

## REVIEW ON PREPARATION, CHARACTERIZATION AND APPLICATIONS OF HYDROGEL

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### ABSTRACT

*Hydrogel products are a class of polymeric materials with a hydrophilic structure that allows them to retain enormous quantities of water in three-dimensional networks. The widespread use of these goods in a range of manufacturing and environmental applications is seen as critical. Natural microgels were progressively phased out in favor of synthetic biomaterials, which have a greater water absorption capacity, a longer service life, and a wider range of basic chemical resources. The literature on this topic is growing, particularly in scientific fields of study. Nevertheless, a number of papers and technical studies working with gel s from an engineering perspective were reviewed in order to get a broad overview of the technological elements of this rapidly expanding interdisciplinary area of study. The main goal of this paper is to examine the literature on hydrogel categorization on several grounds, physical and chemical properties of these products, and technological feasibility of their use. It also included the technologies used in hydrogel manufacturing, as well as process development considerations, block diagrams, and optimum preparation conditions. In addition, a newly developed category of prior decades of methods for generating was described in considerable depth.*

**KEYWORDS:** *Applications, Hydrogel, Innovative, Preparation, Processing.*

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### 1. INTRODUCTION

In this short overview, the substances of interest are mainly hydrocolloids that are polymer networks that have been heavily inflated with water. Hydrophilic gels, also known as hydrogels, are polymer chain networks that are occasionally found as dispersion gels and have water as the dispersed phase [1].

Hydrogels have been characterized in a variety of ways by scientists throughout the years. The most prevalent is hydrogel, which is a water-swollen, cross-linked polymeric network made by a direct reaction of one or even more monomers. Another description is a polymeric substance that can expand and hold a large amount of water inside its structure but does not dissolve in the water. Due to their outstanding potential in a broad variety of applications, hydrogels have gotten a lot of attention in the last 50 years [2].

Because of their high water content, they have a degree of elasticity that is extremely comparable to real tissue. The hydrophilic functional groups linked to the polymeric backbone provide hydrogels their capacity to absorb water, while cross-links among network chains give them

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resistance to disintegration. Hydrogels are made up of a variety of components, both natural and manufactured. Natural hydrogels have progressively been superseded by synthetic hydrogels, which have a longer service life, a higher water absorption capacity, and high gel strength, during the past two decades. Polymer composites, on the other hand, typically have very well structures that may be tweaked to provide custom digestibility and usefulness. Hydrogels may be made entirely of synthetic materials. It is also stable in the presence of both sharp and severe changes in temperature [3].

Hydrogels are two- or multi - component systems that are made up of a four matrix of polymer and liquid that fills the gap between macromolecules. Such structures in balance can contain several different quantities of water, relying on the properties of polymers (polymers) was using, as well as the essence and specific gravity of the network joints; usually in the hydrated form, the weight percentage of water in an alginate is much greater than the mass ratio of polymer. In practice, thermoplastic materials that are water soluble in their non-cross-linked state are often used to produce significant degrees of swelling. Hydrogels may be made in a variety of "traditional" chemical methods. One-step procedures such as polymers and parallel pass of multi - functional monomers, as well as multi-step procedures involving the synthesis of polymer molecules with chemical groups and their subsequent pass, possibly by responding polymers with appropriate cross-linking agents, are among them. Polymer engineers may create polymerized with molecular-scale command over structure, such as cross-linking density, and customized characteristics, such as microbial degradation, good mechanical, and chemical and biological responsiveness to stimuli [4].

## DISCUSSION

### *2.1. Hydrogel product classification:*

#### *1.1 Polymeric composition-based classification:*

Some significant types of hydrogels are formed as a result of the preparation technique. The following is an example of this:

- a. Homopolymeric hydrogels are polymer networks made up of a single monomer species, which is the fundamental structural and functional unit of every polymer network. Based on the monomer and polymerization method, homopolymers may have a cross-linked skeletal structure.
- b. Copolymeric hydrogels are made up of two or more monomer species, each having at most one hydrophobic component, organized in a random, block, or alternating pattern along the polymer network's chain.
- c. Multipolymer an important type of hydrogels is the interlayer polymeric hydrogel (IPN), which is made up of two separate pass synthetic and/or natural polymer components held together in a network structure. One component of a semiIPN hydrogel is a cross-linked polymer, while the other is a non-cross-linked polymer [5].

#### *1.2 Configuration-based classification:*

Hydrogels may be divided into the following categories due to its physical structure and composition:

- a. Amorphous (non-crystalline).
- b. Semicrystalline: A blend of crystalline and amorphous phases with a complex structure.
- c. Crystalline is a term used to describe a substance that is crystal.

