Study on the Development of Hydrogels and Their Optical Applications

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ABSTRACT

The possibility of using electric hydrogels as materials in lenses with variable focal length ("smart lenses") has been investigated. The focus is on identifying and controlling parameters such as the density of the surface connection and the degree of neutralization that affects the properties of the required gel. These characteristics include optical transparency, structural strength and electrical reactivity. The transmission of an electrical signal to the gel is investigated by determining the ideal shape, location, and material for the electrodes used in Smart Lens applications. Types of materials are tested with mixed results, and suitable electrode materials are recommended. The structural and optical properties of the gels are evaluated through swelling and optical transmissivity measurements. However, there are some apparent anomalies that are attributed to limitations in existing knowledge about gel swelling processes.

Keywords: CCHP, GSHP, Energy Analysis, Geothermal Heat Pump

1. INTRODUCTION

Currently, millions of people around the world suffer from vision problems such as myopia (hyperopia), hyperopia, astigmatism (distortion of shape of the lens), and presbyopia (age related hyperopia). Although the number of people suffering from some type of refractive error is unreliable (and geographically it is one type), the World Health Organization (WHO) estimates that 35 million people now are in need of low-vision care [1]. In addition, this number is increasing as the world's population grows. Due to increased life expectancy today, it is not impossible to predict that presbyopia will soon become the most common vision problem for people over the age of 45. For this reason, many researchers are investigating ways to create lenses that can deal with the problems caused by cerebral hypertension, a lens with two or more focal lengths. Bifocal and trifocal lenses represent the first attempt to solve this problem, and included two (or three) lenses with different focal lengths to create a single "lens." Progressive Addition Lenses (PAL) have expanded the bifocal and trifocal lenses design by adding an additional area that has a variable power area [2]. Graded-Index (GRIN) Lenses have a continuously variable refractive index and therefore have a continuously variable focal length. Recent developments include a lens system that connects to an engine and an infrared laser and is able to automatically adjust its focal length [3]. In 2001, e-Vision development developed lenses with variable focal length of prototype using a material that changes its refractive index (and hence the focal length) in response to an electric field. Presbyopia will soon become the most common vision problem for people over the age of 45.

2. METHOD

A set of acrylic / sodium acrylate copolymer hydrogels was made by free radical polymerization using 10-40% moles of neutral acrylic acid, using 40 mg (0.14 mmol) of potassium permanganate as the initiator. Different concentrations of N, N-methylenebisacrylamide (BIS) crosslinker were added to pre-gel solutions, and polymerization was performed at 75 75 75 1 4-5 C for 4–5 h in 2-cm diameter glass tubes. The gel cylinders were thoroughly washed with distilled water for removal of unreacted monomers and were cut on discs with a thickness of approximately 7 mm. The discs were kept in a sealed container before use to minimize evaporation. A number of experiments were performed to determine whether the gel discs synthesized were electroactive. Since an important part of any electrical test is the electrodes, a wide range of electrode materials, shapes, and locations have been tested. The shapes of the electrodes examined in Table 1 with a summary of the materials used are given in Table 2. Most of the materials in Table 2 were not suitable to be used use as electrodes because they apparently reacted with hydrogels. The NaCl solution around the two substances, which looked very promising, silver and aluminum, did not respond to gel swelling tests. Silver foil contaminates the hydrogel if an anode is used, however, when it is used as a cathode, no obvious reaction occurs and the electrode can be reused over and over again. A similar situation has occurred with aluminum foil, except that a reaction has occurred if aluminum is used as the cathode. However, if aluminum foil is used as an anode, no obvious reaction has occurred. By combining the two materials, it was possible to produce a pair of electrodes without reaction produced from relatively inexpensive materials.

3. ELECTRICAL RESPONSE

To test the electrical response, the gel discs were subjected to 5 V DC pressure (with a current limit of 200mA) for 5 min, the voltage being applied using a pair of aluminum "rings". The experiment was performed three times, using a different gel sample for each experiment, and in all cases the unpleasant gel disc became a swollen "mushroom". The dimensions of the gel disc are measured before using electricity, and before measuring the dimensions of the swollen fungus and shown in Table 3. Table 3 shows the dimensions (a) and (c) of the change in gel height. Swelling occurs when dimensions (b) and (e) make radial change.

4. OPTICAL PROPERTIES

It has already been shown that the transmission of polymer gels depends on a large extent on the cross-linking material available. To do this, the gels were synthesized using a method previously discussed with 100, 150, 175, 200 and 225 mg cross-linking substances in 2.52 g of monomer. Rectangular pieces with approximate dimensions of 3 ×3.5 0.3 cm were removed from the gel cylinders. The transmission spectrum relative to the deionized water was determined using a Pharmacia Biotech Ultrospec 2000 UV / Spectrophotometer that works in transmission mode. Each transmission amount was determined three times and the mean standard deviation was 5%. The maximum, minimum and average of transmission of gels with 150 to 225 mg of cross-linking material per 2.52 g of monomer, for a wavelength of 400-700 nm, are given in Table 4. Data show that as the concentration of the cross-linking material increases, the transparency of the hydrogel decreases significantly.

