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Introductory Chapter: Hydrogels - From First Natural Hydrocolloids to Smart Biomaterials

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1. Introduction

Hydrogels are part of our everyday life. They are components of our food [1–4], our everyday objects [5–7], but most importantly, they are valuable intermediaries in the most innovative and unexpected attempts to cure, to reduce the effects of the diseases, and to regenerate, in a single word—to heal [8–11].

Hydrogels are known as the first biomaterials useful for therapy in humans [12], but they are still fascinating materials and subject for developing innovative formulations and applications [13–15]. They have unique properties derived from its three-dimensional (3D) viscoelastic network [16], essentially permitting attachment and later diffusion of particles, molecules, in controlled drug or cell/gene delivery [17, 18], as well as serving as 3D bioprinting material [19, 20], in modern medicine, for tissue engineering [21, 22], as implants [23], for diagnostics [24], wound dressing [25], bone regeneration [26, 27], and soft contact lens [28], to exemplify only a few.

Today, modern therapy gives a great value to tissue engineering and regenerative medicine (TERM) in various disease treatments [29]. In TERM, a great number of biomaterials are developed, and among them, hydrogels and scaffolds are occupying important places. The interest of the researchers in this subject is enormously expanding.

This book comes to give a small overview for multidisciplinary hydrogel research and widen applicability. That is the reason why the book opens with a board overview of the hydrogel applications in drug delivery over last 10 years.

The chapters of the book were majorly focused on the latest and emergent fields of interest: superabsorbent hydrogels, natural hydrogels based on chitosan, and a clinical grade hydrogel platform for drugs or cell/gene delivery, with potential-derived future organoid culture or bioprinting applications.

An innovated class of recent generation of hydrogels includes superabsorbent hydrogels, and among them, cellulose-based superabsorbent hydrogels are important representative, due to a large availability of cellulose, it being environmental friendly, and its biocompatibility. It is largely presented in one of the chapters of the book. It is noted as smart materials, displaying stimuli-sensitive responsiveness to specific environmental cues.

Among the natural hydrogels, those based on chitosan and chitosan derivatives are described in another important chapter, with their biomedical application. Chitosan, as natural hydrophilic polymer, presents important deal of interest for hydrogel structures due to its biocompatibility and biodegradability. As biological

devices, chitosan-based hydrogels are potentially engineering scaffolds to obtain tissue repair.

A hydrogel platform, designed and obtained at clinic grade, and able to overcome problem of stability of small molecules of drugs, proteins, or cells co-packaged with the hydrogel matrix, is detailed in another important chapter of the book. HyStem® hydrogels are addressed to this issue and solve the problem, mixing the matrix with the active components at the point of administration. It is open the road for incorporating of therapeutic growth factors, antibodies or cells, and by their flexibility, HyStem® hydrogels become a basis for a new generation of therapeutics: patient-derived organoid culture in order to novel drug design, as well as for bioprinting to new organs manufacture.


Significant advances have been made in the field of hydrogels as intelligent and functional materials. Their application in the biomedical field has been inherently hidden by the toxicity of crosslinking agents. Emerging knowledge in the field of chemistry, as well as the proper understanding of biological processes, has led to the rational use of hydrogels as versatile materials, hydrogel matrices helping to minimize invasive therapies, and nowadays, hydrogels appear to have tremendous promising application potentials [30]. However, there are still a number of challenges for clinical translation.

