Development and Optimization of a Novel Rapid-Acting PVA-Glycerol Hydrogel Optical Clearing Patch for Enhanced Light Transmission Through Tissue-Mimicking Phantoms

Khan, Parishey (School: McIntosh High School)

Human skin scatters light because of collagen fibers and cellular structures. This can make it hard to utilize noninvasive imaging through skin in the medical industry. This project aimed to develop a safe, low-cost (PVA) based optical clearing hydrogel patch capable of increasing light transmission and clarity through biological tissue within 20 minutes. Seven main hydrogel prototypes with differences in glycerol, glucose, and propylene glycol concentrations, as well as patch thickness. All patches were cast as thin PVA films and applied to ex vivo dehydrated chicken skin, selected as a relevant tissue model. A controlled LED-sensor imaging system measured transmitted light intensity, while printed clarity charts tested changes in image visibility through the phantoms. Light transmission was recorded between 0 and 15 minutes for all prototypes and compared to a no-patch control All three prototypes increased light transmission relative to the control. Prototype 6 (0.5mm, PVA with propylene glycol-glycerol formulation) produced the greatest improvement, achieving a +53.7% rise in transmitted light and the highest clarity improvement. Prototype 2 also dramatically increased light at +32.5%, and was less harsh on the skin. Other prototypes showed moderate gains depending on the composition, highlighting the importance of diffusion rate and index matching in optical clearing. The findings suggest that inexpensive PVA based hydrogel patches can safely and quickly increase optical transparency of skin-like tissues. This approach may support future development of improved noninvasive imaging in the medical industry.

Awards Won: