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Editorial: The role of polymer hydrogels in the bio-medical field

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Editorial on the Research Topic
The role of hydrogels in the bio-medical field

Hydrogels are chemically or physically cross-linked materials for use in several real-world applications across industrial, military, and bio-medical technology applications. With multidisciplinary research, promising advancements and insights have been developed in hydrogel technology. Related materials with differing compositions include aerogels, cryogels, xerogels, or sol-gels (Job et al., 2005; Coradin et al., 2006). An initial hydrogel technology began as a water-based crosslinked network material utilizing polyhydroxyethylmethacrylate (pHEMA) for the purpose of permanent contact applications with human tissues for uses inside a patient (Chirani et al., 2015). Over time, biogel hydrogels were synthesized to have varying viscosities and elastic properties leading to the modern development of "smart hydrogels". Smart hydrogels are localized personalized medicine gel-based microenvironments containing specific tunable properties to produce desired effects, are surgically injectable, and are sensitive to stimuli (Shojaeifard et al.). Hydrogels offer several benefits, including a less pro-inflammatory immune response compared to other less biocompatible materials, such as metallic implants (Carossino et al., 2016). Since hydrogels are porous, they also allow for more natural diffusion than other materials when incorporated into a human body. There is also a potential for hydrogels to be more cost effective than other biotechnologies.

Additionally, hydrogels are tunable and can have formation adjusted quickly to environmental changes, can be synthesized to be biodegradable, and are an acceptable environment for cellular incorporation and scaffolding for 3D-cell culture. Further advancements in clinical mapping of these hydrogel properties, optimization of pore-microstructure, and rheological measurements could help practical applications of selecting the right gels for the right clinical procedure. Varying the Young's modulus and chemical composition of hydrogels can change the levels of cell responsivity, cell migration, and cell adhesion. For applications involving synthetic tissues during ongoing tissue and organ shortages, hydrogels with growth factors such as vascular endothelial growth factor (VEGF) can be utilized to guide the overall shape of tissue growth and recovery. Potentially using hydrogel-encapsulated autologous stem cells could lower the chance of a body rejecting tissue (Lu et al., 2024). Peptide incorporation can also affect mechanical stiffness of the hydrogel (Shen et al., 2007). Polylactic acid, polyethylene glycol, and natural materials have been suitable for synthesis of hydrogels (Farman et al.). Other example material incorporation with hydrogel includes but is not limited to chitosan, alginate, collagen nanofibers, nanoparticles, gelatin, elastin, hyaluronic acid, dextran, polyvinyl alcohol, poly (hydroxyethyl methacrylate), and polyN-isopropylacrylamide. Conjugated hybrid hydrogels with bio-active components have also had successful formation for synthetic tissue design (Zhu and Marchant, 2011).

Potential objectives of hydrogel research include but are not limited to: Matrigel, artificial cartilage, synthetic synovial fluid, synthetic vitreous humor, plastic surgery implants, liquid bandages, liquid stitches, scaffolding for tissue recovery in burn victims, soft-robotics, bioprinting, water processing membranes, and even in cosmetic industries and textiles. Furthermore, wearable electronic sensors could be an excellent usage of hydrogels for people at the early stages of neuromuscular disorders or other clinical manifestations where controlling prosthetic soft-robotic devices would have a larger range of motion than the person. If there is environmental pollution from a factory or shipping spill, absorptive hydrogels can be used with enzymatic incorporation for environmental recovery for health and safety (Du et al., 2020). Hydrogels are also currently, one of the most promising materials for promoting vascularization due to its biocompatibility in human tissues (López-Gutierrez et al.). The biodegradability of the hydrogel can also be modulated to make quick release or long release biotherapeutics. Sustained biotherapeutic compound delivery in pharmaceutical applications has been shown to be widely utilized with hydrogels (Umar et al.; Goyal and Mitra, 2022).

With cross-collaborative research, hydrogels can be used in the real-world across various fields to assist lives for the better. Advances in hydrogel technology could produce match-ready hydrogels specific to the patient's situation. Journal editors would like to thank the authors for their contributions to this Research Topic and hope for an inspiring journey ahead with the continuation into research advancements.

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