Journal of Pharmaceutics & Drug Development
Volume 1 | Issue 1
ISSN: 2348-9782

Editorial Open Access

Biocompatible Polymers and Processing Techniques in Drug Delivery and Tissue Engineering

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Citation: Giamonna G, Fiorica C, Di Stefano M, Palumbo FS, Pitarresi G (2013) Biocompatible Polymers and Processing Techniques in Drug Delivery and Tissue Engineering. J Pharm Drug Devel 1(1): e101. doi: 10.15744/2348-9782.1.e101

Received Date: June 28, 2013 **Accepted Date:** July 29, 2013 **Published Date:** August 01, 2013

In recent years many progress has been achieved in the biomedical and biopharmaceutical fields particularly in drug delivery and regenerative medicine [1]. This has been possible thanks to the increased expertise in polymers chemistry as well as the advent of innovative techniques of materials manipulation that have lead to the production of new "smart" polymeric devices with peculiar propertiesable to selectively reach almost all areas of the human body, in the case of drug delivery systems, or to reduce the chemical-physical gap between human tissues and synthetic devices, in the case of tissue engineering. A precise molecular composition results in the production of materials with optimal chemical and morphological characteristics that can be exploited for new diagnostic and therapeutic applications [2-4].

Numerous works have been published on a variety of international journals on the production of polymeric micelles, nanoparticles and microparticles employed for the controlled and targeted [5] release of drugs or genetic material.In particular many efforts have been focused on the development of anti tumoral drug delivery systems since cancer is one of the leading causes of death worldwide. Chemotherapeutic agents have numerous disadvantages and in order to overcome the technological and pharmacological limitations of these drugs an optimal delivery system should be able to selectively reach tumoral cells, avoid side effects, limits the number of administrations and be eliminated from the organism avoiding accumulation phenomena. To obtain such an "intelligent" device the choice of the starting materials is of crucial important but also the use of chemical procedures capable of varying the chemical-physical and biological properties of the entire structure have to be considered [6]. Both natural and synthetic polymers such as hyaluronic acid, chitosan, fibroin, polylactic acid, polylactide-co-glycolic acid, polycaprolactone, α, β-Poly(N-2-hydroxyethyl)-D, L-aspartamide (PHEA), α, β Polyaspartylhydrazide (PAHy) etc represent the raw materials of most drug delivery systems. However, very rarely these polymers are used in native form, in fact they are often chemically modified to improve both mechanical and biological properties.

Graft co-polymers are an excellent example of how it is possible to combine the characteristics of two or even more polymers to obtain devices with unique properties. As example, by binding polylactic acid, and polyethylene glycol chains onto the polymeric backbone of hyaluronic acid it was possible to obtain a graft co-polymer able to self-assemble in aqueous environment by forming micelles able to encapsulate in their core an antitumoral drug such as doxorubicine and sustain its release over the time [7]. In this work the biological properties of hyaluronic acid (capacity to be recognize from CD 44 receptors that are overexpressed in several tumoral cell lines) are associated with the properties of polylactic acid (lipophilicity in this case, essential to obtain the self assembling properties) and the characteristics of polyethylene glycol which gives stealth properties to micelles.

Important chemical modifications have been recently made possible by the advent of innovative polymerization techniques such as Atom Transfer Radical Polymerization (ATRP) which is a technique used for the first time by Coessens, et al. [8] that allow to overcome most of the typical problems of the common grafting procedures (especially the control of the grade of functionalization, and the polydispersity of the obtained products). Nanoparticles for the pH sensitive delivery of doxorubicine were producted by ATRP of sodium methacrylate onto the polymeric backbone of (PHEA), a synthetic polymer soluble both in organic solvents and in water [9]. In this case the chemical versatility of PHEA has made possible the insertion in the macromolecule of several chemical groups able to trigger ATRP process in a way to obtain a copolymer through a "growing from" process. In the

field of tissue engineering the most important challenge is to produce device able to temporarily replace those body tissues damaged by diseases or trauma of various kinds.

These "bioengineered tissue", must have morphological, structural and chemical-physical properties similar to those of native extracellular matrix in order to promote adhesion and proliferation of cells, integrate with host tissues, stimulate endogenous cells colonization and be removed gradually by the body once that the new tissue is produced. Is therefore easy to understand that for the realization of these structures are fundamental once again the choice of the starting materials and the materials manipulation technique. Concerning the choice of materials it will affect the biological gap between bioengineered tissue and native ones, for this reason, highly functionalisable polymers are often preferred as they offer the possibility to chemically bind bioactive molecules (chemotactic agents, drugs etc) capable of representing a biochemical stimulus for the resumption of normal physiological conditions. The choice of manipulation technique on the other hand will affect the morphological gap between the synthetic biomaterial and tissues of the human body. Since the native extracellular matrix is highly fibrillar thanks to the presence of collagen fibrils, in the processing of biomaterials for tissue engineering we tend to mimic these characteristics.

