Hydrogels for biomedical applications: Characteristics, applications and processing

Anisa Mahomed

Department of Chemical Engineering and Applied Chemistry, College of Engineering and Physical Sciences, Aston University
Birmingham B4 7ET, United Kingdom
Phone +44 121 2044891, E-Mail: a.mahomed2@aston.ac.uk

Current Position(s): Lecturer, Department of Chemical Engineering and Applied Chemistry, Aston University, Birmingham

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Abstract

This talk briefly discusses the **unusual properties** of hydrogel polymers and how these are processed and ingeniously adapted for applications such as breast implants, burn dressings, chronic wound dressings, soft contact lenses, tissue engineering scaffolds and many more medical and industrial applications.

Hydrogels are three-dimensional hydrophilic polymer networks, either natural or synthetic in origin, capable of imbibing large amounts of water or biological fluids but do not dissolve due to the presence of crosslinks. The water contained within a hydrogel strongly influences its behaviour. This water governs the unique mechanical, surface and permeability properties that give hydrogels the interface **compatibility with living tissues**.[1]

A characteristic advantage of hydrogels is that their properties can be tailored by modifying the ratio of the comonomers to obtain different degrees of hydrophilicity. Hydrogels can be formulated to have a similar water content to body tissue and thus also have the ability to transport nutrients and waste. On the contrary, a disadvantage intrinsic to hydrogels is their low mechanical strength, although this can be overcome by altering the degree of crosslink or by forming interpenetrating networks. Importantly, hydrogels can be tailored to behave as "**smart**" materials that are environment- or stimuli-sensitive. These hydrogels may for example, change their degree of swelling reversibly and reproducibly in response to temperature, pH, light, etc. This gives hydrogels enormous potential as drug delivery vehicles.[2][3]

Aside from composition, equally critical to ensuring hydrogels have the desired properties are the processing conditions to produce the final product. In general, the process involves **free-radical polymerisation** of solubilised multifunctional vinyl monomers in the presence of a relatively small amount of crosslinker. It is important to note that the initial stage of hydrogel processing involves the mixing of solids and liquids that may vary significantly in volume and have a wide range of physical properties. The conditions required to produce a homogenous liquid mix thus need to be carefully determined. Polymerisation is then initiated through either chemical catalysts, heat, irradiation or photoradiation amongst other initiation systems. The choice and conditions of these influence the final product property as much as composition. The physical aspects of processing also need to be considered, for example for smaller hydrogel medical devices, such as soft contact lenses, there is a choice between traditional techniques, such as spin-casting, mould-casting and lathe-cutting as well as the patented CibaVision Lighstream technology based on ultraviolet radiation. On the other hand, for larger medical devices such as chronic wound dressings, rolls of hydrogel can be produced by combining high throughput liquid coating on a specified substrate in combination with ultraviolet curing. The hydrogel can then be laminated, slit and die cut to specification. Thus, effective processing requires a carefully determined specific set of conditions to produce a final product that meets both the design specifications and regulatory requirements.

Keywords: hydrogels, biomaterials, drug delivery, transport, processing.

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