Peertechz

Archives of Pulmonology and Respiratory Care

CLINICAL GROUP

ISSN: 2581-3684 DOI: https://dx.doi.org/10.17352/aprc

Opinion

Smart polymers: Challenges and future

Hernandez-Martinez AR*

Center for Applied Physics and Advanced Technology (CFATA), National Autonomous University of Mexico (UNAM), Blvd. Juriquilla 3000, Querétaro, Mexico

Received: 21 September, 2022
Accepted: 28 October, 2022
Published: 29 October, 2022

***Corresponding author:** Hernandez-Martinez AR, Center for Applied Physics and Advanced Technology (CFATA), National Autonomous University of Mexico (UNAM), Blvd. Juriquilla 3000, Querétaro, Mexico, Tel: (+52) 442-238-1170; Fax: Fax: (+52) 442-238-1170; E-mail: arhm@fata.unam.mx, angel.ramon.hernandez@gmail.com

ORCID: https://orcid.org/0000-0003-1594-2546

According to the International Union of Pure and Applied Chemistry (IUPAC) Smart Polymers (SP) or stimulus-responsive polymers are "polymers that respond or that is designed to respond to a stimulus like pH, light, heat, etc. change, and provides a predetermined action". These changes are generally abrupt and relatively large, involving changes in phase or properties due to structural adaptations of the polymer [1-4]. Smart polymers that present a response to changes in pH and/or temperature are among the most studied since they present molecular/structural changes with small changes in pH or temperature. These structural changes are reversible and are reflected in a macroscopic change in the properties of the material, such as shape (shrinkage or bending), wettability, solubility, optical properties, conductivity, adhesion, etc. Therefore, various reports have discussed the use of these PIs in information storage applications, flexible robots, artificial muscles, catalysis, chromatography, tissue engineering, DNA separation, drug delivery, sensors, and biosensors [5-9].

Thermo-responsive polymers consist of functional groups, both hydrophilic and hydrophobic, and undergo abrupt changes in their electrostatic and hydrophobic interactions in an aqueous medium at a critical solution temperature. The most common behavior of these materials is to act as hydrophilic materials below a specific lower critical solution temperature (LCST), forming homogeneous polymer/solvent solutions. But above the LCST, they behave as hydrophobic materials forming heterogeneous polymer/solvent solutions; therefore, thermo-sensitive PIs are appropriate for the development of sensors sensitive to temperature variations [10-12]. On the other hand, pH-responsive polymers consist of functional groups such as weak ionizable acids (carboxylic acid, phosphoric acid) or basic publications [13] (amines groups, morpholino, pyrrolidine, pyridine, or imidazole groups). Therefore, they can accept or release protons in response to small changes in environmental pH, which produces macroscopic changes in the solubility and swelling properties of polymers. PH-responsive PIs have been shown to be useful for the development of blood glucose biosensors, by detecting variations in pH due to the presence of glucose [12-14].

Smart polymers (SP) are particularly useful for the design of biosensors due to their intrinsic response to different stimuli, especially those that occur under physiological conditions, which was first raised in the 1990s by Liu [13] and Hoffman [6], among others. However, even though the polymeric chains of SPs allow the incorporation of biological material or biomimetics such as receptors and recognition probes, as well as integration with other materials for their incorporation into bio-sensing devices, they have been a relatively unexplored application. The application of SPs.

Biosensor development has advanced slowly, mainly due to their own "great success" in controlled drug release, tissue engineering, and DNA separation applications.

Additionally, there is a limited variety of monomers (precursor molecules) for the synthesis of SP, which represents an interesting challenge to solve. Therefore, one of the challenges within the SP area is the design and synthesis of

Citation: Hernandez-Martinez AR (2022) Smart polymers: Challenges and future. Arch Pulmonol Respir Care 8(1): 010-011. DOI: https://dx.doi.org/10.17352/aprc.000076

new intelligent polymers through (i) the synthesis of new monomers, (ii) copolymerization between known SP monomers and (iii) copolymerization between monomers that do not have SP properties but that can provide hydrophilic and hydrophobic groups in an adequate way to provide the physicochemical balance that allows the stimulus-responsive property.

The design and synthesis of SP is still a fertile area with great challenges, from computer-aided design, through synthesis, and even its use in the development of novel technological devices such as biosensors.

