ejpmr, 2024, 11(2), 550-553

SJIF Impact Factor 6.222

EUROPEAN JOURNAL OF PHARMACEUTICAL AND MEDICAL RESEARCH

www.ejpmr.com

Review Article

ISSN 2394-3211

EJPMR

A REVIEW ON HYDROGELS

Anshika*, Sonu Verma* and Vishakha Thakur

Department of Pharmaceutics, Sri Sai College of Pharmacy, Badhani, Pathankot 145001, Punjab, India, Rayat Bahra University Kharar 140103 Mohali, Aakash Group of Medical Sciences Nalagarh.

***Corresponding Author: Anshika**

Department of Pharmaceutics, Sri Sai College of Pharmacy, Badhani, Pathankot 145001, Punjab, India, Rayat Bahra University kharar 140103 Mohali, Aakash Group of Medical Sciences Nalagarh.

Article Received on 25/12/2023 **Article Revised on 15/01/2024** **Article Accepted on 05/02/2024**

ABSTRACT

The Purpose of this study is to understand that hydrogels are a unique class of cross-linked polymeric three-dimensional networks that can accommodate a significant fraction of aqueous solvents and biological fluids. Hydrogels now have attracted a growing interest from most of the scientists in various research fields. Hydrogels have played a significant role in a wide range of applications including drug delivery systems. Different methods, general benefits, general limitations, technical features, classifications, types, characterization, advantages, disadvantages, applications were studied.

INTRODUCTION

The term hydrogel describes a three-dimensional cross-linked polymeric network obtained from synthetic or natural polymers which has capacity to hold water within its porous structure.[1,2] The water holding capacity of the hydrogels arise mainly due to the presence of hydrophilic groups, viz. amino, carboxyl and hydroxyl groups, in the polymer chains. These polymeric materials do not dissolve in water at physiological temperature and pH but swell considerably in an aqueous medium Hydrogels can be made from virtually any water-soluble polymer, encompassing a wide range of chemical compositions and bulk physical properties. Further- more, hydrogels can be formulated in a variety of physical forms informs including microparticles, nanoparticles, coatings, and films.[3] Hydrogels have been widely used as a drug carrier due to its ease in manufacturing and self-application in clinical and fundamental applications. Applications of hydrogels in the biomedical field include contact lenses, artificial corneas, wound dressing, coating for sutures, catheters, and electrode sensors.[4]

GENERAL BENEFITS OF HYDROGELS[5,6]

- Biocompatible
- Can be injected in vivo (in a whole, living organism) as a liquid that then gels at body temperature
- Protect cells
- Good transport properties (such as nutrients to cells or cell products from cells)
- Timed release of medicines or nutrients
- Easy to modify
- Can be biodegradable or bioabsorbable

GENERAL LIMITATIONS OF HYDROGELS[7,10]

- High cost
- Low mechanical strength
- Can be hard to handle
- Difficult to load with drugs/nutrients
- May be difficult to sterilize
- Non-adherent.

HYDROGEL TECHNICAL FEACTURES[11]

The functional features of an ideal hydrogel material can be listed as follows:

- The highest absorption capacity (maximum equilibrium swelling) in saline.
- The desired rate of absorption (preferred particle size and porosity) depending on the application requirement.
- The highest absorbency under load (AUL).
- The lowest soluble content and residual monomer.
- The lowest price.

CLASSIFICATION OF HYDROGEL[12]

Hydrogels can be classified into two groups based on their natural or synthetic origins. Classification according to polymeric composition, the method of preparation leads to formations of some important classes of hydrogels:

- Homopolymeric hydrogels
- Copolymeric hydrogels
- Multipolymer interpenetrating polymeric hydrogel (IPN)

Fig. 1: Classification of Hydrogels.

TYPES OF HYDROGELS[13]

Depending on the type of polymer, hydrogels are divided into two categories: natural and synthetic hydrogels. Hydrogenated by natural or synthetic polymers are considered as raw materials for medical applications. Natural and synthetic polymers used to make hydrogels must be biocompatible, biodegradable, and in some applications where the hydrogel is in contact with the blood must be blood compatible.

- Natural Hydrogels
- Synthetic Hydrogels

METHOD FOR PREPARATION OF HYDROGEL[14]

In general, hydrogels can be prepared from either synthetic polymers or natural polymers. The synthetic polymers are hydrophobic in nature and chemically stronger compared to natural polymers. Their mechanical strength results in slow degradation rate, but on the other hand, mechanical strength provides the durability as well. These two opposite properties should be balanced through an optimal design. Also, it can be applied to the preparation of hydrogels based on natural polymers provided that these polymers have suitable functional groups or have been functionalized with radically polymerizable groups. In the most succinct sense, a hydrogel is simply a hydrophilic polymeric network cross-linked in some fashion to produce an elastic structure. Thus, any technique which can be used to create a cross-linked polymer can be used to produce a hydrogel. Copolymerization/cross-linking free-radical poly-merizations are commonly used to produce hydrogels by reacting hydrophilic monomers with multifunctional cross-linkers. Water-soluble linear polymers of both natural and synthetic origin are cross-linked to form hydrogels in a number of ways:

1. Linking polymer chains via chemical reaction.
2. Using ionizing radiation to generate main-chain free radicals which can recombine as cross-link junctions.
3. Physical interactions such as entanglements, electrostatics and crystallite formation.

