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REVOLUTIONIZING SCIENCE WITH HYDROGELS

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ABSTRACT

Three-dimensional networks of hydrophilic polymers called hydrogels have the capacity to absorb and hold large volumes of water. Hydrogels' high water content, biocompatibility and adjustable qualities have led to a wide range of biomedical uses, such as tissue engineering, drug administration and wound healing. They are categorized according to their cross-linking methods, stimulus sensitivity and degradation behavior and can be made from natural, synthetic or hybrid polymers. Covalent forces create chemical hydrogels, while weak secondary forces create physical hydrogels. The three most important properties of hydrogels are swelling, mechanical properties and biological properties. These properties all affect the morphology and structure of the hydrogel. This article's main goal is to discuss the various basis on which hydrogels are classified, as well as their characteristics, preparation technique and evaluation.

KEYWORDS

Properties, Types, Classification, Evaluation and Application.

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INTRODUCTION

Hydrogels are networks of polymers that absorb and retain vast amounts of water. The polymeric network contains hydrophilic groups that hydrate in aqueous environments to produce a hydrogel structure[1]. Hydrogels were initially put forth in the 1960s by Witchterle and Lim[2]. Food additives are among the many uses for hydrogel that are frequently found in clinical practice and experimental medicine[3]. Pharmaceuticals, tissue engineering and regenerative medicine[4] Hydrogel, cellulose, chitosan and metal-based polymers are typically employed in biomedical applications. Hydrogel materials are also utilized to encourage

healing and aid in the growth of new cells. One of the three-dimensional hydrophilic polymers, hydrogel typically contains a lot of water[5]. Hydrogels are extremely helpful for a variety of biological applications due to their unique set of properties.

Biodegradability, biocompatibility, hydrophilicity, super absorbency, viscoelasticity, softness and fluff are some of these qualities. Hydrogels are also sensitive to a range of stimuli, which expands the range of uses for them. These stimuli may consist of biological molecules, ionic strength, electric and magnetic fields and temperature[6,7]. Because of the hydrophilic groups in their structure, hydrogels-three-dimensional networks of insoluble polymers-are able to absorb large amounts of water or bodily fluid[8]. The main hydrogel polymer chain contains hydrophilic functional groups such as amine (NH2), sulfate (SO3H-), carboxyl (COOH-) and hydroxyl groups (OH-)[9]. The soft, rubbery consistency and low interfacial tension with water or biological fluids that fully swelled hydrogels possess are traits of living tissues. The elastic qualities of completely hydrated or swollen hydrogels have been found to lessen tissue discomfort following implantation[10].

PROPERTIES OF HYDROGEL

Swelling property

Chains of the hydrogel polymer are chemically or physically cross-linked to one another. Reversible changes in hydrogel may react quickly to small changes in environmental conditions. Temperature, pH, electric signals, enzymes and ionic species are some examples of environmental conditions that can affect gels' physical texture. The following equation illustrates how the weight difference method can be applied experimentally to determine the proportion of swelling:

Percentage swelling = [(Ws-Wd)/Wd] x 100

Where,

Ws is weight of swollen gel and

Wd is weight of dry gel[11,12]

MECHANICAL PROPERTY

The degree of crosslinking can be changed to achieve the desired mechanical property of the hydrogel. A stronger hydrogel can be produced by increasing the degree of crosslinking, although this results in a more brittle structure as the higher degree of crosslinking reduces the hydrogels' percentage elongation[13].

BIO COMPATABILITY

The capacity of a substance to function with a suitable host reaction in a particular application is known as biocompatibility. There are essentially two components that make up biocompatibility:

Bio-functionality or a material's capacity to carry out the precise function for which it was designed.

Biosafety, which includes the lack of mutagenesis and cytotoxicity, as well as a suitable host response that is both systemic and local (the surrounding tissue)[14].

SELF- HEALING

Hydrogels are increasingly using self-healing materials, which can fix damage on their own. Dynamic covalent bonds (like Diels-Alderimine and disulfide) and non-covalent contacts (such hydrogen bonds and hydrophobic interactions) are essential to these processes. Self-healing hydrogels that are biocompatible, robust, and flexible are made from synthetic polymers like PEG and PVA as well as natural polysaccharides like chitosan and alginate. Hydrogels with high fracture energy and fire resistance are produced by combining Li alginate with poly (acrylamide-co-stearyl methacrylate)[15].

