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γ-Radiation-Co-Cryogelation Induced Synthesis of Macroporous rpCryogels for Bioengineering Applications

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Abstract

Polymeric porous scaffolds are a key component in several bioengineering and biomedical applications. In a recent development, we have introduced a novel approach for the designing of macroporous matrices by combining γ-radiation with cryogelation technology. This new prototype has been optimized and compared with the classical cryogelation technology. The acrylic derivatives like acrylamide (AAm) and N-(2-hydroxyethyl) methacrylamide (HEMA) have been used in our study as the model precursor units considering their inert behaviour and selective biocompatibility. In the process of radiation-co-cryogelation, optimum radiation dose causes polymerization of monomers, which do not require addition of any reaction initiator and activator for free-radical polymerization. However, simultaneous cryogelation allow the phase separation which leads to the formation of water ice crystals (porozens) at sub-zero temperature. The optimum process parameters like radiation dose, temperature, monomer's concentration, physical/chemical molding, volume and incubation time, are providing suitable environment to fabricate an ideal porous radiation-cryopolymerized cryogel (rpCryogel). This new approach is suitable to fabricate scaffolds with controlled physico-chemical properties like variable pore sizes, pore interconnectivity and desired mechanical integrity and rheological properties by varying the dose of γ-radiation and temperature at constant polymer precursor's ratio. The scanning electron microscopic observation of AAm and HEMA rpCryogels shows presence of interconnected pore morphology having pore size range of 20 to 200 μm at different doses of irradiation. Like classical cryogel, the rpCryogels showed similar behaviour of various physico-chemical properties like hydraulic permeability (10^{-4} $m^4N^{-1}s^{-1}$), density (1 to 1.5 g/cm^3), water uptake kinetic (reach to equilibrium within 1 min) and water retention capacity (more than 10 times its dry weight). Mechanical stiffness of rpCryogel showed a steep decrease (10 times reduction in compression modulus) upon hydration in distilled water suggesting its hydrophilic nature and soft material like property, which is preferable in many bioprocesses. These monoliths can be compressed up

to 70% of their original length without showing permanent deformation presenting their high elastic behaviour. Importantly, unlike classical cryogel which require approximately 18 h for synthesis, this novel integrated approach requires only 3 h for the fabrication of rpCryogels in different formats. The transitional changes between dry and wet state did not show change in its physico-chemical properties, which describe long term storage stability of these rpCryogels in dry state and wet state. Thus, the designing of elastic and macroporous monoliths by integrated controlled radiation and cryogelation process provides novel speedy approach for the fabrication of macroporous rpCryogel for various bioengineering application and could meet the supply requirement for commercial utilization. At present, we are investigating the successive use of macroporous polymeric cryogels for biomolecules immobilization, bioprocessing, tissue-engineering and environmental applications.

Country/Organization invited to participate

India

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