### *1.3 Cross-linking Types and Classification:*

The biochemical or physical side of cross-link junctions divides hydrogels into two types. Permanent junctions form in chemically cross-linked networks, while transitory junctions form in physical networks due to polymer chain interconnections or direct interaction such as ionic contacts, hydroxyl groups, or hydrophobic interactions [6].

### *2. Hydrogel product sensitive to environmental conditions:*

As previously stated, three - dimensional cross covalently bonded hydrophilic polymer networks capable of reversibly swelling and de-swelling in water while holding a significant volume of liquid in a swelled state. Hydrogels may be engineered to contract or expand in reaction to variations in external conditions. They may undergo significant volume transitions in response to a variety of physiochemical stimuli, including temperature, electric or magnetic fields, light, pressure, and sound, as well as pH, solvent composition, ionic strength, and molecular species. The degree of inflating or de-swelling in reaction to changes in the hydrogel's external environment may be so extreme that the process is known as volume collapses or phase separation. Hydrated minerals have been the subject of considerable study over the last four decades, and they are still a hot topic in academia today. [7]

### *3. Technologies adopted in hydrogel preparation:*

Hydrogels were polymer networks with hydrophilic characteristics by definition. While most hydrogels are made using hydrophilic monomers, hydrophobic monomers are occasionally employed to control the characteristics of hydrogels for particular purposes. In general, either synthetic or natural polymers may be used to make hydrogels. In comparison to natural polymers, synthetic polymers were hydrophobic and physically stronger. Their tensile characteristics results in a delayed rate of decomposition, but tensile characteristics also offers durability. Through optimum design, the two opposing characteristics should be balanced.

It may also be used to make hydrogels from natural polymers if the monomers contain effective functional groups or been synthesized and characterized with radical polymerizable groups. A hydrogel is essentially a hydrophilic polymer network that has been cross-linked in some way to create an elastic structure. As a result, any method for making a cross-linked polymer may be utilized to make a hydrogel. By reacting hydrophobic monomers with multifunctional cross-linkers, produced in the industry free-radical polymerizations are widely employed to make hydrogels. Water-soluble linear polymers of natural and synthetic origins are cross-linked in a variety of ways to create hydrogels:

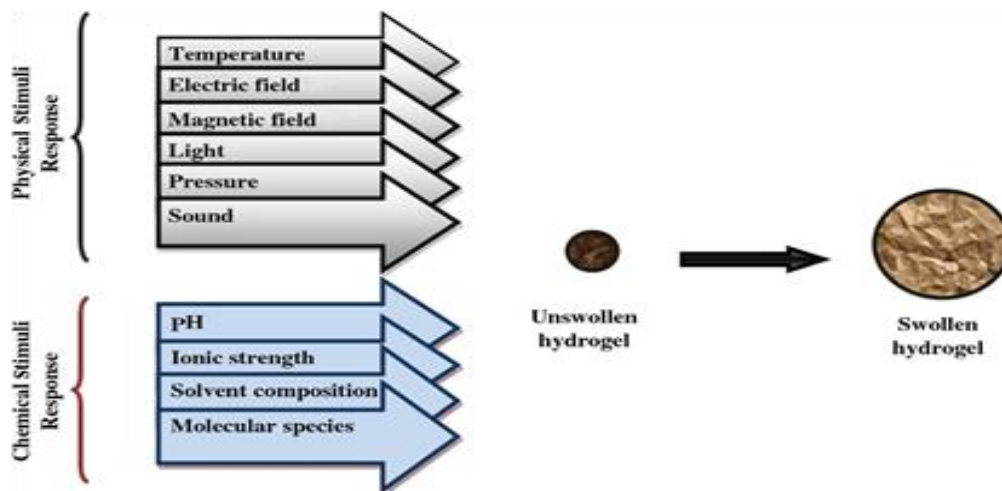
- a. Using a chemical process to link polymer chains.
- b. Ionizing radiation is used to produce main-chain free radicals that may recombine to form cross-link junctions.
- c. Dalliiances, electrostatics, and crystallite formation are examples of physical interactions.

