ISSN PRINT 2319 1775 Online 2320 7876

 Journal Volume 11,Iss 09, 2022

HYDROGELS NANOCOMPOSITE AND IT'S APPLICATIONS

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Abstract

Nowadays, there are many challenges faced in the field of biomedicine to treat patients. Pharmaceutical applications of hydrogel play a very significant role in wound healing, drug delivery, and many more. Hydrogel has become an important tool for many such applications. Hydrogel technology has grabbed attention because of its unique properties and network structure, both physically and chemically. Hydrogels are available as natural or synthetic polymers. Hydrogel moldable properties are the most important characteristic due to which it can be easily modified and used in different applications. We are able to produce polysaccharides, polypeptides, and nucleic acids in hydrogels. Protein-based hydrogels consist of collagen, elastin, fibrin, gelatin, silk fibroin, and many others are mentioned in the research.

Keywords: ***Hydrogels, nanocomposite, chemical physical cross-link, biomedical, Smart devices, agricultural , pharmaceutical applications.***

1. Introduction

Hydrogels are a polymer chain or a network, they are three dimensional water swollen like structure. They are also called as Aqua gels. They cannot be dissolved in water as they are super permeable i.e. they contain 99% of water in it. They are formed by mainly hydrophilic homopolymers or copolymers. Due to their chemical and physical cross-links they are insoluble and also provide shape. Recently it was found that hydrogels play a very important role in drug delivery and biomedical applications. The new hydrogel system has various chemical and structural responsive components which sensitively demonstrate the external stimuli including temperature, ionic concentration, light, pH, magnetic fields, electrical fields, and chemicals. [1] They are similar to most human tissues, and also affect the metabolic processes of the living body and also allows them to discharge. for the survival and growth, the matrix structure also provides suitable environment. Due to the irregular structure of hydrogel it becomes brittle and the complex network like structure is very helpful in solving problems. [2].

Wichterle and Lim in 1960, studied hydrogels and came up with many new uses and properties in biomedical field which is the base in today's platforms for drug delivery and tissue engineering. [3]. Hydrogels are classified in different categories on the basis of nature of the bond between the framework and the polymeric molecules they can be physically or chemically cross-linked hydrogels. The structure of hydrogels depends on weak or temporary interactions which are ionic bonds, hydrogen bonds , hydrophobic forces , and molecular entanglements as they are reversible and has the ability to get altered by some environmental changes which are physical changes but the chemical structure does not get modified.[4].

From a last few years it is seen that natural hydrogels are replaced by synthetic hydrogels as they have high capacity of water absorption, long shelf life and high gel strength. Hydrogels can retain their weight in water. It is a polymer of carboxylic acid. Then polymer leaves several negative charges as the acid group ionize in water. Due to this it has two effects first the polymer is forced to expand because of the repulsion between the negative charges and if the negative charges attract the polar water molecules then the viscosity is increased due to which it takes more space and resist the flow of solvent molecules. [5]

Hydrogels can improve the retention effect of the nanomaterials and can produce good plasticity and this is very helpful in biomedical applications. It is very significant to combine hydrogels with new and different materials for improvements shortcoming. Nanomaterials are considered as zero –dimensional, one- dimensional, and two-dimensional. Because of the small size of nanoparticle, it has huge applications in various fields [13]

2. Natural Hydrogels

Three categories of naturally formed hydrogels exist:

1) hydrogels based on proteins
2) hydrogels based on polysaccharides, and
3) hydrogels derived from decellularized tissue. [20,21]

