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Introduction to "Biomedical Polymer Materials"

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Biomedical polymer materials have revolutionized medicine and healthcare through their versatile applications and significant impact on improving patient outcomes. These materials, encompassing a wide range of synthetic and natural polymers, are meticulously engineered to interact harmoniously with biological systems, making them integral to modern medical devices, disease detection, drug delivery, tissue engineering, and regenerative medicine. The development of biomedical polymers is driven by the need for materials that can perform specific functions in the body without causing adverse reactions. This themed collection on Biomedical Polymer Materials highlights advances in the synthesis of new biomedical polymer biomaterials.

Over 70% of the publications in this collection are original research studies that delve into various biomedical domains, including cancer theragnostics, arthritis treatment, antimicrobial therapy, wound healing, and implantable devices. In cancer therapy, researchers have developed a spectrum of biomedical polymers to enhance the efficacy of chemotherapy (**https://doi.org/10.1039/d4bm00003j**; **https://doi.org/10.1039/d3bm01088k**), gene therapy (**https://doi.org/10.1039/d3bm02071a**; **https://doi.org/10.1039/d3bm01629c**), immunotherapy (**https://doi.org/10.1039/d4bm00241e**; **https://doi.org/10.1039/d3bm01746j**), and boron neutron capture therapy (**https://doi.org/10.1039/d3bm01262j**). Additionally, engineered materials were also modified with contrast agents for multi-modal, precise *in vivo* cancer diagnosis (**https://doi.org/10.1039/d3bm01198d**; **https://doi.org/10.1039/d3bm01171b**). Utilizing the natural polymer hyaluronic acid (HA), NO-scavenging nanoparticles for osteoarthritis treatment were developed by modifying the side chain of HA with *o*-phenylenediamine (**https://doi.org/10.1039/d3bm01918g**).

Huayu Tian

Professor Huayu Tian is Nanqiang Distinguished Professor at Xiamen University (China). From 1994 to 2000, he completed his bachelor's and master's degrees at the Harbin Institute of Technology. In 2005, he received his PhD in Polymer Physics and Chemistry from the Changchun Institute of Applied Chemistry (Chinese Academy of Sciences), where he started his research career after his PhD. During this time, he has conducted visiting research at KAIST (South Korea), Kyushu University (Japan) and the University of Utah (USA). In 2022, he moved to Xiamen University. His research focuses on biomedical polymers, smart gene/drug delivery systems, and the development of key materials for biomanufacturing.

Xuesi Chen

Professor Xuesi Chen received his bachelor's degree in chemistry from Jilin University in 1982 and his PhD from Waseda University, Japan, in 1997. He was a postdoctoral fellow at the University of Pennsylvania, USA, from 1997 to 1999. He is currently a Professor at the Changchun Institute of Applied Chemistry (Chinese Academy of Sciences), and has been elected as an Academician of the Chinese Academy of Sciences and a Fellow of the American Institute for Medical and Biological Engineering (AIMBE). He has made outstanding achievements in the controlled synthesis, industrialization, and application of biodegradable and biomedical poly(lactic acid)s and poly(amino acid)s, propelling the rapid development of the industrialization of environment-friendly materials and medical absorbable polymer materials and devices.

Furthermore, natural proteins were altered with double bonds and zwitterions to fabricate hydrogels that resist fibrous capsule formation and degrade in a controlled manner as implantable devices (**https://doi.org/10.1039/d3bm01783d**). Beyond the post-modification of natural polymers, synthetic polymers were also tailored with various functional groups. For instance, quaternary ammonium was incorporated into the surface of hyperbranched polyurea to achieve potent antibacterial activity in diabetic wound infection models (**https://doi.org/10.1039/d3bm01519j**). Dopamine modification of polyglutamic acid was carried out to prepare hydrogels that, in conjunction with mild heat, rapidly promoted wound healing (**https://doi.org/10.1039/d3bm01978k**). Moreover, pharmaceutical excipients with high biosafety were blended from commercially available polymers in optimized ratios for non-setting periodontal dressings (**https://doi.org/10.1039/d3bm01314f**).

Beyond the aforementioned advancements and optimization of polymer materials across various fields, approximately 20% of the publications within this themed collection are dedicated to the design methodologies of biomedical polymers tailored to meet specific refined requirements. For instance, Dankers' research group explored the internalization of albumin into ureidopyrimidinone (UPy)-aggregates, discovering that these materials could be internalized in the presence of albumin without the necessity of cell membrane anchoring (**https://doi.org/10.1039/d3tb02631k**). Wu's research group developed and synthesized a multi-arm copolymer with PAMAM cores, which introduced collagenase to the material's surface, significantly enhancing tumor accumulation efficiency (**https://doi.org/10.1039/d3bm02123h**). Peppas' research group engineered a series of stimuli-responsive polymers with adjustable swelling rates and critical swelling pH by varying the ratios of non-ionizable comonomers such as acrylamide (AAm), 2-hydroxyethyl methacrylate, and *N*-isopropylacrylamide (NIPAM) (**https://doi.org/10.1039/d3bm01765f**). In addition to intravenous drug delivery, Minari's research group innovated pH-responsive oral drug delivery systems by generating poly(*N*-vinylcaprolactam) nanogels, which were then combined with Eudragit ®L100-55 (EU), thereby enhancing patient compliance (**https://doi.org/10.1039/d3bm01422c**). Furthermore, Eudragit® polymers were blended with PEG, PVP, and PVA to formulate hydrogels for *in situ* controlled drug delivery against ocular diseases (**https://doi.org/10.1039/d3tb01579c**). To expand biomaterial-based therapeutic applications, Tirella's research group successfully developed intracerebral haemorrhage disease models using natural polymers such as alginate and hyaluronic acid (**https://doi.org/10.1039/d4bm00039k**).

In addition to the primary research papers, review articles constitute approximately 25% of the publications within this themed collection. These reviews encompass a broad spectrum of studies, including functional polymers for chemotherapeutic (**https://doi.org/10.1039/d3tb01700a**) and nucleic acid delivery (**https://doi.org/10.1039/d3bm01394d**), biomimetic polymer functionalization for the targeted delivery of therapeutics in acute kidney injury (**https://doi.org/10.1039/d3bm01772a**) and renal-clearable diagnostics (**https://doi.org/10.1039/d3bm01776a**), nanomaterials for bacteria-related tumor therapy (**https://doi.org/10.1039/d3bm01952g**), dendrimer architectures designed to improve blood–brain barrier penetration efficiency (**https://doi.org/10.1039/d4bm00043a**), biomaterials in the treatment of intracerebral hemorrhage (**https://doi.org/10.1039/D4BM00630E**), and the development of hybrid materials for tissue regeneration (**https://doi.org/10.1039/d3bm01766d**). These thorough reviews provide a comprehensive understanding and overview of targeted application of biomedical polymer materials across diverse medical fields. Of note, there remains significant potential for further expansion, precise design, and optimization of these materials to enhance their utility and effectiveness in healthcare applications.

In conclusion, biomedical polymer materials have substantially propelled medical science forward, enhancing diagnostics, therapies, and patient care. This themed collection aims to aid scientists and clinicians in comprehending the extensive applications of existing biomaterials and recognizing areas for improvement. Future research should prioritize the refinement of these materials to achieve greater specificity, efficacy, and biocompatibility, thereby promising significant advancements in personalized medicine and healthcare technologies.