Gels may be made using a variety of polymerization methods, comprising bulk, solution, and suspension polymerization. Monomer, initiator, and cross-linker are the three essential components of hydrogel production. Diluents, including such water or other aqueous solutions, may be employed to regulate the heat of polymerization as well as the characteristics of the resulting hydrogel. The hydrogel mass must next be cleaned to eliminate any remaining contaminants from the preparation procedure. Nonreacted monomers, initiators, cross-linkers, and undesirable compounds generated by side reactions are among them. Opposite polymerization and dilute solution polymerization have been used to produce hydrogels based on acryl, acrylic acid, and its salts. Concentrated form solution polymer of acrylic monomer, which are mainly patented, has received less research.[8]

Chen used potassium persulphate as a thermal initiator to create acrylic acid-sodium acrylate superabsorbent in a saturated (43.6 wt%) solution polymerization. Typically, polar monomers are used to make hydrogels. Biopolymers hydrogels, synthetic rubber hydrogels, and mixtures of the two types may be classified based on their starting ingredients. Graft polymerization, cross-linking polymerization, network creation of water-soluble polymer, and irradiation cross-linking, among other methods, may be used to produce them. Hydrogels come in a variety of forms, but the most common are weakly cross-linked acrylate and acrylic acid copolymers, as well as grafted carbohydrate acid polymers made via reverse suspension, polymerization, and solution gelation.[9]

#### 4. Utilization of hydrogel products:

Since Wichterle and Lim created the first synthetic hydrogels in 1954, hydrogel techniques have been applied to good hygiene products, agricultural production, drug delivery, trying to seal, coal drying, artificial snow, food ingredients, pharmaceutical, biomedical, synthetic biology and regenerative medicines, diagnostics, and tissue engineering and regenerative medicines. Figure 1 Hydrogel that swells in reaction to stimuli. Preparation, characterization, and uses of hydrogels 107 Furthermore, the ever-expanding range of monomer units and macromeres expand their usefulness.[10]

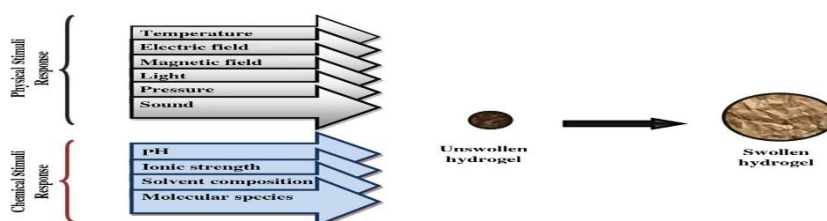


**Figure 1: Stimuli response swelling hydrogel[5]**

They were first utilized in irrigated agriculture absorbents based on biopolymer, where hydrophilic monomers were grafted onto maize and other polysaccharides. Acrylic acid as well as its salts are the most common ingredients in sanitary hydrogels. Acrylamide is a key ingredient in the manufacturing of agricultural hydrogels. The synthetic techniques and uses of hydrogels have been extensively explored in a number of papers on the topic. For example, different chapters of a collection published by Peppas provide a thorough overview of the chemistry and different synthetic methods used for hydrogel production. Khoylou just released a paper on hydrogels made via radiation polymerization and grafting. The production and chemical characteristics of hydrogels used in agricultural applications were reported by Mi-Ran Park. The possibility of hydrogels in sensor applications has been explored by Vijayalakshmi and Kenichi. The customization of hydrogels for different medicinal purposes was addressed by Dimitrios et al.

### 3. CONCLUSION

Many hydrogel-based networks have recently been developed and customized to suit the requirements of various applications. The capacity of these hydrogels to expand when exposed to an aqueous solution is one of their most appealing features. The literature on hydrogel categorization on several grounds, physical and chemical properties of these products, and technological feasibility of their use is given in this study. It also included the technologies used in hydrogel manufacturing, as well as process design considerations, block diagrams, and optimum preparation conditions. In addition, a newly developed class of subsequent generations of methods for generating was described in considerable depth. Super-porous hydrogels are novel materials that quickly expand to a huge size, regardless of their initial size. SPHs have developed throughout time to meet the demands of many applications. Based on the findings of the literature review, batch or semi-batch reactor are appropriate for polymerization operations. Temperature, pressure, batches cycle duration, reactant quantity, and feed addition technique are all factors in batch reactors. Continuous variables having constant values, such as batch cycle duration and reactant quantity, are optimization variables for a batch reactor system that is primarily based on energy and material balance. Three Impellers are known to be effective in high viscosity ranges: ribbon mixer with such a screw all around axis, screw homogenizer with four baffles, and double ribbon mixer.



