Multicomponent bio and nano-polymeric system: From synthesis to modern medical applications

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Abstract

The strategy to design a multicomponent polymer system is to achieve inventive multifunctional polymeric biomaterials. Both natural and synthetic polymers represent ideal structural properties favourable for biological applications. In the recent trends, the polymeric biomaterials are designed to be used as scaffolds for bone-tissue regeneration, as implants for dental, cell therapeutics etc. Hydrogels being hydrophilic and three dimensional polymeric network, can provide sufficient strength to be utilized for constructing several medical devices. In the search of new generation of polymeric hydrogels which are bioactive in nature, composite material is prepared using bio minerals in form of $CaCO_3$/$CaPO_4$ as they mimic natural structures in form of bones or teeth's etc. Apart from this, magnetic nanoparticles (MNP's-Fe_3O_4) are also utilized in soft matter for application in water-purification filtration, artificial vegetation, soft actuators, electrophoresis etc. In such magneto-rheological materials, the mechanical properties can be tuned under the applied external magnetic field. The MNP's are prone to reveal superparamagnetic behavior and magnetic hysteresis when inside such soft hydrogels. We focused on preparation of mineralized hydrogels in an attempt to construct new composite biomaterial which will possess high mechanical performance along with good biotolerance. To accomplish this, polyvinylpyrrolidone (PVP) as synthetic polymer and carboxymethylcellulsoe (CMC) as natural polymer were used and hydrogel in form of matrix was prepared by solvent casting technique. Further, mineralization process using liquid diffusion and in-situ precipitation technique was carried out to obtain calcium carbonate ($CaCO_3$) and Fe_3O_4 PVP-CMC matrix respectively.

Moving towards the amphiphilic polymers, over the last few decades they have drain a large interest to improve hydrophobic drug encapsulation and delivery because of the mesoscopic size range and the high drug-loading capacity. The polymer-based particulate systems (PPS) symbolizes a noteworthy progress in the formation of supramolecular entities. In the engineering for constructing drug / gene delivery system, poly(2-oxazolines) (POx) considered as pseudopeptides are attracting interest in both, their rich chemistry and their versatility in the synthesis of several functionalized polymers, copolymers, homopolymers etc. They are easily accessible by cationic ring-opening polymerization have replaced the utilization of PEG based system. Further, using biocompatible and biodegradable amphiphilic copolymer micelles / nanoparticles as nanocarriers have also attracted more interest to the researchers for controlled / sustained drug delivery. The current research focuses on investigating and synthesizing block / gradient copolymers of 2-ethyl-2-oxazoline / 2-methyl-2-oxazoline as hydrophilic part and 2-(4-butyloxyphenyl)-2-oxazoline (BuPhOx) as hydrophobic part implementing living cationic ring-opening polymerization (LCROP). Further, polymeric nanoparticles were prepared according to the thin film hydration technique in organic solvent (for e.g. in ethanol) with gradient copolymer and using hydrophobic drugs (for e.g. rifampicin, caffeic acid, curcumin etc.) Preliminary results revealed the size of polymeric nanoparticles found in the sub-100 nm range. The ability of the nanoparticles to encapsulate the drug (up to 35%) and encapsulation efficiency (up to 95%) was achieved and this was subsequently, followed by the release mechanism studies. Until now, through the performance related parameters for the prepared polymeric nanoparticles such as its size, loading capacity, uptake and drug release, it is envisioned to be considered as drug delivery vehicle for anti-tubercular or cancer diseases. Present talk will focus on facts about how the above all mentioned polymeric system has been constructed with perspective to their implementation in different bio-based applications.

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