

# “Frontiers in Transition Metal-Containing Polymers”

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This book surveys the wide range of current research activities concerned with transition metallopolymer-based functional materials. There are thirteen chapters. The first chapter, by C. U. Pittman, Jr. and C. E. Carraher, Jr., is devoted to the early stages of research and development of metallopolymer in the 1960s and 1970s. This is followed by twelve chapters addressing different categories of transition metal-containing polymers, dendrimers and biopolymer systems with regard to their preparation, potential applications and future prospects. Some of the chapters having relevance to the platinum group metals (pgms) are highlighted in this review.

## Metal-Containing Polymeric Materials

Since the early 1990s, organometallic compounds have been at the forefront of interdisciplinary (science and engineering) research. Polymeric materials based on the bonding of metals to polymeric chains, their synthetic methodologies, their properties as well as their applications are highlighted in the second chapter, entitled ‘Recent Developments in Organometallic Polymers’, by A. S. Abd-El-Aziz and P. O. Shipman. This covers the diverse synthetic routes for the preparation of transition metal-containing macromolecules, and their chemical and physical properties. These metallopolymeric materials are classified on the basis of the bonding of the metals to the macromolecular chain: metallic moieties in the polymer backbone, pendent to the polymer backbone or in the side chains, and the orientation of the metallic counterpart in star structures, dendrimers and hyperbranched polymers. A wide range of transition metals, including platinum,

palladium, ruthenium and osmium, and other elements (such as aluminium, silicon, tin and gold) serve as the metallic component in these kinds of organometallic polymers. The unique electrical, optical, catalytic and magnetic properties of such organometallic polymers have attracted many research groups around the world, as evidenced by the more than 350 references given in this chapter.

Metal-containing block copolymers are one of the most active research areas in the metallopolymer field as a result of their properties and wealth of potential applications. Metallopolymer with precisely controlled chain length, or with block, star, or dendritic architectures, are currently attracting much attention. The third chapter, ‘Block Copolymers with Transition Metals in the Main Chain’, by D. A. Rider and I. Manners, covers a wide range of block copolymers with metallo-linkers, metal-centred star structures, and polyferrocenylsilane (PFS)-based materials. Self-assembly of PFS block copolymers with single-walled carbon nanotubes could, for example, be used in high-throughput field-effect transistors. This chapter discusses this and many other such exciting possibilities for the development of new functional nanostructured materials *via* a self-assembly approach.

Integrating metals into the conjugated framework of a polymer can influence its electronic, optical and magnetic properties. The metal may act as an *n*- or *p*-dopant to alter the polymer’s conductivity, provided that the metal and polymer are electronically coupled. The fourth chapter, ‘Metal-Containing  $\pi$ -Conjugated Polymers’, by M. J. MacLachlan, covers the broad range of zinc(II) porphyrin systems. An excellent review of metal-containing polythiophene-based polymers has been

included in this chapter, in which ruthenium, palladium, osmium, iron, cobalt, nickel, copper, zinc and gold have been incorporated as the metallic counterpart in the polythiophene system.

The fabrication of well-defined nanosized patterns composed of organics, metals and semiconductors has been one of the major challenges to chemists, physicists and material scientists alike. Such materials are showing great promise in various technological areas, such as photonics, electronics, catalysis, sensing, energy conservation and biomedical applications. Metal-containing block copolymers are a novel class of materials that have potential for wide application in nanofabrication. The fifth chapter, 'Metal Coordination Polymers for Nanofabrication', by W. K. Chan and K. W. Cheng, reviews a variety of block copolymers such as the derivatives of poly(2-vinylpyridine) and poly(4-vinylpyridine), porphyrin-containing polymers and derivatives of polynorborene. Platinum and palladium can be attached to methyltetracyclododecane (MTD) to form the complex-blocks  $[\text{Pt}]_{50}[\text{MTD}]_{113}$ ,  $[\text{Pd}]_{50}[\text{MTD}]_{113}$  and  $[\text{Pd}]_{10}[\text{MTD}]_{163}$ . Block copolymers offer an alternative approach to the fabrication of large areas of regular and ordered patterns. They are thus potentially useful in the fabrication of new-generation molecular electronic devices.

## Luminescence and Sensors

Highly branched macromolecular architecture has become a key fundamental research area. The tenth chapter, 'Metallo-dendrimers and Their Potential Utilitarian Applications', by S.-H. Hwang and G. R. Newkome, discusses such unique compounds in terms of their luminescence and sensor properties. Luminescence is an excited-state phenomenon and is used in laser, display and sensor applications. The ruthenium-based dendritic tetranuclear Ru(II) complex shows nonexponential luminescence decay with a lifetime in the range  $10^{-5}$  to  $10^{-8}$  s. Metallo-dendrimers consisting of encapsulated palladium, platinum or iridium porphyrins are used for the quantification of dissolved molecular oxygen. This chapter reviews a range of examples of the unique features of dendritic archi-

ture, and the organotransition metal complexes that have been combined in metallo-dendrimers creating the potential for practical applications.

## Other Topics

Other chapters discuss such topics as rigid-rod polymetallaynes, polymers with metal-metal bonds along their backbones, polypeptide-based metallo-biopolymers, supramolecular metal arrays on artificial metallo-DNAs and peptides, metallo-dendritic iron complexes, redox-based functionalities of multinuclear metal complex systems, and one-dimensional transition metal-containing coordination/organometallic polymers.

## Conclusions

The book covers many areas of current research in the exciting and emerging fields of organometallics, metal-polymer/dendrimer complex materials, metallo-biopolymers, and metallo-DNA and metallo-peptide supramolecular compounds. The book would interest scientists from diverse research areas associated with materials science as well as very specialised organometallic and organic chemists.

Nanotechnology offers an extremely broad range of potential applications in electronics, optical communication and biological systems. Platinum group/transition metal ions and nanoparticles with different sizes and shapes, combined with organic molecules, can give rise to host supramolecules with interesting physical properties and important potential applications. Such compounds are thoroughly discussed in this book on the basis of the techniques used for their synthesis and their properties. The challenges ahead are detailed, as are the many present and possible future applications and directions for such systems.

A prominent future for the pgms in this area is certain. The editors state that the "book aims to survey recent research at the frontiers of the subject". Their aim is achieved. The book contains 533 pages with the chapters quoting references dated typically up to 2005. It is an excellent collection of research results and measured predictions for the future.