Superabsorbent polymers (SAPs) were first used in agriculture and diapers about three decades ago, and then their applications were expanded to include other industries that required a high level of water absorption. Superporous hydrogels (SPHs) were first recognized as a distinct class of moisture polymer systems in 1998. SPHs with more useful characteristics, such as good mechanical toughness and elastic properties, were evolved from the original SPHs. The development of SPHs is detailed in this article, as well as the distinctions among SPHs and

superabsorbents (SAPs). SAPs, like SPHs, are architecturally cross-linked hydrophilic polymers with the ability to absorb large quantities of water or soluble fluids in a short amount of time (10–1000 times their original weight or volume).

The inflating rate of SAPs varies depending on the production method and the materials employed during preparation. It may vary from a quarter of a minute to many hours. The rapid swelling, on the other hand, is mostly due to the tiny diameter of the SAP samples. SPHs, on either hand, have a rapid swelling kinetics independent of the ultimate product size. Several methods are used to make the porous hydrogels, including freeze-drying, microemulsion production, and phase separation.

Modern SAPs and SPHs, on the other hand, are often made using a gas blowing method that takes advantage of acid-induced breakdown of a bicarbonate molecule. Although both SAPs and SPHs have a porous structure, they are not the same. SPHs expand instantly when they come into touch with water, regardless of size while dry. Depending on the presence of a foaming agent, foaming assist, and foam stabilizer, the same monomer solution may create various kinds of liquid polymer networks, including such nonporous, porous, and super porous architectures.

The synthesis of acrylamide-based SPH in the presence of salt alginate, following by the cross-linking of alginate chains by calcium ions, is an example of SPH hybrids. The gels in SPH hybrids are extremely elastic in their swelled form, which is one of their distinguishing features. SPH hybrids, unlike ordinary SPHs and SPH composites, are not readily broken when stretched. SPH hybrids are a good option for situations where robust gels are desired because of their elastic and rubbery characteristics. The completely waterswollen SPHs' resilience had never been seen before. Tension, compression, bending, and twisting are all possible stresses for elastic water-swollen SPH hybrids. Distinct generations of SPHs have different structural, swelling, and mechanical characteristics.

## REFERENCES

1. Hu Y, Yu X, Dan W, Yin T, You J, Xiong S. Preparation, characterization and biomedical applications of collagen based hydrogels. *Gongneng Cailiao/Journal of Functional Materials*. 2017, doi: 10.3969/j.issn.1001-9731.2017.01.006.
2. Devi A, Nautiyal U, Kaur S, Komal K. Hydrogels: a smart drug delivery device. *Asian Pacific J. Heal. Sci.*, 2014;1(4(S)):92–105. doi: 10.21276/apjhs.2014.1.1s.19.
3. Ahmed EM. Hydrogel: Preparation, characterization, and applications: A review. *Journal of Advanced Research*. 2015;6(2):105-121. doi: 10.1016/j.jare.2013.07.006.
4. Shivani P, Shetye A., Godbole S, Bhilegaokar, Gajare P. Hydrogels : Introduction, Preparation , Characterization and Applications. *Int. J. Res. Methodol.*, 2015;1(1): 47-71.
5. Aroguz A Z, Baysal K, Baysa BM. Preparation and characterization of hydrogels of several polysaccharides for biomaterials applications: Hydrogels for biomaterials applications. in *ACS Symposium Series*, 2010, doi: 10.1021/bk-2010-1061.ch007.
6. Gulrez SKH, Al-Assaf S, Phillips GO. Hydrogels : Methods of Preparation , Characterisation and Applications. *Prog. Mol. Environ. Bioeng.*, 2003.
7. Gulrez SKH, Al-Assaf S, Phillips GO. Hydrogels: Methods of Preparation, Characterisation

and Applications in Progress in Molecular and Environmental Bioengineering – From Analysis and Modeling to Technology Applications, 2011.

8. Aroguz AZ, Baysal K, Adiguzel Z, Baysal BM. Alginate/polyoxyethylene and alginate/gelatin hydrogels: Preparation, characterization, and application in tissue engineering. *Appl. Biochem. Biotechnol.*, 2014;173:433–448. doi: 10.1007/s12010-014-0851-0.
9. Yuk KY. et al. Preparation and characterization of biodegradable hydrogels for tissue expander application. *Polym.*, 2010, doi: 10.7317/pk.2010.34.3.253.
10. Sirousazar M, Forough M, Farhadi K, Shaabani Y, Molaei R. Hydrogels: Properties, Preparation, Characterization and Biomedical, Applications in Tissue Engineering, Drug, Delivery and Wound Care. in *Advanced Healthcare Materials*, 2014;43(3): 773-781.