Fluorochromic and Schiff base linkage-based hydrogels that self-heal at room temperature are examples of developments in rapid self-healing hydrogels, which use flexible polymer networks for speedy repairs[16]**.** After being cut, two hydrogels of various colors-one red with rhodamine B-were put together. After ten minutes, they showed rapid self-healing by adhering and healing on their own without assistance. The interface was somewhat obscured by dye dispersion, but the hydrogel was still able to stretch without breaking, suggesting that its mechanical strength and three-dimensional structure had returned. The internal structure of the

hydrogels recovered quickly, according to rheological analysis, with storage modulus G' increasing from 200 Pa to 2016 Pa, which was the same as the initial value. The hydrogels demonstrated a thixotropic, elastic response under various oscillatory stresses, demonstrating their capacity for self-healing[17].

TYPES OF HYDROGELS

Hydrogels are separated into two groups based on the kind of polymer: natural and synthetic hydrogels. Hydrogenated polymers, whether synthetic or natural, are considered raw materials for medical applications. In certain applications, where the hydrogel comes into contact with blood, it must be composed of natural and synthetic polymers that are blood compatible, biocompatible, and biodegradable[18].

NATURAL HYDROGEL

Hydrogels made of natural polymers, such as proteins and polysaccharides, that are obtained from plants or animals, are essential for encasing insecticides[19]. They are prized for their biodegradability, biocompatibility and safety, which guarantee ecologically benign breakdown following usage. These hydrogels are good at absorbing and holding onto water, which helps control pesticide release in soil to increase effectiveness and reduce environmental damage from overuse. Because of its structural properties, cellulose, which is found in large quantities in nature, improves pesticide encapsulation. Carboxymethyl cellulose and other derivatives create networks that stop leaks and extend the time that insecticides are released[20]. Derived from chitin, chitosan interacts with other polymers to regulate release rates and swells in response to pH changes. Proteins, with their amino acid chains, can be engineered for enzymatic destruction and precise pesticide release, whereas sodium alginate and calcium ions form stable networks for regulated pesticide release. Hydrogels made from natural polymers have enormous potential for environmentally friendly farming practices and sustainable conservation, despite obstacles like the inherent mechanical strength fluctuations in natural sources. The goal of ongoing research is to improve their qualities for broader uses in precision agriculture and pesticide encapsulation[21].

SYNTHETIC HYDROGEL

Synthetic polymers like polyamides and polyethylene glycol (PEG) are used to create synthetic hydrogels. In hydrogel manufacturing, synthetic polymers have recently replaced natural polymers because of their longer lifespan, higher water absorption capacity and gel strength. Hydrogels are made from synthetic polymers and have a number of medical uses. The mechanical structure and chemical composition of synthetic polymers are superior to those of natural polymers, and they are hydrophobic. These polymers include PEG, polyvinyl alcohol, and polyacrylamide and its derivatives.

PEG is one of the most popular polymers used for synthetic hydrogenation in various medical applications such as drug release, tissue engineering, bone prostheses and wound dressings. Because of its qualities, including resistance to protein adsorption, non-stimulation of the immune system, and biocompatibility, this polymer finds usage in a wide range of medical applications. PEG can create insoluble network structures on its own. Nevertheless, the crosslinking in the hydrogen network's structure is enhanced by the addition of factor groups[22].

PREPARATION OF HYDROGEL

Both physical and chemical cross-linking methods are used to create hydrogel. The formation of cross-linking is by covalent interaction or either non-covalent interactions. Hydrogel Chemical gels are produced by processing covalent connection, while physical gels are produced by processing non-covalent contact[23].

PHYSICAL CROSS LINKING

The interactions between polymer chains in physically cross-linked hydrogels are based on

physical interactions rather than covalent ones. Van der Waals forces, coordination bonds, hydrophobic contacts and hydrogen bonds are a few examples of these interactions. In contrast to chemical cross-linking, physical cross-linking can be reversed in specific circumstances, allowing the hydrogel to alter structurally without rupturing any covalent bonds. Physically cross-linked hydrogels are more sensitive to external stimuli such as temperature, pH, or ionic strength because of this property. They might have special qualities, like "self-healing" behavior, in which the gel can mend itself after breaking. These interactions create hydrogels, which are special physical gels with great temperature reversibility and water sensitivity. The longevity of these hydrogel types in physiological medium is brief, ranging from a few days to a maximum of one month. Thus, when a short-term medication release is needed, hydrogels are utilized in this way. Since no harmful covalent crosslinking molecules are needed for the gelation process, these hydrogels are safe to employ in therapeutic settings. Using non-covalent techniques including electrostatic, hydrogen bonding, and hydrophobic forces between polymer chains, this technique creates hydrogels. High water sensitivity and heat reversibility are two benefits of the physical techniques used to create hydrogel[25]. Because no harmful covalent crosslinking molecules are needed for the gelation process, hydrogels made this way are extremely safe for use in therapeutic settings. Using physical techniques, chitosan containing tiny anionic molecules such phosphates, citrates and sulphates of Pt, Pd, and Mo can be utilized to make hydrogel. The size and charge of the anions as well as the amount of chitosan that has been deacetylated determine the produced hydrogels.

