A REVIEW ON NANOCOMPOSITE HYDROGELS: BASICS AND DEVELOPMENTS

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Abstract

Nanocomposite hyrdogels a novel type of drug delivery system which involves the incorporation of nanomaterials based on carbon, metallic or ceramic into a hydrogel network to yield a better physiologically and therapeutically effective hydrogels. The properties of hydrogel are based on the nanomaterials used. Prepared by in-situ free radical polymerization they are used in biomedical, tissue-engineering, food industry etc. The review article focuses on the basic development considerations applications and advancements in the nanocomposite hydrogels uses in therapy.

Index Terms: Nanotechnology, Hydrogels, NCH, nanomaterials, free radical polymerization

I. INTRODUCTION

Nanotechnology incorporation in the pharmaceutical field plays an important role in developing various nanomaterials based therapeutically active moieties to be used in the prevention and treatment of various diseases. In this technique nanosized therapeutics agents of size range 1-100 nm are used, which are incorporated to a carrier to get specified activity.

HYDROGELS

Hydrogels represent a class of soft materials of synthetic or natural origin. Hydrogels are physically or chemically cross linked three dimensional networks, which can be cast into various shapes with high water retention properties. The water retention properties are due to the hydrophilic groups in them and the swelling degree depends on polymer composition. Due to highly porous structure, soft and elastic consistency, hydrogels have the properties similar to biological tissues. A wide range of materials like carbon based, metallic or ceramic nanomaterials can be incorporated in the hydrogel network to obtain nanocomposite hydrogels.

ADVANTAGES

: They have high degree of flexibility

: Environmentally sensitive hydrogels have ability to sense changes in pH, Temperature etc.

: They are biocompatible

: They are easy to modify

DISADVANTAGES

: They are non adherent, may need a secondary dressing

: They have low mechanical strength

: Difficulty in loading and expensive

To overcome the main limitation of hydrogels i.e., the low mechanical strength nanocomposite particles are incorporated into the hydrogels, which helps in improving the performance of hydrogel. This incorporation of nanocomposite particle into hydrogels form nanocomposite hydrogels (NCH).

NANOCOMPOSITE HYDROGELS (NCH) is hydrated polymeric networks with physically or covalently cross-linked 3-D structure swollen with water, in presence of nanoparticles or nanostructures. Nanocomposite represents to a class of components with properties absent in individual components.

II. TYPES OF NANOCOMPOSTE HYDROGELS

CARBON BASED NCH: Due to their high mechanical strength, electrical conductivity and optical properties, carbon based NCH are widely used. They have important effect in the swelling of hydrogels. Ex: carbon nanotubes, graphane etc.

POLYMERIC BASED NCH: They are hybrid type of NCH which have a controlled drug release system. They are highly polymerized structure and rigidity. They have ability to incorporate hydrophilic as well as hydrophobic drugs.

METAL BASED NCH: Metallic or metallic oxide based NCH are widely used to formulate desired NCH. They incorporate metals, metal oxides, magnetic nanoparticles to formulate metal based NCH.

INORGANIC BASED NCH: various inorganic agents are required of the proper functioning of the body. They are widely used in the implantable devices for body. EX: Nano-hydroxyapatite (nHA), bioactive glasses, glass ceramic etc.

III. SYNTHESIS OF NANOCOMPOSITE HYDROGELS

The nanocomposite HYDROGELS are prepared by in-situ free radical polymerization under mild conditions of temperature.

The monomer is purified, dissolved in deoxygenized deionized water of inorganic clay dispersion. Polymerization was done under mild conditions with use of monomer, initiator and catalyst .After the reaction, the NC gels are removed and cut into discs of required thickness, then placed in deionized water to remove unreacted products for 2 days and then dried under vacuum.

INCORPORATION

The nature of nanoparticles incorporated in the hydrogels determines the type of stimuli to which the nanocomposite hydrogels are responsive. The polymers of synthetic or natural origin like polyvinyl alcohol, poly (ethylene glycol), gelatin, collagen etc. combines with nanomaterials like of carbon based, polymeric nanomaterials, ceramic or metal or metal oxides to form nanocomposite of increased mechanical strength, increased bioavailability.

IV. EVALUATION

MORPHOLOGICAL CHARACTERISTICS: Size, shape, surface area and charge of NCH are evaluated by using Scanning Electron Microscope (SEM), UV–visible spectroscopy (UV–Vis), Zeta potential determination.

CHEMICAL COMPOSITION: Determined by using Fourier-transform infrared spectroscopy (FTIR), Nuclear Magnetic Resonance Spectroscopy (NMR), etc

RHEOLOGICAL STUDIES: Rheological studies are used to study the various cross linking properties of the NCH. Determined by using Rheometer.

THERMAL ANALYSIS: The change in the behavior of NCH is determined by thermal analysis. Thermo gravimetric Analyses is used to determine thermal stability, decomposition temperature etc.

SWELLING INDEX: The swelling rate of hydrogels are determined by immersing the NCH discs in water or saline solution for some days and change in weight is determined.

Swelling index, % Swelling = $(M_t - M_o)/M_o * 100$

Where, M_t- mass of swollen hydrogel

M_o- mass of dry hydrogels

V. APPLICATION AND RECENT ADVANCES

Nanocomposite hydrogels could be an appropriate carrier to load and transport biochemical factors. Physical properties of nanocomposite hydrogels can be controlled by the chemical properties of hydrogel network.

By incorporating various functional nanoparticles in hydrogels with improved mechanical properties and functions can be used in tissue engineering. NCH with good wound dressing properties, and could stop bleeding, absorb exudates, relieving pain and protect the wound from infection and mechanical damage.

Clay and silica based NCH are used in enhanced oil recovery process. Carbon based NCH are effective suggestion in Food industry.

Future studies may shift toward combining multi phases or multi components to design improved nanocomposite hydrogels. Micro fabrication approaches of making hybrid NCH is a major advancement in the field.

VI. CONCLUSION

Hydrogels are soft cross-linked 3D polymer network with some limitations. Nanomaterial of nanometer size when incorporated within polymeric hydrogels gives an attractive approach to increase the mechanical strength of hydrogels and overcome the limitations. Compared with natural hydrogels, nanocomposite gels have improved performances in their mechanical properties higher swelling rate and biodegradability which are prepared by in-situ free radical polymerization under mild conditions. Most of the approaches made to improve the nanoparticle-hydrogel interactions are based on the surface modification of the nanoparticles. The biological properties like cell adhesion, protein adsorption, and cell differentiation are considered during the design of nanocomposite hydrogels. Various advancements like inclusion of NCH in various fields of tissue-engineered, biomedical and food industrys are innovative steps taken by researchers.

VII. REFERENCE

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