Polymer engineering focusing on drug/gene delivery and tissue engineering: from simple towards complex architectures and hybrid materials

Bogdan C. Simionescu

Romanian Academy, Romania

Abstract: Nowadays there is a pronounced need for new materials for biomedical application, able to provide more efficient treatments and to insure minimization of the side effects, to increase patient compliance and satisfaction. Advances in polymer science – focusing on an improved control of polymer molecular weight and polydispersity, structure, properties and functionality through new synthetic approaches – have led to the development of several novel systems designed for drug/gene delivery and tissue engineering, areas with pivotal role for both research/academic community and industry, generating new niche markets. In this respect, recent years have witnessed an increased interest in the rational design of complex polymeric structures. The main objectives are related to the development of tailored polymer materials, engineered to exert distinct biological functions, implying multifunctionality as well as appropriate form/architectural features (with implication of nanotechnology), giving rise to specificity and high responsiveness.

Several types of macromolecular compounds including micelles, polymersomes, nano- and microparticles (-capsules/-spheres), molecular imprinting polymers, dendrimers, nanogels, hydrogels and interpenetrated polymer networks have been developed and tested as potential systems of interest for the envisaged applications. To gain further clinical importance the new materials (resulting in preformed or *in-situ* forming biomedical systems) must provide not only high physicochemical and biological performances but also processing ability (required by the manufacturing techniques). These demands – and especially the last one – often imply combination of natural and synthetic polymers (blends, block/graft copolymers, bioconjugates, interpenetrating networks, etc.), while improved performances may be mainly achieved by composite materials (inorganic/organic, biocomposites). The targeted application site or cargo may require specific material category (biodegradable, bioresorbable), dimension scale (micro/nano size) and topographic characteristics. Some of the existing essential obstacles and limitations may be surpassed by combining systems and approaches from apparently different application domains. Thus, controlled drug delivery and its application in tissue engineering for tissue growth support and stimulation attracted much attention over the last decade, while combination of gene therapy and tissue engineering within a single system resulting in a powerful synergism of treatment options for regenerative medicine (scaffold mediated gene therapy) seems to be the favored alternative for tissue healing. Recent results make the domain very attractive, but key issues are to be solved to develop technologies of clinical impact.

In this context, the presentation summarizes the history and challenges in the discussed domains, pointing on polymers as a possible solution to specific challenges, and outlines the current state of the art, focusing on the newest strategies to improve systems

effectiveness and responsiveness (design keys, preparative approaches). Expected future directions are underlined. After discussing the rationale for using newest advances in macromolecular chemistry, technologies and characterisation tools, as well as for the need of computer assisted design /mathematical modeling systems, some recent original results are briefly described.

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Biographical Sketch:

Bogdan C. Simionescu obtained a polymer engineering degree from the Polytechnic Institute of Iasi (1971) and the PhD degree from the Catholic University of Leuven, Belgium (1975).

Present position: Professor of polymer science (Department of Natural and Synthetic Polymers, "Gheorghe Asachi" Technical University of Iasi), and senior researcher of "Petru Poni" Institute of Macromolecular Chemistry of Romanian Academy, Iasi, Romania; director of the Centre of Excellence "Polymers" and of the Interdisciplinary Platform (education and research) "Multifunctional polymeric materials", "Gheorghe Asachi" Technical University of Iasi.

Visiting/associate professorships/visiting scientist: Ecole Nationale Superieure de Chimie de Mulhouse, Mulhouse, France (1991); Universite du Littoral, Dunkerque, France (1995); Freiburger Materialforschungszentrum, FMF, Freiburg, Germany (1996); Society of Polymer Science, Japan (1996); Centre of Polymer Chemistry, Zabrze, Poland (2001, 2005); Universite Montpellier 2, LEMP/MAO, Montpellier, France (2001); Universite d'Angers, Angers, France (2005); Universite de Rouen, Rouen, France (2007); University of Czestochowa, Czestochowa, Poland (2014).

Scientific interests: radical polymerization and copolymerization; unconventional polymerizations; combined polymer synthesis techniques; solution properties of ultrahigh molecular weight polymers; polysiloxanes and siloxane-containing block and graft copolymers; functional micro- and nanoparticles; macromolecular architectures; biomaterials

Publications/ lectures: more than 350 papers; books and book chapters; more than 100 lectures in Europe, Japan, Canada, USA.

Member of Romanian Academy (since 2000); President of the Iasi Branch of Romanian Academy (2012 – 2014); Vice-president of Romanian Academy (since 2014); member of the European Academy of Sciences and Arts (since 2007).