CHEMICAL CROSS LINKING

Hydrogels that can undergo covalent bonding to transition from a liquid to a solid state are those that can be chemically cross-linked. It is also used in in situ hydrogel systems. To produce hydrogels, this method employs a number of procedures, such as click, enzymatic, and optical polymerization. The steps mentioned above for making these hydrogels will be discussed in this section[26]. The great mechanical strength of chemically crosslinked hydrogels has drawn interest[27].

BULK POLYMERISATION

It may be possible to use many vinyl monomers to create hydrogels. At least one type of monomer can be used to create bulky hydrogels. The simplest approach, bulk polymerization, uses only monomer and similar dissolvable starters. Increased centralization of the monomer causes an increase in the rate and degree of polymerization. In any event, the warmth during polymerization is produced solely by the uniformity of rejoinder enhancement with change[28,29]. Shiny framework bloats become delicate and flexible when submerged in water.

DISPERSION POLYMERISATION

Because the products of dispersion polymerization are produced as powder or microspheres (beads), it is a beneficial technique, using this technique, the initiator and monomers are dispersed throughout the hydrocarbon phase as a uniform mixture. The polymerization is known as "inverse suspension" since the water-in-oil (W/O) technique is used rather of the more popular oil-in-water (O/W) process[30].

POLYMERISATION BY IRRADIATION

Initiators such ionizing high energy radiation, such as electron beams and gamma rays, have been employed to create hydrogels of unsaturated molecules. Radicals are created on the polymer chains when an aqueous polymer solution is exposed to radiation. Ultimately, a cross-linked structure is created when the macro-radicals on various chains recombine to form covalent connections. Irradiation is used to polymerize polymers such as vinyl alcohol, ethylene glycol, and acrylic acid. This approach produces hydrogels that are quite pure and free of initiators[31].

GRAFTING TO A SUPPORT

Grafting is the process of polymerizing a monomer on a preexisting polymer's backbone. Chemical reagents or high-energy radiation therapy are used to activate the polymer chains. On activated macrorodicals, the development of functional monomers causes branching and ultimately crosslinking[32].

FREE RADICLE POLYMERIZATION

In the process of formation of hydrogels Vinyl lactams, Acrylates and amides are the primary monomers used. These polymers are functionalized with radically polymerizable groups or have appropriate functional groups. The chemistry of common free-radical polymerizations, including the processes of propagation, chain transfer, initiation, and termination, is used in this procedure. A large range of thermal, UV, visible, and redox initiators can be used for the radical formation in the initiation stage. The radicals react with the monomers to change them into active forms[33].

BASED ON SOURCE

Depending on the type of polymer they include, hydrogels are categorized as either natural or synthetic. Hydrogenated polymers, whether synthetic or natural, are considered raw materials for medicinal applications. Natural and manmade polymers that are biocompatible, biodegradable, and occasionally blood compatible when the hydrogel comes into contact with blood are used to make hydrogels[34].

A.NATURAL POLYMER

Natural hydrogels are gels made using polymers that come from natural sources. Hydrogels made from natural polymers have the benefits of being non-toxic, biocompatible and biodegradable.. Whether or not hydrogels are made with natural polymers depends on the purpose of employing biomaterials. Hydrogels used for products with controlled release, for example, must be non-hazardous, biocompatible, and biodegradable[35]. Examples of naturally occurring polymers that are commonly used as chemical release carriers include polysaccharides and related proteins. In-body testing proved the biocompatibility of these polymers; polysaccharides are superior due to their enzymatic breakdown, high durability, absence of toxicity and biocompatibility[36].

B.SYNTHETIC POLYMER

Polymeric synthetic hydrogels are three-dimensional swelling networks of hydrophilic homopolymers that are covalently or ionically cross-linked, also referred to as copolymers hydrogels. Various synthetic monomers are polymerized to create synthetic hydrogels, including poly (hydroxyethyl methacrylate) or PHEMA, polyethylene glycol (PEG) hydrogels, and polyacrylic acid (PAA)[37]. Polyamides and polyethylene glycol (PEG) are two examples of synthetic polymers that are utilized to make synthetic hydrogels. Because of their superior water-absorbing ability, long lifespan and gel strength, synthetic polymers have recently supplanted natural polymers in the production of hydrogels. Hydrogels composed of synthetic polymers have many uses in medicine. Synthetic polymers are hydrophobic and perform better than natural polymers in terms of mechanical structure and chemical composition[38]. These polymers include PEG, polyvinyl alcohol, and polyacrylamide and its derivatives. One of the most often used polymers for synthetic hydrogenation in a range of medical applications, such as prosthetic limbs, tissue engineering, drug release, and wound dressings, is PEG[39].

