrogels. Such devices seek to develop a platform of well-controlled functions in the micro- or nano-level. They include nanoparticulate systems, recognitive molecular systems, biosensing devices, and microfabricated and microelectronic devices.

For example, polymer surfaces in contact with biological fluids, cells, or cellular components can be tailored to provide specific recognition properties or to resist binding depending on the intended application and environment. The design of surfaces for cellular recognition and adhesion, analyte recognition, and surface passivity encompasses a number of techniques such as surface grafting (ultraviolet radiation, ionizing radiation, electron beam irradiation). Certain techniques can change the chemical nature of surfaces and produce areas of differing chemistry as well as surfaces and polymer matrices with binding regimes for a given analyte.

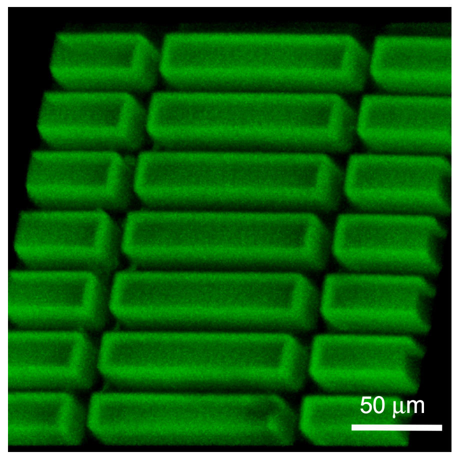

Figure 1. 3D Projection a slice of a micropatterned square array of biomimetic polymer networks obtained utilizing a confocal microscope.

In addition, biomimetic methods are now used to build biohybrid systems or even biomimetic materials (mimicking biological recognition) for drug delivery, drug targeting, and tissue engineering devices.

Yet, such systems are not widely available and they have not been approved yet by FDA. Frankly, most of these systems are still in the very early research level and they have not been tested yet in long-term applications. At least three of the companies that were started based on nanotechnology initiatives have folded. Thus, our immediate lesson is that nanotechnology promises a lot to the biological field, but that there is much to be screened before we can talk about truly nanotechnology-based systems.