References

1. Jeong B, Gutowska A. Lessons from nature: stimuli-responsive polymers and their biomedical applications. Trends Biotechnol. 2002 Jul;20(7):305-11. doi: 10.1016/s0167-7799(02)01962-5. Erratum in: Trends Biotechnol. 2002 Aug;20(8):360. PMID: 12062976.
2. Galaev IY, Mattiasson B. 'Smart' polymers and what they could do in biotechnology and medicine. Trends Biotechnol. 1999 Aug;17(8):335-40. doi: 10.1016/s0167-7799(99)01345-1. PMID: 10407406.
3. Hoffman AS, Stayton PS, Bulmus V, Chen G, Chen J, Cheung C, Chilkoti A, Ding Z, Dong L, Fong R, Lackey CA, Long CJ, Miura M, Morris JE, Murthy N, Nabeshima Y, Park TG, Press OW, Shimoboji T, Shoemaker S, Yang HJ, Monji N, Nowinski RC, Cole CA, Priest JH, Harris JM, Nakamae K, Nishino T, Miyata T. Founder's Award, Society for Biomaterials. Sixth World Biomaterials Congress 2000, Kamuela, HI,May 15-20, 2000. Really smart bioconjugates of smart polymers and receptor proteins. J Biomed Mater Res. 2000 Dec 15;52(4):577-86. doi: 10.1002/1097-4636(20001215)52:4<577::aid-jbm1>3.0.co;2-5. PMID: 11033539.
4. Kikuchi A, Okano Yt.Intelligent thermoresponsive polymeric stationary phases for aqueous chromatography of biological compounds, Prog. Polym. Sci., 27(6) 2002; 1165-1193, doi: 10.1016/S0079-6700(02)00013-8.
5. Tanaka T, Fillmore D, Shao-Tang S, Nishio I, Swislow G, Shah A. Phase Transitions in Ionic Gels, Phys. Rev. Lett. 45, (1980) 1636
6. Hoffman AS. Applications of thermally reversible polymers and hydrogels in therapeutics and diagnostics J. Contr. Rel., 6 ,1987; 297-305
7. Hoffman AS. Intelligent polymers in medicine and biotechnology Macromol. Symp., 98 ,1995; 645-664
8. Zhang Q, Hou Z, Louage B, Zhou D, Vanparijs N, De Geest BG, Hoogenboom R. Acid-Labile Thermoresponsive Copolymers That Combine Fast pH-Triggered Hydrolysis and High Stability under Neutral Conditions. Angew Chem Int Ed Engl. 2015 Sep 7;54(37):10879-83. doi: 10.1002/anie.201505145. Epub 2015 Jul 24. PMID: 26212481.
9. Hernández-Martínez AR, Bucio yE, Novel pH- and Temperature-Sensitive Behavior of Binary Graft DMAEMA/PEGMEMA onto LDPE Membranes, Des. Monomers Polym., 12(6) 2009; 543-552, doi: 10.1163/138577209X12478293300757.
10. Cabane E, Zhang X, Langowska K, Palivan CG, Meier W. Stimuli-responsive polymers and their applications in nanomedicine. Biointerphases. 2012 Dec;7(1-4):9. doi: 10.1007/s13758-011-0009-3. Epub 2012 Feb 11. PMID: 22589052.
11. Chan A, Orme RP, Fricker RA, Roach P. Remote and local control of stimuli responsive materials for therapeutic applications. Adv Drug Deliv Rev. 2013 Apr;65(4):497-514. doi: 10.1016/j.addr.2012.07.007. Epub 2012 Jul 20. PMID: 22820529.
12. Ravichandran R, Sundarrajan S, Venugopal JR, Mukherjee S, Ramakrishna S. Advances in polymeric systems for tissue engineering and biomedical applications. Macromol Biosci. 2012 Mar;12(3):286-311. doi: 10.1002/mabi.201100325. Epub 2012 Jan 25. PMID: 22278779.
13. Ofridam F, Tarhini M, Lebaz N, Gagnière E, Mangin D, Elaissari A. pHsensitive polymers: Classification and some fine potential applications. Polymers for Advanced Technologies, 32(4), 2021; 1455-1484.
14. Liu F, Song SC, Mix D, Baudys M, Kim SW. Glucose-induced release of glycosylpoly(ethylene glycol) insulin bound to a soluble conjugate of concanavalin A. Bioconjug Chem. 1997 Sep-Oct;8(5):664-72. doi: 10.1021/bc970128e. PMID: 9327129.

Citation: Hernandez-Martinez AR (2022) Smart polymers: Challenges and future. Arch Pulmonol Respir Care 8(1): 010-011. DOI: https://dx.doi.org/10.17352/aprc.000076