***C.HYBRID* POLYMER**

Hybrid hydrogels are formed by combining natural and synthetic polymer hydrogels. Natural biopolymers including collagen, chitosan and dextran have been combined with synthetic polymers like poly (N-isopropylacrylamide) and polyvinyl alcohol. Alginate/PEG and CTN/PVA hydrogels are examples of hybrid hydrogels[40].

BASED ON POLYMERIC COMPOSOTION:

Homo-polymeric hydrogels

These are networks of polymers made from a single species of a monomer, which is the fundamental structural component of all networks of polymers. Depending on the type of monomer and the method of polymerization, homopolymers can have a cross-linked skeleton.

Co-polymeric hydrogels

Two or more different monomer species with at least one hydrophilic component combine to form co-polymeric hydrogels. These monomers are organized randomly, in blocks, or alternately throughout the polymer network's chain.

Multi-polymer interpenetrating polymeric hydrogel (IPN)

This significant class of hydrogels consists of two separate cross-linked natural or synthetic polymer components that form a network system. Cross-linked and non-cross-linked polymers make up the two components of semi-IPN hydrogel[41].

BASED ON CROSSLINKING

Depending on the type of cross-linking-chemical or physical-hydrogels are divided into two classes.

BASED ON CHARGES

The cross-linked chains of hydrogels can be categorized into four groups based on whether or not they are electrically charged.

Non-ionic.

Ionic, including cations and anion.

Ampholytic (amphoteric) refers to an electrolyte that has both basic and acidic groups.

Zwitterionic (each basic repeating unit contains both positive and negative groups)[43]

BASED ON STRUCTURE

Unstructured hydrogels. (Amorphous)

Hydrogels that are semi-crystalline (a complex blend of crystalline and amorphous phases) C. Hydrogels that are hydrogen linked[44].

APPLICATIONS

DRUG RELEASE

By using ultrasonic technology to make a hydrogel containing fluoroexamine, Abdullahi *et al*. were able to demonstrate the controlled release of the drug in a physiological simulation. They argue that the process of drug release from the hydrogel is influenced by several factors, with pH being one of the most important ones, including the hydrogel's composition, geometric structure, preparation method, type of drug, and ambient circumstances at the time of release[46]. In a separate investigation, Ganji *et al*. were able to employ temperature-sensitive injectable hydrogel to progressively release pyridostigmine bromide from chitosan. They believe that the addition of glycerol phosphate salt is what created the darker solution when compared to the unsalted chitosan solution. For solutions containing 8% by weight/volume of salt, variations in the turbidity of chitosan and chitosan/glycerol phosphate solutions have been observed over time. The turbidity of the chitosan solution did not significantly alter over time at 37° C. Therefore, it can be concluded that a chitosan solution devoid of glycerol phosphate salt is insensitive to temperature fluctuations and maintains its consistency for a considerable amount of time at 37°C[47].

DRUG DELIVERY IN ORAL CAVITY

For the local treatment of oral issues such as stomatitis, fungal and viral infections, periodontal disease and oral cavity malignancies, drug administration to the oral cavity can be highly advantageous[48]. For example, Aftachw, a bioadhesive pill, has been created and is currently available for purchase. This product consists of two layers: A bio-adhesive layer composed of hydroxypropyl cellulose and polyethylene and a lactose-free, non-adhesive backing layer (acrylic acid). Triamcinolone is used to treat ulcers locally[49,50]. For the local treatment of oral conditions such as stomatitis, fungal infections, periodontal disease, viral infections and

malignancies of the oral cavity, medication is mixed into hydrogels and applied to the oral cavity[51].
Hydrogel delivery systems were developed for the oral administration of a variety of active ingredients, including non-steroidal anti-inflammatory drugs (NSAIDs)[52].

OCCULAR DRUG DELIVERY

Gel-forming polymers like xyloglucan have been employed for long-term drug administration in ocular drug delivery systems for pilocarpine and timolol. Numerous anticholinergic medications are available, such as timolol and atenolol, which are especially helpful as the polymer for hydrogel formation and processing. For the delivery of anticholinergic medications like Atenolol, an ocular drug delivery device is especially crucial[53].

RECTAL DRUG DELIVERY

Rectal administration offers a number of advantages, such as controlled release of the drug, low risk of side effects, rapid compound absorption and gastrointestinal tract avoidance. According to a previous study that showed excellent biocompatibility on the digestive tract, rectal administration of hydrogels based on catechol-chitosan that have mucoadhesive properties has been tested in mouse models and, after 10 days, no negative effects have been noted[54].

