

3D Printing Assisted Fabrication of Novel Intraocular Lens Structure with Autonomous Focal Shifting

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Recent advances in materials and micro-engineering have led to biomimetic optical devices that no longer require complicated mechanical units to tune optical performance (Appl. Phys. Lett. 85, 2004; Nature 442, 2006; J. Mater. Chem. B 3, 2015). However, considerable work is required to transform those concepts into IOL technology as the liquid/solid interactions and stimuli (electric field, PH, etc) for actuation are hard to facilitate in the actual environment (human eye). Compared with traditional IOL materials (PMMA, Silicone, acrylics) that provide fixed focal length of 52.6 mm (1/19 metres), Poly(N-isopropylacrylamide) gel (PNIPAM, **Fig1a**) holds promise for achieving switchable focal length with its good bio-compatibility, reversibility and designable multi-responsive features (temperature, PH, ion content, etc) (Nature 373, 1995; Biomaterials 30, 2009; Sci. Transl. Med. 9, 2017).

In this work, we will use PNIPAM gel to develop novel IOL technology. By chemically adjusting the gel composition and applying the structural design, we will develop an IOL of 1:1 (**Fig1b, e & f**) to existing products (focal length of 52.6 mm) with a shifting focal distance of 7 mm, high flexibility and adaptability, anti-bacterial properties and resistance to calcification. There are various IOL haptics designed with the same optical lens. Three diopters (-5, 20, 30) optical lens designed for future optical test. All of these IOLs manufactured by 3D printed moulds (**Fig1c & d**). The high concentration of calcium caused calcium deposition on the surface of IOL, IOL becomes white like cataract. The concentration in normal human lens is 0.15 to 0.5 $\mu\text{mol/g}$, the value increased up to 9.31 $\mu\text{mol/g}$ in cataracts (Cell Biochemistry and Function, 18, 2000).

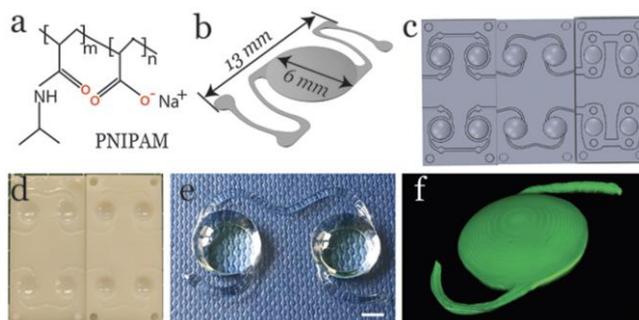


Fig.1. (a) The chemical composition for PNIPAM gel. (b) Illustration of angle supported IOL design. (c) Other attempted IOL design. (d) 3D printed mold. (e) The optical microscopic image and (f) the laser confocal image of the fabricated IOL design.