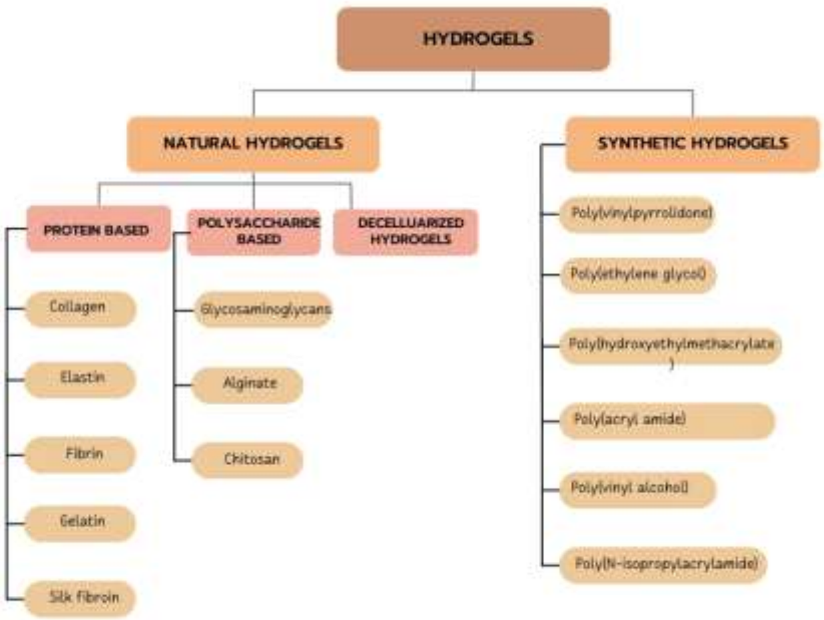

Figure1.Hydrogel classification

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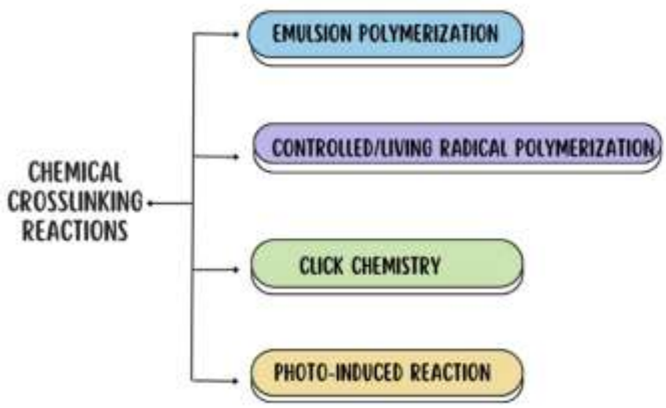

Physical Crosslinking:

Physical networks have transient junctions that upload from either polymer uniting entanglements or physical interactions as hydrogen bonds or hydrophobic interactions. When

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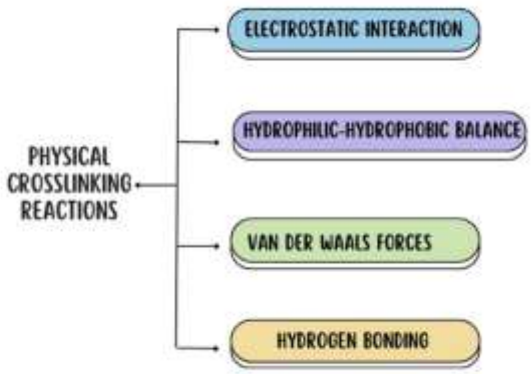
the liquid phase changes to a gel due to environmental transpiration (pH, temperature, mixing of two components, or ionic concentration), the hydrogels are known as physical hydrogels [18]. This cross-linking method is based on the insemination of hydrogen bonds between the polymeric molecules to form a nanostructured network [19]. This cross-linking method is based on the use of genetically modified proteins or through antigen-antibody interactions. The former is produced by modifying the peptide sequence, enabling the maintenance of the hydrogels' physicochemical properties.

Here are some names of physical crosslinking reactions:



4.0Biomedical Applications:

The biomedical field seems to be the most abundant field. frequently considered with several products once successfully transferred to the market. This is mainly due to the fact that the most important properties of hydrogels, Le, which are worthiness to swell without losing their shape and mechanical strength, are kindly met in a number of natural elements of the human soul (muscles, tendons, cartilage, etc.). The other important issue is good biocompatibility in contact with blood, bodily fluids, and tissues.

1.Drug Delivery:

In the medical field, drug delivery plays an important role in drug vehicles. [14]

4.1. Oral Delivery:

The main purpose of the oral drug wordage is to transport drugs into the intestine safely, since most of the drugs orally taken are undivided in the gastrointestinal (GI) tract. Moreover, they have to squander other obstacles such as the poor permeability wideness of the Gl mucosa and the wounding-catalysed or proteolytic ousting of drugs, which is particularly