GENE DELIVERY

By altering the hydrogels' composition, nuclei acids can be efficiently targeted and delivered to particular cells for gene therapy. Hydrogels have more potential for use in the management of numerous inherited or acquired illnesses[55].

WOUND HEALING

Alginate-based hydrogels and other super absorbent hydrogels, also known as super porous hydrogels, are perfect for wound-healing dressings since they can absorb up to 90% of their weight in water without degrading. They provide sealing and bioadhesive mechanisms as substitutes for sutures or staples. Homeostasis, inflammation, proliferation, and remodeling are the four stages of wound healing[56,57]. Chronic wounds can result from healing delays, particularly if they last longer than three months. This is frequently caused by persistent inflammation. Because hydrogel dressings may be tailored with growth factors, biomolecules, and medications, they work well for chronic wounds. Hydrogels can be improved by adding anti-inflammatory ingredients, such as plant extracts or phenolic compounds from honey, which reduce inflammation and hasten healing. By using a Schiff base reaction to combine oxidized Gastrodia elata polysaccharide (OGEP) with a gastrodin-chitosan combination (GAS/CS), Xin *et al*. created a hydrogel for diabetic wound healing. In addition to its biosafety, rheology, and hemostasis qualities, the hydrogel containing EGCG microspheres was evaluated for its potential therapeutic benefits on diabetic wounds[58].
Diagrammatic representation of the preparation and application of EGCG@GEL/GAS/CS-OGEP hydrogel for diabetic wound healing[58].

CONTACT LENSES

Critical area in the use of bio-based synthetic hydrogels. To change corneal power, a contact lens is a small optical device that is applied directly to the cornea. A good contact lens must have the highest possible oxygen permeability since direct contact with the cornea inhibits the exchange of ambient oxygen, disrupting the cornea's physiological metabolism known as hypoxic stress. Thus, the hydrogels used to make contact lenses meet the majority of the parameters needed for use in a range of physiological conditions. A hydrogel material needs to fulfill certain requirements in order to create contact lenses that are comfortable to wear. Among other requirements, there must be sufficient water content, suitable mechanical characteristics, oxygen permeability, surface wetness, acceptable optical facilities, and stability against hydrolysis[59]. Poly (2-hydroxyethyl methacrylate) (p(HEMA)) soft contact lenses are created by thermally or photopolymerizing HEMA solutions with ethylene glycol Di methacrylate as

the cross-linker and different ratios of N-vinyl-2-pyrrolidone or methacrylic acid as comonomers. The medication loading capacity and release characteristics of soft contact lenses based on p(HEMA) were improved by adjusting the hydrogel composition and making microstructural changes with water during the polymerization process[60]. Hydrogels based on poly (2-hydroxyethyl methacrylate) are used for soft contact lenses because of their many different qualities[49]. Two distinct approaches were taken by the first silicon hydrogels to be marketed commercially. After developing silicon monomers with enhanced compatibility in hydrogel-forming monomers, Bausch and Lomb's original approach was a natural next step. Ciba's second idea was the creation of siloxy monomers with oxygen-permeable polysiloxane units and hydrophilic polyethylene oxide segments[61] variety of techniques, such as spin casting, mold casting, and lathe cutting, can be used to create soft contact lenses. Cast lenses are made by pouring a small amount of a liquid monomer combination into specialized optical molds that are "concave" so they can spin. During spin-casting, the concave mold rotates to create the lens, causing the liquid monomer to flow out equally and cover the whole surface[62].

COSMETOLOGY

Hydrogels have been inserted into breasts to highlight them for aesthetic reasons. In an aquatic environment, these hydrogels swell in vivo and hold onto water. Hydroxyl propyl cellulose polysaccharide gel fills the silicone elastomer shell of these breast implants. Because of the many qualities that hydrogels have acquired, pharmaceutical companies are concentrating on developing sophisticated drug delivery formulations to offer stable and cost-effective drug delivery systems polymers that serve as the foundation for creating modified release dosage forms[63].

