Birefringence Measurements of the Stretched Hydrogel Materials and Shark Corneas by Photoelastic Method
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1. Introduction
The human cornea comprises many tissues and structures [1], which can be divided into epithelium, anterior elastic lamina, stroma, descemets membrane and endothelium of the anterior chamber from the outside to the inside. The stroma accounts for about 80% to 90% of the total thickness of the human cornea. It mainly consists of about 200 layers of lamellae. Each layer is about 2 micrometer thick [2]. The interlayer collagen fibers are arranged in different directions to form a staggered structure. Due to the staggered structure of the collagen fibers of the stroma, the cornea has specific optical properties, for example, birefringence [3]. To design successfully an artificial cornea, it is necessary by imitating the fibrous tissue and material properties of the human cornea stroma to increase mechanical properties and to maintain good optical properties. Polyvinyl alcohol (PVA) is the primary material of artificial cornea because of its high biocompatibility and a layered structure similar to the matrix [4]. In this work, we took PVA hydrogel samples which were fabricated by the mold and stretching methods [5] We used the photoelastic method to analyze the stress of the sample and then used the phase and stress analysis to calculate the birefringence [6]. In addition, to show we can apply this method to the biological sample, we also measured the birefringence property of the shark corneas.

2. Methodology and Results
The setup of the photoelastic measurement system is shown in Fig. 1. The sample is placed in the fixture and pumped to simulate the intraocular pressure. When the light passes through, the photoelastic stripes are generated. At this time, the camera is used to record the photoelastic stripes produced by different pressures.

Fig. 1. The photo of the photoelastic experiment setup.

The experimental results of photoelastic photos are shown in Fig. 2.(a)~(d). We extract the photoelastic stripes at the edge of Fig. 2.(a)~(d) to become Fig. 2.(e). As the pressure increases, the stripes will be expanded outward from the center (i.e. leftward in the figure).

Fig. 2. (a)~(d) Patterns of hydrogel sample under different pressures and (e) Extraction patterns of photoelastic stripes.

In addition, to show that the biological sample can also be measured by this method, we did the measurement of the shark cornea. After analyzing the photoelastic fringe for red, blue, and green colors and the data substituting into the formula of the photoelastic method [6], a set of different refractive index values can be obtained. Furthermore, using the refractive index measured in the literature i.e. n1=77 and difference in refractive index i.e. n1-n2, the birefringence of the sample can be measured, as shown in Table 1.

Table 1. Birefringence measurement results.

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3. Conclusion
The photoelastic experiment measurement results show that the PVA hydrogel sample with the multilayer structure and the shark cornea has two different refractive indexes i.e. birefringence characteristics. These results can be used for artificial corneal designs with birefringence characteristics.

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References