ISSN PRINT 2319 1775 Online 2320 7876

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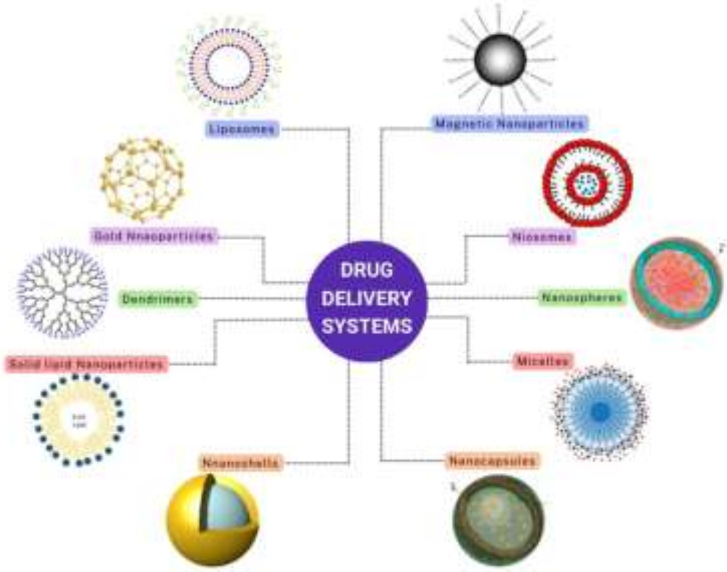
relevant in the wordage of molecules such as peptides or proteins. [6,14]



4.2. Transdermal Delivery:

The transdermal route of administration has traditionally been considered only for topical use to treat skin diseases; in recent years, it has also been considered for systemic use of drugs [7, 14].

4.3. Ocular drug delivery:

Hydrogels are most widely used in the ocular drug wording system. Hydrogel shows controlled or sustained release in order to reduce the frequency of dosing or to increase the effectiveness of the drug by localising at its site of action, decreasing the dose required, or providing uniform drug delivery. [8]

4.4. Wound Dressing:

Wound healing is a ramified process that includes the replacement of devitalized or missing cellular structure and tissue layers, and it is strongly dynamic since it involves several lamina populations, the extracellular matrix, and the intervention of mediators (i.e., growth factors) [9]. One of the main drawbacks of the use of hydrogels as wound dressings is that exudate unifying can cause maceration and bacterial proliferation in the wound. Moreover, the low mechanical strength of hydrogels leads to difficulty in handling.

Outside the wound We don’t need to experience the process of drug diffusion, as the nanomaterial composite can deliver drugs directly inside the wound. [13]

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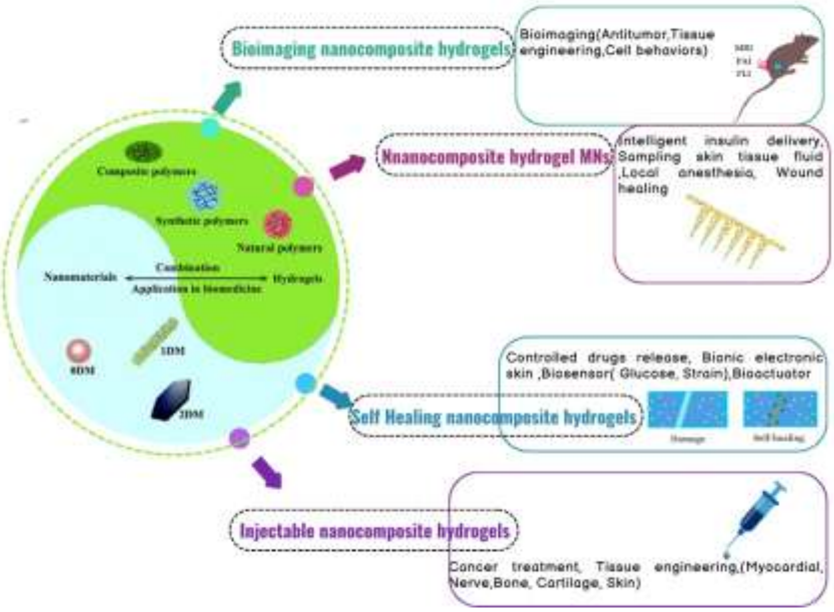

5.0 Pharmaceutical Applications:

5.1.Gene therapy:

A change in the structure of hydrogels leads to constructive targeting and delivery of nucleic acids to specific cells for gene therapy. Hydrogels have increasingly potential applications in the treatment of many genetic or uninventive diseases. [10]

5.2. Tissue engineering:

As described earlier, hydrogels are three-dimensional chemical recipe scaffolds utilised in many sustainable applications in technical textile withdrawal with tissue engineering [11]. A wide range of necessary clusters of techniques are therefore referred to as in vivo tissue regeneration. Micronized hydrogels are used to unhook macromolecules into the cytoplasm of antigen-presenting cells. Natural hydrogel materials used for tissue engineering include agarose, methylcellulose, and other naturally occurring products [12].