TISSUE ENGENEERING

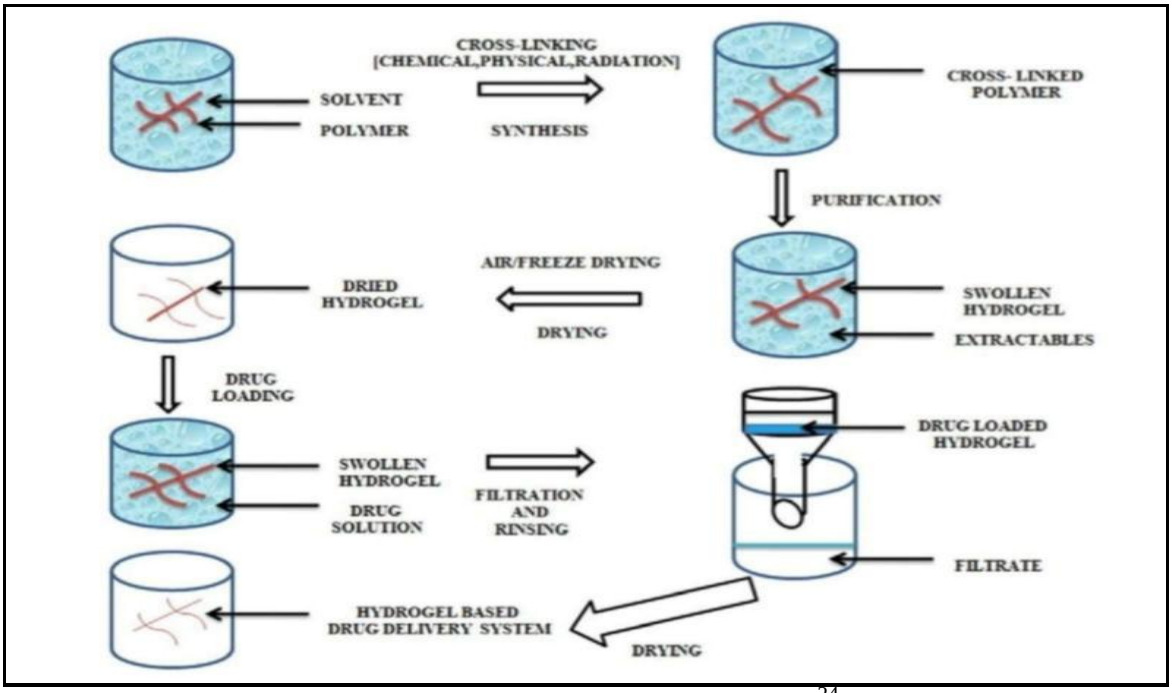
Hydrogels are networks of insoluble hydrophilic polymers that have a high water content and tissue-like mechanical properties. These properties make them ideal for use as scaffolds in empty tubular nerve prostheses or for direct injection at the site of a lesion to promote cell growth and attachment[64]. Diagrammatic representation of methods for creating injectable hydrogels for use in bone tissue and cartilage engineering[65].

CANCER THERAPY

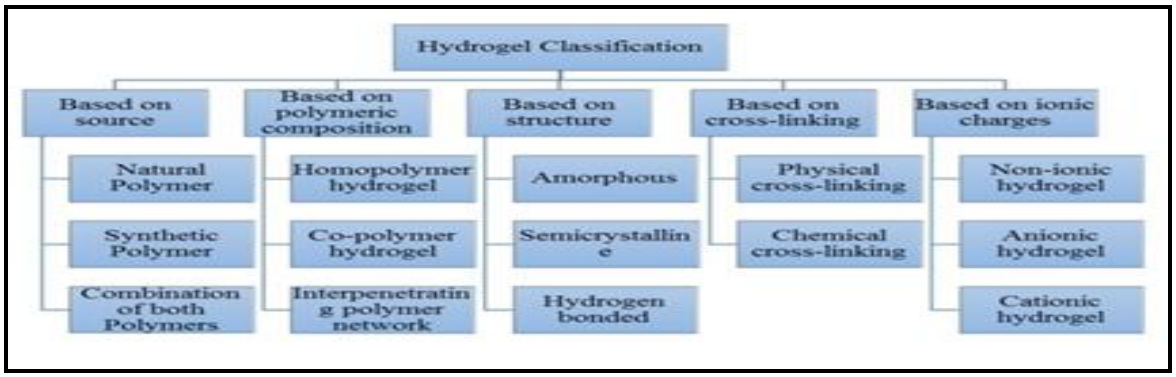
Drugs that significantly lessen the body's load can be extended and targeted via hydrogel microparticles[66]. Superporous hydrogels will be more beneficial than regular hydrogels since they require faster and higher swelling. Hydrogels can be injected or transplanted directly into the tumor for direct administration, such as in intratumoral injection. As a result, the anticancer agent is more effective. An-other strategy for multiple dosage conventional therapy is hydrogel implantation[67]. Because thermo-responsive hydrogels can be injected into the tumor as a liquid and subsequently gel at body temperature, they have been used as delivery systems for chemotherapy drugs. An example of a thermo-responsive hydrogel loaded with an anticancer medication is OncoGelTM, which is designed to deliver paclitaxel locally into the tumor while greatly reducing the negative effects of traditional drug administration. Using a syringe to directly deposit the formulation in the desired spot for superficially accessible tumors or more specialized instruments for deeper solid tumors are two advantages of OncoGelTM[68,69]. A novel class of stimuli-responsive hydrogels called magnetic hydrogel nanocomposites (NCs) is being created for in vivo drug release in tumor treatment. A tunable NC that can be remotely controlled by a magnetic field is produced by incorporating magnetic nanoparticles, such as iron oxide (Fe3O4), into a hydrogel matrix[70].