CHARACTERIZATIZATION OF HYDROGELS[15,16]

- Morphological characterization
- Fourier Transform Infrared Spectroscopy(FTIR)
- Swelling Studies of IPN hydrogel

APPLICATIONS[17,24]

- Drug delivery in the oral cavity
- Drug delivery in the gi tract
- Rectal delivery
- Ocular delivery
- Wound healing
- Hydrogels for transdermal drug delivery

ADVANTAGES OF HYDROGELS[25,27]

- Their degree of flexibility extremely similar to natural tissue which is due to their remarkable water content.
- The environmentally sensitive hydrogels can sense the changes in temperature, pH or the metabolite concentration and sensing these changes they release the load.
- They are biocompatible, biodegradable and are also injectable.
- Entrapment of microbial cells with in hydrogel beads has the advantage of low toxicity.
- Timed release of growth factors and other nutrients to ensure proper tissue growth.
- Hydrogels have good transport properties.

DISADVANTAGES OF HYDROGELS[25,26]

- They are high in cost and possess low mechanical strength.
- They are non-adherent and may need to be secured by secondary dressing.
- They may cause a sensation similar to that which is felt by movement of maggots.
- They can be hard to handle.
- Difficulty to load with drugs/nutrients can be experienced.

- Hydrogels used as contact lenses causes lens deposition, hypoxia, dehydration and red eye reactions.

CONCLUSION

Hydrogels are polymer crosslinked networks that absorb significant amounts of aqueous solutions. The hydrogel are more resemble natural living tissue than any other type of synthetic biomaterial because of their high-water content. Hydrogels used in drug delivery in the oral cavity, drug delivery in the gi tract, rectal delivery, ocular delivery, wound healing, hydrogels for transdermal drug delivery. Different methods, general benefits, general limitations, technical features, classifications, types, characterization, advantages, disadvantages, applications were studied.

