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Engineered Polymeric Hydrogels for 3D Tissue Models

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ABSTRACT

Since of its specific properties, such as multi-tunability, biocompatibility and simple manufacturing, polymeric biomaterials are commonly used in a wide variety of biomedical applications. Polymeric hydrogel materials in particular are commonly used as therapeutic implants and as therapeutic vehicles for drug delivery systems and tissue regeneration. Because of the structural and physiological similarity to native extracellular matrices, hydrogels have recently been formed as artificial cellular microenvironment. With recent developments in hydrogel materials, several researchers are using engineered hydrogels and various cell sources to build three-dimensional tissue models, which are a promising medium for tissue regeneration, drug discovery, regenerative medicine, biosensors, in drug delivery systems, Alternatives to animal models and reference cell biology studies.

Different monomer components can easily modulate their physico-chemical and biological properties and add bioactive molecules (e.g. proteolytic degradable sites, growth factor-binding molecules and cell adhesive sites). Various manufacturing methods can be used to produce polymeric biomaterials including hydrogel formation, salt leaching, electrospinning, solvent casting and electrospraying. Extracellular matrices (ECMs) consist of polysaccharides, structural proteins and various soluble factors that show a range of physical properties (e.g. concentration of oxygen, pH, mechanical properties and topologies). The cellular microenvironments are well known to play a critical role in cell growth, differentiation into the native tissues and migration. As 3D artificial extracellular microenvironments, polymeric hydrogel matrices have recently attracted attention due to their structural similarity to natural ECMs, which provide complex and convoluted cellular environments. A number of researchers have developed 3D tissue models for tissue engineering and regenerative medicine using artificial ECMs. In addition, these engineered tissue models were used as alternatives to animal models and conventional two-dimensional (2D) culture models for toxicity testing, drug efficacy evaluation and screening, and for a better understanding of basic cell biology in pathological and healthy tissues. Several experiments have shown that animal models and 2D tissue models have shown crucial shortcomings, such as interspecies-dependent inconsistencies, failure to analyze in real time and lack of realistic experimental control.

Different types of polymeric hydrogels were designed to build engineered tissue constructs as 3D cellular micro-environments. Within this study, we address how polymeric hydrogels are currently being used to manufacture engineered models of 3D tissues. In addition, we are incorporating emerging technologies to generate advanced tissue models that accurately recapitulate in vivo cellular microenvironments, combined with emerging methods such as Nano / micro-manufacturing techniques.

Keywords: basic cell biology, polymeric hydrogels; drug screening, engineered tissue models; artificial extracellular matrices; tissue engineering