EVALUATION PARAMETERS[45]

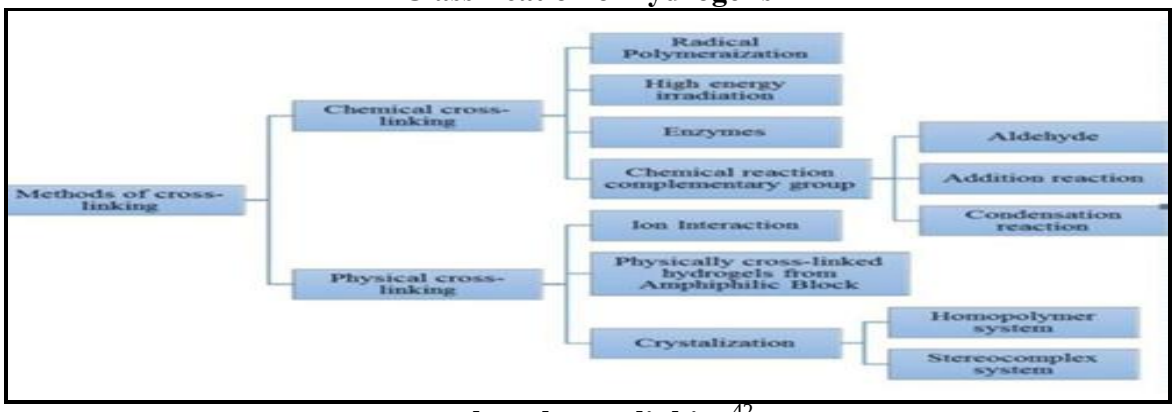
S.No	Parameters	Descriptions
1	Appearance	Hydrogel compositions' physical characteristics will be examined visually and findings should be documented
2	Homogeneity	Through visual evaluation, the hydrogels' physical characteristics, such as tone, clarity and stage division, will be examined
3	Grittiness	The hydrogels will be examined to determine if the created formulation batches contain any discernible particles.
4	Wash-ability	It is necessary to test the hydrogels on the skin and manually determine how easily and thoroughly they can be removed with water.
5	Extrud-ability	The hydrogels will be placed in squeezable aluminum or metal tubes. It is necessary to squeeze the material out of the tubes and assess how easy it is to squeeze the formulation.
6	pH	One can use a digital pH meter to measure the pH of the hydrogel formulations. The pH meter has to dissolve one gram of hydrogel in 25 milliliters of pure water in order to provide a reliable reading. The measurement must be recorded.
7	Viscosity	The viscosity of the hydrogel was measured using a Brookfield Digital Viscometer. When the viscosity was measured, the temperature was 25°C and the spindle number six was rotating at 10rpm.
8	Spreadability	When applied, spreadability refers to how easily the gel covers a big area. It is determined by timing the separation of two slides with gel between them when subjected to a specific weight. The spreadability improves with the speed at which the slides split.
9	Stability	The formulations' stability investigations will be conducted. For two months, it should be kept in the stability chamber in a wide-mouth container with a regulated temperature of 40± 2°C and a relative humidity of 75%



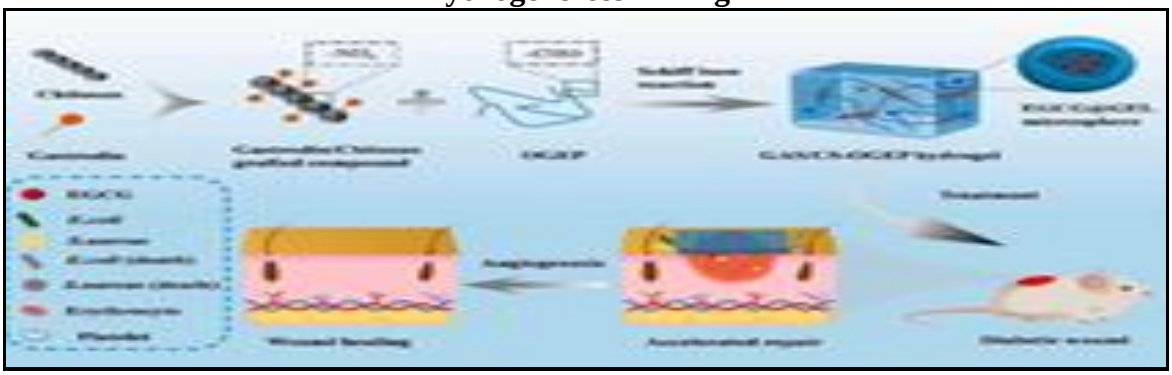
Method of preparation of Hydrogel[24]