REFERENCES

1. A. Nasitha, K. Krishnakumar, and B. Dineshkumar, ―Hydrogel in Pharmaceuticals: a Review, 2016; 3(3): 265–270.
2. N. Das, ―Preparation methods and properties of hydrogel: A review, International Journal of Pharmacy and Pharmaceutical Sciences, 2013; 5(3): 112–117.
3. T. R. Hoare and D. S. Kohane, ―Hydrogels in drug delivery: Progress and challenges,‖ Polymer, 2008; 49(8): 1993–2007.
4. K. Pal, A. K. Banthia, and D. K. Majumdar, ―Preparation and characterization of polyvinyl alcohol-gelatin hydrogel membranes for biomedical applications,‖ AAPS PharmSciTech, 2007; 8: 1.
5. Ahmed EM. Hydrogel: Preparation, characterization and applications: A review. Journal of Advance Research, 2015; 6: 105-121.
6. Advancing the chemical science, drug delivery page 1of 2, index4.4.3
7. Peppas NA, Huang Y, Torres M-Lugo, Ward JH, ZhangJ. Physicochemical, foundations and structural design of hydrogels in medicine and biology. Annu Rev Biomed Eng., 2000; 2: 9–29.
8. Peppas NA, Bures P, Leobandung W, Ichikawa H. Hydrogels in pharmaceutical formulations Eur J Pharm Biopharm, 2000; 50: 27–46.
9. Mc-Neill NE, Graham NB. Properties controlling the diffusion and release of water soluble solutes frompoly (ethyloxide) hydrogels1, Polymer composition. J Biomater Sci Polyymer composition. J Biomater Sci Poly, 1993; 4: 305-22.
10. George A. Paleos, Pittsburgh plastics manufacturing. Butler Pam., 1993; 4: 305-22.
11. Flory PJ. Principles of polymer chemistry, Cornell Univ. Press: Ithaca, NY., 1953; 672.
12. Peppasa NA, Buresa P, Leobandunga W, Ichikawa H. Hydrogels in pharmaceutical formulations. *European Journal of Pharmaceutics and Biopharmaceutics*, 2008; 28(50): 27-46.
13. Bin Jeremiah D. Barba, Charito Tranquilan Aranilla, Lucille V. Abad Hemostatic potential of natural/synthetic polymer based hydrogels crosslinked by gamma radiation. Radiation Physics and Chemistry, 2016; 118: 111-113.
14. Muhammad U, Mahmood A, Liaqat A, Muhammad S. Synthesis of chemically cross-linked polyvinyl alcohol-co-poly (methacrylic acid) hydrogels by copolymerization; a potential graft-polymeric carrier for oral delivery of 5-fluorouracil. Daru journal of pharmaceutical sciences, 2012; 21: 41-44.
15. Wichterle O, Lim D. Hydrophilic gels inbiologic use. *Nature*, 1960; 185(4706): 117.12. Campoccia D, Doherty P, Radice M, Brun P, Abatangelo G, Williams D F. Semisyntheticresorbable materials from hyaluronanesterification. *Biomaterials*, 1998; 19(23): 2101–2127.
16. N. A. Peppas, P. Bures, W. Leobandung, and H. Ichikawa, "Hydrogels in pharmaceutical formulations.," European journal of pharmaceutics and biopharmaceutics: official journal of Arbeitsgemeinschaft fur Pharmazeutische Verfahrenstechnik e. V, 2000; 50(1): 27–46.
17. N. A. Peppas, P. Bures, W. Leobandung, and H. Ichikawa, "Hydrogels in pharmaceutical formulations.," European journal of pharmaceutics and biopharmaceutics: official journal of Arbeitsgemeinschaft fur Pharmazeutische Verfahrenstechnik e. V, 2000; 50(1): 27– 46.
18. V. R. Patel and M. M. Amiji, Preparation and Characterization of Freeze-dried Chitosan-Poly (Ethylene Oxide) Hydrogels for Site- Specific Antibiotic Delivery in the Stomach,‖ Pharmaceutical Research, 1996; 13(4): 588–593.
19. M. Lowman, M. Morishita, M. Kajita, T. Nagai, and N. A. Peppas, "Oral delivery of insulin using pH-responsive complexation gels.," Journal of pharmaceutical sciences, 1999; 88(9): 933–937.
20. J.-M. Ryu, S.-J. Chung, M.-H. Lee, C.-K. Kim, and Chang-Koo Shim, Increased bioavailability of propranolol in rats by retaining thermally gelling liquid suppositories in the rectum,‖ Journal of Controlled Release, 1999; 59(2): 163–172.
21. S. Cohen, E. Lobel, A. Trevgoda, and Y. Peled, A novel in situ-forming ophthalmic drug delivery system from alginates undergoing gelation in the eye, Journal of Controlled Release, 1997; 44(2): 201–208.
22. Saarai, V. Kasparkova, T. Sedlacek, and P. Saha, A comparative study of crosslinked sodium alginate/gelatin hydrogels for wound dressing, Recent Researches in Geography, Geology, Energy, Environment and Biomedicine - Proc. of the 4th WSEAS Int. Conf. on Emeseg,, 11, 2nd Int. Conf. on World-GEO,,11, 5th Int. Conf. on EDEB, 2011; 11: 384–389.
23. O. Nnamani, Characterization and controlled release of gentamicin from novel hydrogels based on Poloxamer 407 and polyacrylic acids, African Journal of Pharmacy and Pharmacology, 2013; 7(36): 2540–2552.
24. H. E. Boddé, E. A. van Aalten, and H. E. Junginger, Hydrogel patches for transdermal drug delivery; in-