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References

- [1] Chen L, Remondetto GE, Subirade M. Food protein-based materials as nutraceutical delivery systems. *Trends in Food Science & Technology*. 2006;**17**(5):272-283. DOI: 10.1016/j.tifs.2005.12.011. ISSN: 0924-2244
- [2] Liu LS, Kost J, Yan F, Spiro RC. Hydrogels from biopolymer hybrid for biomedical, food, and functional food applications. *Polymers*. 2012;**4**:997-1011. DOI: 10.3390/polym4020997
- [3] Limbach HJ, Kremer K. Multi-scale modelling of polymers: Perspectives for food materials. *Trends in Food Science & Technology*. 2006;**17**(5):215-219. DOI: 10.1016/j.tifs.2005.11.001. ISSN: 0924-2244
- [4] Farris S, Schaich KM, Liu LS, Piergiovanni L, Yam KL. Development of polyion-complex hydrogels as an alternative approach for the production of bio-based polymers for food packaging applications: A review. *Trends in Food Science & Technology*. 2009;**20**:316-332. DOI: 10.1016/j.tifs.2009.04.003. ISSN: 0924-2244
- [5] Ali A, Ahmed S. Recent advances in edible polymer based hydrogels as a sustainable alternative to conventional polymers. *Journal of Agricultural and Food Chemistry*. 2018;**66**(27):6940-6967. DOI: 10.1021/acs.jafc.8b01052
- [6] 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. ISSN: 2090-1232
- [7] Bahram M, Mohseni N, Moghtader M. An introduction to hydrogels and some recent applications. In: *Emerging Concepts in Analysis and Applications of Hydrogels*. Rijeka, Croatia: IntechOpen; 2016. DOI: 10.5772/61692. ISBN: 978-953-51-2510-5
- [8] Hoffman AS. Hydrogels for biomedical applications. *Advanced Drug Delivery Reviews*. 2012;**64**(Suppl):18-23. DOI: 10.1016/j.addr.2012.09.010. ISSN: 0169-409X
- [9] Caló E, Khutoryanskiy VV. Biomedical applications of hydrogels: A review of patents and commercial products. *European Polymer Journal*. 2015;**65**:252-267. DOI: 10.1016/j.eurpolymj.2014.11.024. ISSN: 0014-3057
- [10] Kapoor S, Kundu SC. Silk protein-based hydrogels: Promising advanced materials for biomedical applications. *Acta Biomaterialia*. 2016;**31**:17-32. DOI: 10.1016/j.actbio.2015.11.034
- [11] Preda RC, Leisk G, Omenetto F, Kaplan DL. Bioengineered silk proteins to control cell and tissue functions. *Methods in Molecular Biology*. 2013;**996**:19-41. DOI: 10.1007/978-1-62703-354-1_2
- [12] Chirani N, Yahia L'H, Gritsch L, Motta FL, Chirani S, Faré S. History and applications of hydrogels. *Journal of Biomedical Science*. 2015;**4**(2):1-23. DOI: 10.4172/2254-609X.100013
- [13] Ozcelik B. Degradable hydrogel systems for biomedical applications. In: Poole-Warren L, Martens P, Green R, editors. *Woodhead Publishing Series in Biomaterials. Biosynthetic Polymers for Medical Applications*. Cambridge, UK: Woodhead Publishing Limited, Elsevier; 2016. pp. 173-188. DOI: 10.1016/B978-1-78242-105-4.00007-9. ISBN: 9781782421054
- [14] Kamoun EA, Kenawy E-RS, Chen X. A review on polymeric hydrogel membranes for wound dressing applications: PVA-based hydrogel dressings. *Journal of Advanced Research*. 2017;**8**(3):217-233. DOI: 10.1016/j.jare.2017.01.005. ISSN: 2090-1232