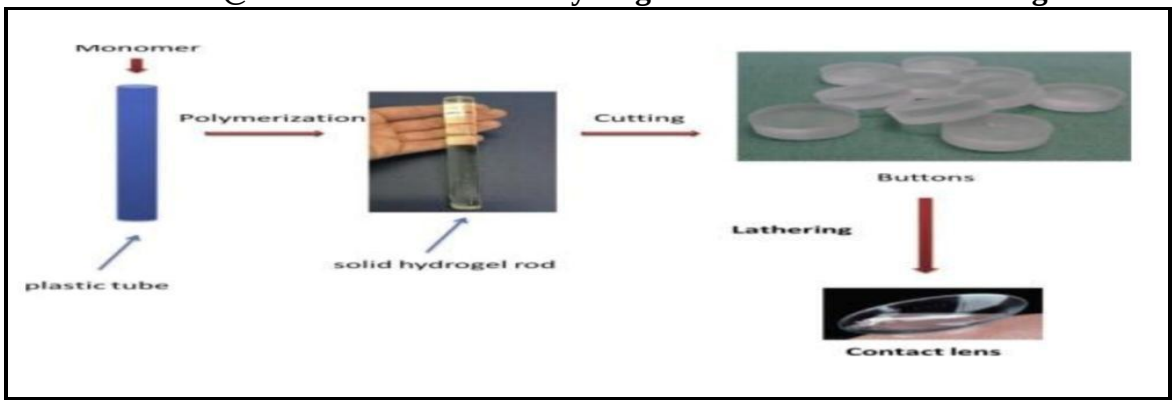
Classification of hydrogel's



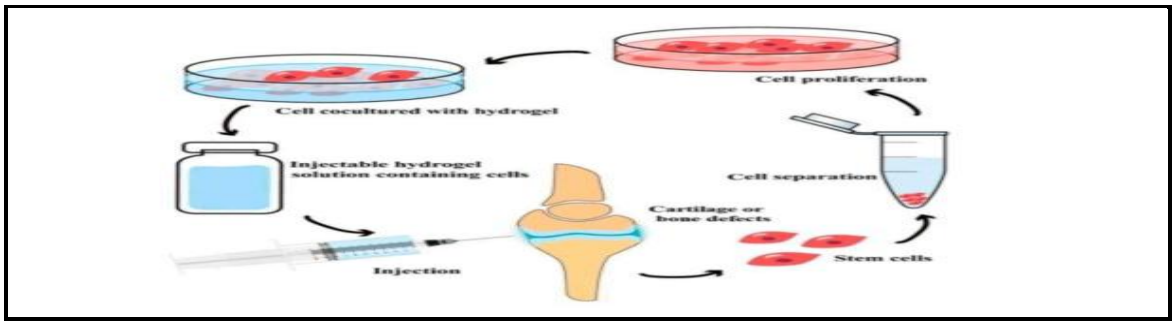
Hydrogel cross linking[42]



EGCG@GEL/GAS/CS-OGEP hydrogel for diabetic wound healing



Bio-based synthetic hydrogels



Creating injectable hydrogels for use in bone tissue and cartilage engineering

CONCLUSION

The unique properties of hydrogels, including their elasticity, biocompatibility, high water content and flexibility, make them extremely appealing. There are numerous uses for hydrogels in medication delivery systems. They are perfect for the controlled release of medications because of their capacity to absorb water and change from a liquid to a gel state. Because of their high water content and delicate softness, hydrogels-which more closely mimic natural living tissue than any other type of synthetic biomaterials-can be employed in oral, ophthalmic, epidermal, and subcutaneous applications. In order to satisfy the requirements of various applications, numerous hydrogel-based networks have recently been created and customized. These hydrogels have the capacity to swell when they come into touch with an aqueous solution. The classification of hydrogels according to various bases, their physical and chemical properties, the technological viability of using them and their manufacture and application methods are all covered in this review. Hydrogels can currently be made using a variety of techniques. This article discusses a few of them.

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CONFLICT OF INTEREST

I declare that I have no conflict of interest.

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