5.3.Colon-Specific Hydrogels:

Colon-specific hydrogels of polysaccharide have been specifically designed considering the presence of higher concentrations of polysaccharide enzymes in the colon region of Gl. Dextran hydrogel is formulated for colon-specific drug delivery.

6.0 Agricultural Applications:

Hydrogel in Urban Agriculture:

Nowadays, urbanisation has led to the reduction of arable and fertile land area for increasing population, creating a shortage of food supplies. The concept of the use of hydrogel in urban agriculture provides a solution for high-quality food products. The lack of land availability in metropolitan areas has produced the need for sustainable agriculture. Current development in urban farming involves manipulating light, nutrient solutions, and mediums for plant growth. All of these 'water sources' hold a major role as they are essential for plant growth. 'Hydrogel', one of the critical innovations in the field of science, is a main component in plant growth.

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Hydrogel has been used in agriculture over the past five decades and has proven efficient as a water-holding reservoir and nutrient mobilizer when used in soil. [40] It plays an important role as a superabsorbent polymer and is widely used in the agriculture industry due to its role in soil enhancement, allowing plants to grow in arid areas, and facilitating seed germination. [41] Hydrogel has many more advantages in urban agriculture, like 'Hydrogel as a Potting Medium', 'An Alternative to Soilless Agriculture', and 'Efficient Irrigation and Fertiliser Application'. Everything in this world that has advantages also comes with some limitations, just as hydrogel has some limitations in the urban agriculture field, such as structural stability and physical integrity. [42]

There are many successful applications of hydrogel in agriculture. A successful hydrogel-based product is 'Hydro membrane'. The hydrophobic membrane is a thin film that can hold plants while filtering viruses and microbes, protecting them from diseases. It is also a water-proof sheet that can eliminate water runoff and minimise contamination. A brand named 'IMEC' is using this application of Hydrogel for cultivating plants like tomatoes, cucumbers, melon, paprika, and lettuce. S. L. Bangare et al. [55-59] done machine learning research is healthcare.

7.0 Applications for Smart Devices and Modals:

Mams:

MAMs include a broad range of materials, sensitivity, and synthesis methods that combine to programme specific reactions. [43] The exact advantages and disadvantages that each distinct combination of these properties produces in a MAM determine the material's intended function. We talk about the application of certain MAMs that have been proven in the scientific literature, as well as their consequences for further research in the area. [44]

Mams towards Soft Robotics:

A machine that can automatically perform a complex series of actions is referred to as a traditional robot. The primary material used to construct these robots is a soft, compliant substance meant to mimic biological systems.[45] Some academics consider a soft actuator to be the same as a soft robot, while others view soft actuators as a functional part of a soft robot. [46]

Towards Magnetically Actuated Robotic Systems:

This application is a good fit for magnetic actuation of robotic systems since it provides a practical way to operate MAMs remotely and without a tether, which has been preferred in previous searches.

Paramagnetic and ferromagnetic actuations are two further subclassifications of magnetic actuation. To be activated by paramagnets, the hydrogel robots are only drawn in the direction of the strongest magnetic field.[47]

Hydrogel in Smart Windows:

A viable method of varying solar light transmittance—which is essential for constructing energy-efficient buildings—is through smart windows. [48]

Thermochromic Hydrogel Smart Window

Thermochromics hydrogels have been widely applied in different areas, including tissue engineering, drug delivery, sensors, and devices [48].

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Thermochromic Hydrogel Smart Window

Thermochromic hydrogels have been widely applied in different areas, including tissue engineering [49, 50], drug delivery [51–54], sensors [55], and devices. [56-58]

8.0 **Conclusion:**

Despite the fact that hydrogels have existed for many centuries, their charm is still unquestioned. Due to their fascinat they have, they have always attracted both scientific and industrial communicators. In this paper, summarised information about each and every hydrogel, the properties of hydrogel, ons of it, etc. Because of the high water content and void structure of hydrogels, they have limited application in the development of hydrogels with special physial properties, ensuring good biodegradability and overcoming the limitations of Altogether, we can conclude that this 'Hydrogel' will definitely bring revolution in every field of nature.

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