Next-Gen Smart Materials: Thermo-Responsive and Conductive 3D Printable Polymer Gels

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Smart, thermo-responsive polymeric gel compositions were developed using alginate-p-NIPAM (poly-N-isopropylacrylamide) and biocompatible conductive segments. These waterborne formulations were thoroughly characterized for their rheology and flow behavior, then optimized to be 3D printable using low-cost syringe-extruder printers. This eliminates the need for sophisticated printers that are expensive, difficult to maintain, and lack portability. The polymer formulations were made conductive using ultra-conductive special grade graphene, then evaluated for electrical properties. Various intricate structures were 3D printed and further crosslinked by post-treatment with safe chemicals such as calcium chloride to optimize material properties like hardness, flexibility, and performance. This approach allows the use of live cells in 3D printing without being damaged by alternative crosslinking methods such as UV radiation exposure or toxic crosslinkers. The developed conductive gel was evaluated as a low impedance medium for recording high-quality electroencephalogram (EEG) tests. The smart gel, which was optimized for rheology, was also 3D printed using Hyrel printers to produce human tissue-like models.

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