Very interesting results in this direction have been obtained in the past decade with the technique of electrospinning by which it is possible to obtain polymer fibers with a diameter in the order of nanometers by forcing a polymeric solution through an electric field [10].

An interesting example is represented by the electrospinning of a graft copolymer of the aforementioned PHEA with polylactic acid. In this case the polymeric backbone of the PHEA was used to bind bioactive molecules such as an anti-inflammatory, in the case of the production of a bioengineered skin covering system [11], or heparin in the production of scaffolds for the regeneration of blood vessels [12]. In both cases the polyester linked to PHEA has had the function of improving the mechanical properties of the scaffold and affect the rate of degradation in vitro. Fibrillar structures can be obtained also through the use of biomaterials capable of gelling "in situ" due to various stimuli. An amino derivative of hyaluronic acid functionalized with benzoyl-cysteine it is able to form a chemical hydrogel when injected in phosphate buffer thanks to staking interactions and formation of thiolic bridges by incorporating human chondrocytes [13].

This system combines the biological properties of hyaluronic acid to the self assembling properties of benzoyl-cysteine and is capable of allowing the obtainment of a fibrillar hydrogel highly similar to the native ECM that can potentially restore the articular cartilage. Despite the many advances achieved in the field of chemistry and processing of polymers in recent years, the development of new devices (both for drug delivery and for tissue engineering) remains a widely open field of study with countless scenarios opened up by the advent of new biotechnologies capable of producing innovative bioactive molecules and the progress made in the knowledge of the potential of stem cells.

In our opinion the efforts of the research groups should be targeted particularly to the development of increasingly innovative polymeric materials able to overcome the limitations of existing polymers creating in this way new devices able to interface the human tissues.

References

1. Langer R, Tirrel DA (2004) Designing materials for biology and medicine. Nature 428: 487-492.

2. Matyjaszewski K, Tsarevsky NV, Braunecker WA, Dong H, Huang J, et al. (2007) Role of Cu-0 in controlled/ “living” radical polymerization. Macromolecules 40: 7795-7806.

3. Hartmann L, Borner HG (2009) Precision polymers: monodisperse, monomer-sequence-defined segments to target future demands of polymers in medicine. Adv Mater 21: 3425-3431.

4. Pitarresi G, Fiorica C, Licciardi M, Palumbo FS, Giammona G (2013) New hyaluronic acid based brush copolymers synthesized by atom transfer radical polymerization. Carbohydr Polym 92: 1054-1063.

5. Licciardi M, Scialabba C, Cavallaro G, Sangregorio C, Fantechi E, et al. (2013) Cell Uptake Enhancement of Folate Targeted Polymer Coated Magnetic Nanoparticles. J Biomed Nanotechnol 9: 949-964.

6. Licciardi M, Cavallaro G, Di Stefano M, Pitarresi G, Fiorica C, et al. (2010) New self-assembling polyaspartylhydrazide copolymer micelles for anticancer drug delivery. Int J Pharm 396: 219-228.

7. Pitarresi G, Palumbo FS, Albanese A, Fiorica C, Picone P, et al. (2010) Self-assembled amphiphilic hyaluronic acid graft copolymers for targeted release of antitumoral drug. J Drug Target 18: 264-276.

8. CoessensV, Pintauer T, Matyjaszewski K (2001) Functional polymers by atom transfer radical polymerization. Prog Polym Sci 26: 337-377.

9. Licciardi M, Cavallaro G, Di Stefano M, Fiorica C, Giammona G (2011) Polyaspartamide-graft-polymethacrylate nanoparticles for doxorubicin delivery. Macromol Biosci 11: 445-454.

10. Sill TJ, Von Recum HA (2008) Electrospinning: applications in drug delivery and tissue engineering. Biomaterials 29: 1989-2006.

11. Pitarresi G, Fiorica C, Palumbo FS, Calascibetta F, Giammona G (2012) Polyaspartamide-polylactide electrospun scaffolds for potential topical release of Ibuprofen. J Biomed Mater Res A 100: 1565-1572.

12. Pitarresi G, Fiorica C, Palumbo FS, Rigogliuso S, Ghersi G, et al. (2013) Heparin functionalized polyaspartamide/polyester scaffold for potential blood vessel re generation. J Biomed Mater Res A: in press.

13. Palumbo FS, Pitarresi G, Fiorica C, Matricardi P, Albanese A, et al. (2012) In situ forming hydrogels of new amino hyaluronic acid/benzoyl-cysteine derivatives as potential scaffolds for cartilage regeneration. Soft Matter 8: 4918-4927.