Table 1. Electrode shapes [7] R.A. Paxton, A.M. Al-Jumaily, A.J. Easteal,

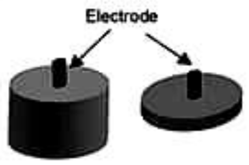
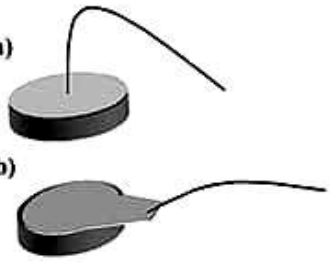
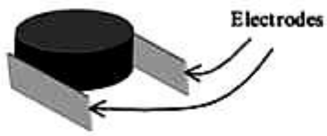
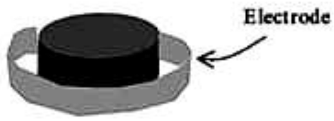
Diagram	Name	Summary
	"Rod" electrode	Frequently used by other authors, although not suited for applications where the gel surface is required. Also, charge enters the gel at one centralized point.
(a) (b) 	"Disk" electrode "Spoon" electrode	Electrode shapes developed in this work. Spoon electrode used frequently in experimentation, due to ease of attachment. Disk electrode slightly more difficult to attach. Offers the advantage of "distributed charge".
	"Sheet" electrode	Least-used design, but may offer some advantages as the entire surfaces of the gel is left uncovered.
	"Ring" electrode	An idea first mentioned by Salehpoor [5]. Utilized frequently in this research as it leaves the gel surface uncovered.
	"Circular" electrode	Overcomes the problem of "centralized charge" whilst still allowing most of the surface to remain uncovered.
	"Conducting sheath" electrode	Perhaps the ultimate electrode, but also the most difficult to design. Will require further research to be fully realized.

Table 2. Electrode materials [7] R.A. Paxton, A.M. Al-Jumaily, A.J. Easteal,

Material	Purity	Dimensions	Obtained from
Copper foil	99%	Thickness : 0.1 mm	BDH Chemicals
Carbon	unknown	Diameter: 6.1 mm Weight: 3.1862 g	Standard laboratory supply
Surgical-grade stainless steel	unknown	Diameter: 1 mm	unknown
Zinc foil	99%	Thickness: 0.1 mm	BDH Chemicals
Silver foil	99.9%	Thickness: 0.025 mm	Aldrich Chemical Company
Aluminum foil	unknown	Thickness: 0.1 mm	RS Components

Table 3. Parameters of swollen gel [7] R.A. Paxton, A.M. Al-Jumaily, A.J. Easteal,

Gel #	1	2	3
a	6.5 mm	7.5 mm	9.0 mm
b	17.6 mm	20.8 mm	20.0 mm
c	7.0 mm	8.5 mm	9.0 mm
d	3.0 mm	3.0 mm	5.0 mm
e	17.5 mm	20.8 mm	17.0 mm
f	21.5 mm	23.4 mm	23.0 mm

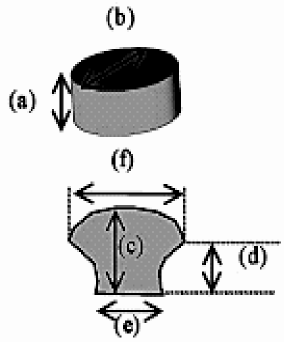


Table 4. Transmission of hydrogels [7] R.A. Paxton, A.M. Al-Jumaily, A.J. Easteal,

Amount of crosslinking agent#	T(max) (%)	T(min) (%)	T(mean)(%)
150	94	84	91
175	78	64	73
200	32	28	31
225	18	17	18

5. DISCUSSION

This work has shown that polyhydric (acrylic acid- Sodium oxalate) hydrogels can be formed under the influence of an electric current. In addition, swelling can be repeated, and in this case, the rate of swelling is relatively constant. The optical transparency of the hydrogels decreases with increasing distance of the connection, with a significant decrease in the connection density between 175 and 200 mg of BIS per 2.52 g of monomer. The source of large reduction in transmissivity in that range of crosslink densities is still unknown: it may indicate the presence of a discrete difference in structure between gels with crosslink densities in the lower and upper ranges.

6. CONCLUSION

This work has shown the potential viability of applying poly (acrylic acid-co-sodium acrylate) hydrogels as materials in a new generation of Smart Lenses. A lot of obstacles still exist, and they must be addressed before significant progress can be made.

In particular, work must be done to determine the concentration of the ideal cross-linking material that balances the optical properties with the structural properties

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