vivo water exchange and skin compatibility., The Journal of pharmacy and pharmacology, 1989; 41(3): 152–155.
25. R. Sankula, ―a Review on Hydrogel Pharmaceutical Preparations, 2019; 8(02): 6–9.
26. R. Article and S. Jawad, ―A Review on novel approach of drug delivery, 2020; 9(6): 791–800.
27. G. Thakur and D. Rousseau, ―Hydrogels: Characterization, Drug Delivery, and Tissue Engineering Applications,‖ Encyclopedia of Biomedical Polymers and Polymeric Biomaterials, 2014; 3853–3878.
28. Garg S, Garg A, Vishwavidyalaya RD. Hydrogel: Classification, properties, preparation and technical features. Asian J. Biomater. Res., 2016; 2(6): 163-70.
29. Gharat JS, Dalvi YV. Compressive review on hydrogel. Asian Journal of Pharmacy and Technology, Sep. 10, 2018; 8(3): 172-81.
30. Zhang W, Zhang YM, Liu Y. Cyclodextrin- Cross-Linked Hydrogels for Adsorption and Photodegradation of Cationic Dyes in Aqueous Solution. Chemistry–An Asian Journal, Aug. 16, 2021; 16(16): 2321-7.
31. Kumar GA, Wadood SA, Maurya SD, Ramchand D. Interpenetrating polymeric network hydrogel for stomach-specific drug delivery of clarithromycin: Preparation and evaluation. Asian Journal of Pharmaceutics-October-December, 2010.
32. Budianto E, Muthoharoh SP, Nizardo NM. Effect of crosslinking agents, pH and temperature on swelling behavior of cross-linked chitosan hydrogel. Asian Journal of Applied Sciences, Oct. 26, 2015; 3(5).
33. Sreenivasachary N, Lehn JM. Structural Selection in G- Quartet- Based Hydrogels and Controlled Release of Bioactive Molecules. Chemistry–An Asian Journal, Jan. 4, 2008; 3(1): 134-9.
34. Sharma S, Goutam S, Nama N, Khinchi MP, Singh SP. A Review on Hydrogels. Asian Journal of Pharmaceutical Research and Development, Mar. 1, 2017: 1-0.
35. Prasad V. Hydrogels: A review. Asian Journal of Multidimensional Research, 2021; 10(10): 935-40.
36. Fang W, Zhang Y, Wu J, Liu C, Zhu H, Tu T. Recent advances in supramolecular gels and catalysis. Chemistry–An Asian Journal, Apr. 4, 2018; 13(7): 712-29.
37. Bhoi NK, Jain G, Singhai AK, Mishra SS. Asian Journal of Pharmaceutical Education and Research.
38. Higashi D, Yoshida M, Yamanaka M. Thixotropic Hydrogel Formation in Various Aqueous Solutions through Self- Assembly of an Amphiphilic Tris-Urea. Chemistry–An Asian Journal, Nov. 2013; 8(11): 2584-7.
39. Deng W, Yamaguchi H, Takashima Y, Harada A. Construction of chemical- responsive supramolecular hydrogels from guest- modified cyclodextrins. Chemistry–An Asian Journal, Apr. 7, 2008; 3(4): 687-95.
40. Kong W, Huang D, Xu G, Ren J, Liu C, Zhao L, Sun R. Graphene oxide/polyacrylamide/aluminum ion cross- linked carboxymethyl hemicellulose nanocomposite hydrogels with very tough and elastic properties. Chemistry–An Asian Journal, Jun. 6, 2016; 11(11): 1697-704.
41. Bhattacharjee S, Bhattacharya S. Charge Transfer Induces Formation of Stimuli- Responsive, Chiral, Cohesive Vesicles- on- a- String that Eventually Turn into a Hydrogel. Chemistry–An Asian Journal, Mar., 2015; 10(3): 572-80.
42. Du X, Zhou J, Xu B. Supramolecular hydrogels made of basic biological building blocks. Chemistry–An Asian Journal, Jun., 2014; 9(6): 1446-72.
43. Gr TS, Zaman N, Alamelu B, Dhamankar V, Chu C, Perotta E, Kadiyala I. Mechanical characterization of extracellular matrix hydrogels: comparison of properties measured by rheometer and texture Analyzer. Asian Journal of Pharmaceutical Technology and Innovation, 2018; 6(28).
44. Prasad V. Hydrogels: A review. Asian Journal of Multidimensional Research, 2021; 10(10): 935-40.
45. Komatsu H, Tsukiji S, Ikeda M, Hamachi I. Stiff, Multistimuli- Responsive Supramolecular Hydrogels as Unique Molds for 2D/3D Microarchitectures of Live Cells. Chemistry–An Asian Journal, Sep. 5, 2011; 6(9): 2368-75.
46. John T, Rajpurkar A, Smith G, Fairfax M, Triest J. Antibiotic pretreatment of hydrogel ureteral stent. Journal of endourology, Oct. 1, 2007; 21(10): 1211-6.
47. Mukherjee S, Kar T, Kumar Das P. Pyrene- Based Fluorescent Supramolecular Hydrogel: Scaffold for Energy Transfer. Chemistry–An Asian Journal, Oct., 2014; 9(10): 2798-805.
48. Li J. Self-assembled supramolecular hydrogels based on polymer–cyclodextrin inclusion complexes for drug delivery. NPG Asia Materials, Jul., 2010; 2(3): 112-8.
49. Kaneko Y, Fujisaki K, Kyutoku T, Furukawa H, Kadokawa JI. Preparation of Enzymatically Recyclable Hydrogels Through the Formation of Inclusion Complexes of Amylose in a Vine-Twining Polymerization. Chemistry–An Asian Journal, Jul. 5, 2010; 5(7): 1627-33.
50. Sun X, Liu D, Xu X, Shen Y, Huang Y, Zeng Z, Xia M, Zhao C. NIR-triggered thermo-responsive biodegradable hydrogel with combination of photothermal and thermodynamic therapy for hypoxic tumor. Asian journal of pharmaceutical sciences, Nov. 1, 2020; 15(6): 713-27.