- [15] Weller C. Interactive dressings and their role in moist wound management. In: Rajendran S, editor. Woodhead Publishing Series in Textiles. Advanced Textiles for Wound Care. Cambridge, UK: Woodhead Publishing Limited, Elsevier; 2009. pp. 97-113. DOI: 10.1533/9781845696306.1.97. ISBN: 9781845692711
- [16] Spizzirri UG, Curcio M, Cirillo G, Spataro T, Vittorio O, Picci N, et al. Recent advances in the synthesis and biomedical applications of nanocomposite hydrogels. *Pharmaceutics*. 2015;7(4):413-437. DOI: 10.3390/pharmaceutics7040413
- [17] Lee SC, Kwon IK, Park K. Hydrogels for delivery of bioactive agents: A historical perspective. *Advanced Drug Delivery Reviews*. 2013;65(1):17-20. DOI: 10.1016/j.addr.2012.07.015. ISSN: 0169-409X
- [18] Larrañeta E, Stewart S, Ervine M, Al-Kasasbeh R, Donnelly RF. Hydrogels for hydrophobic drug delivery. Classification, synthesis and applications. *Journal of Functional Biomaterials*. 2018;9(1):13. DOI: 10.3390/jfb9010013. Epub: January 24, 2018
- [19] Merceron TK, Murphy SV. Chapter 14: Hydrogels for 3D bioprinting applications. In: Atala A, Yoo JJ, editors. *Essentials of 3D Biofabrication and Translation*. London, UK: Academic Press, Elsevier; 2015. pp. 249-270. DOI: 10.1016/B978-0-12-800972-7.00014-1. ISBN: 9780128009727
- [20] Bishop ES, Mostafa S, Pakvasa M, Luu HH, Lee MJ, Wolf JM, et al. 3-D bioprinting technologies in tissue engineering and regenerative medicine: Current and future trends. *Genes & Diseases*. 2017;4(4):185-195. DOI: 10.1016/j.gendis.2017.10.002. ISSN: 2352-3042
- [21] Matricardi P, Di Meo C, Coviello T, Hennink WE, Alhaique F. Interpenetrating polymer networks polysaccharide hydrogels for drug delivery and tissue engineering. *Advanced Drug Delivery Reviews*. 2013;65(9):1172-1187. DOI: 10.1016/j.addr.2013.04.002. Epub: April 17, 2013
- [22] Kundu B, Rajkhowa R, Kundu SC, Wang X. Silk fibroin biomaterials for tissue regenerations. *Advanced Drug Delivery Reviews*. 2013;65(4):457-470. DOI: 10.1016/j.addr.2012.09.043. Epub: November 5, 2012
- [23] Ambrosio L, De Santis R, Nicolais L. Composite hydrogels for implants. *Proceedings of the Institution of Mechanical Engineers, Part H: Journal of Engineering in Medicine*. 1998;212(2):93-99. DOI: 10.1243/0954411981533863
- [24] Jung IY, Kim JS, Choi BR, Lee K, Lee H. Hydrogel based biosensors for in vitro diagnostics of biochemicals, proteins, and genes. *Advanced Healthcare Materials*. 2017;6(12). DOI: 10.1002/adhm.201601475. Epub: March 31, 2017
- [25] Quarfoot AJ, Hyla PH, Patience D. Hydrogel wound dressing. Patent No. US4909244A
- [26] Kim J, In SK, Cho TH, Lee KB, Hwang SJ, Tae G, et al. Bone regeneration using hyaluronic acid-based hydrogel with bone morphogenic protein-2 and human mesenchymal stem cells. *Biomaterials*. 2007;28(10):1830-1837. DOI: 10.1016/j.biomaterials.2006.11.050. ISSN: 0142-9612
- [27] Bai X, Gao M, Syed S, Zhuang J, Xu X, Zhang X-Q. Bioactive hydrogels for bone regeneration. *Bioactive Materials*. 2018;3(4):401-417. DOI: 10.1016/j.bioactmat.2018.05.006. ISSN: 2452-199X

[28] Jahangir MA, Imam SS, Gilani SJ. Chapter 5: Polymeric hydrogels for contact lens-based ophthalmic drug delivery systems. In: Grumezescu AM, editor. *Organic Materials as Smart Nanocarriers for Drug Delivery*. Kidlington, UK: William Andrew Publishing, Elsevier; 2018. pp. 177-208. DOI: 10.1016/B978-0-12-813663-8.00005-1. ISBN: 9780128136638

[29] Fisher MB, Mauck RL. Tissue engineering and regenerative medicine: Recent innovations and the transition to translation. *Tissue Engineering. Part B, Reviews*. 2013;**19**(1):1-13. DOI: 10.1089/ten.teb.2012.0723

[30] Kopeček J. Hydrogel biomaterials: A smart future? *Biomaterials*. 2007;**28**(34):5185-5192. DOI: 10.1016/j.biomaterials.2007.07.044