Chapter 26
RESPONSIVE MOLECULAR GELS

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1. Introduction

Responsive materials are characterized by a change in their properties in response to a specific physical or chemical stimulus. Semiconductors, magnetic coatings, and liquid crystals are among the most prominent examples of such materials. Gels represent a completely different class of soft condensed...
materials and are ideally suited to be responsive materials because they combine the elastic behavior of solids with the micro-viscous properties of fluids [1].

The archetype responsive gel is the cytoskeleton, which consists of a highly dynamic network of microtubules and actin filaments embedded in a liquid phase. The continuous assembly and disassembly of the microtubules and actin filaments is governed not only by thermodynamics, but is under active kinetic control via mechanisms involving nucleation and enzymatic covalent modification. As a result of these dynamic processes, the function of the cytoskeleton involves much more than just giving a cell its shape and mechanical stability. The kinetic regulation leads to a number of interesting and unusual phenomena, such as polar growth and self-organization. They are essential to many complex functions such as intracellular transport and organization, endo- and exocytosis, cell movement, and cell division.

The cytoskeleton is, without doubt, one of the most sophisticated gel types that is currently around us, and if mankind were able to incorporate even a few of the aspects of its functionality into artificial systems, it would lead to major progress in areas such as drug delivery, separation and catalysis, microfluidics, and actuator and sensor technology.

1.1. Responsive Chemical Gels

The most widely used gels are the chemical (or polymer) in which a three-dimensional network is maintained by cross-linked covalent bonds. The covalent cross-links make these gels robust and tolerant to physical deformation (Figure 1A). Chemical gels have been developed that can react to a physical

![Figure 1](image)

Figure 1. Schematic representation of a chemical gel (A) and a physical gel (B). The chemical gel alters its volume upon temperature changes, whereas the physical gel dissolves and reassembles.