Gels Horizons: From Science to Smart Materials

Series editor

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This series aims at providing a comprehensive collection of works on the recent advances and developments in the domain of *Gels*, particularly as applied to the various research fields of sciences and engineering disciplines. It covers a broad range of topics related to *Gels* ranging from *Polymer Gels, Protein Gels, Self-Healing Gels, Colloidal Gels, Composites/Nanocomposites Gels, Organogels, Aerogels, Metallogels* & *Hydrogels* to *Micro/Nano gels*. The series provides timely and detailed information on advanced synthesis methods, characterization and their application in a broad range of interrelated fields such as chemistry, physics, polymer science & engineering, biomedical & biochemical engineering, chemical engineering, molecular biology, mechanical engineering and materials science & engineering.

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Editors

Polymer Gels

Synthesis and Characterization

Springer

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Preface

A gel is described as a soft, solid, or liquid-like unique condensed material that has a three-dimensional network composed of several components such as long polymers, species of small molecules, and a large amount of solvent. These 3D network condensed materials usually form through chemical, physical, or supramolecular crosslinking. The weight and size of gels are more like a liquid, but they are treated like a solid. Two important characteristics of gels are phase state and their rheological properties. On the other hand, a polymer is defined as a large molecule (macromolecules) composed of repeating structural units that comprise of multiple assemblies of simple structural units. In gels, the polymer network can be physically or chemically crosslinked. In case of physical gels, the network formation occurs due to various weak interactions, like the entanglement of the polymer chains, hydrogen bonds, or van der Waals interactions. Such structures are usually not permanent, and they dissolve over the time when immersed in their solvents. However, the polymer chains can also be crosslinked through chemical reactions, leading to strong covalent bonds. The chemically crosslinked network is much more stable and cannot be dissolved without the degradation of the polymer. Therefore, chemical gels are usually preferable in the majority of the application fields. Polymer gels comprise a great variety of different polymeric components that present innumerable industrial applications. Polymers can be naturally produced (sometimes referred as bio-based polymers), in which case the most representative group is polysaccharides. Natural polymers' demand is expected to grow 7.1% every year. Moreover, their low toxicity and excellent biodegradability have also attracted researchers to pay attention toward the widespread application of natural polymers. Polymer obtained from natural sources such as chitosan, alginate, dextran, starch, pectin, cellulose, lignin has shown excellent potential for biomedical and other applications in the form of microsphere, nanoparticles, crosslinked hydrogels, beads, membranes, and granules. On the other hand, a wide variety of synthetic polymers capable of forming gels presents different industrial applications, such as polyacrylamide and polyvinyl alcohol-based gels. Both synthetic and natural polymer-based gels find applications from health sciences such as agents for

controlled drug delivery, sustained drug delivery, targeted drug delivery, and various other types of novel drug delivery systems to water purification.

Polymer gels due to their several unique characteristics have become an indispensable part of new advanced and smart materials in the twenty-first century for numerous applications including but not limited to biological, biomedical, electronic, and environmental. Keeping in mind the immense advantages of polymer gel-based materials, *Polymer Gels: Synthesis and Characterization* provides a cutting-edge resource for researchers and scientists in different fields of science and technology as well as for specialists in polymers, biomaterials, bio-nanotechnology, and functional materials. It provides a comprehensive collection of works on the recent advances and developments in science and fundamentals of both synthetic and natural polymer-based gels particularly as applied to the various research fields of sciences and engineering disciplines. Some of the important topics include but not limited to structure and physico-mechanical properties of physically crosslinked polymer gels; polymer gels: molecular design and properties; clinical use and hemostatic application of gelatin; polysaccharide-based polymer gels: synthesis, characterization, and properties; modified polysaccharide gels: characterization and pharmaceutical applications; silica-based polymeric gels as platforms for delivery of pharmaceutics; polymeric nanogel: a flexible nanocarrier for drug delivery; gel-based approaches in genomic and proteomic sciences; polymer gels in vaginal drug delivery systems: synthesis and properties; gel formation through non-covalent crosslinking from amylose formed by enzymatic polymerization; new aspects to physicochemical properties of polymer gels in particularly the coordination biopolymeric metal–alginate; smart polymer gels; neuro-evolutive techniques applied for modeling processes involving polymer gels to name a few.

In editing and organizing this volume *Polymer Gels: Synthesis and Characterization* of the book series *Gels Horizons: From Science to Smart Materials*, we have made our best efforts to cover the growing field of polymer gels and related technologies. It reflects the recent theoretical advances and experimental results and opens new avenues for researchers as well as readers working in the field of polymer and functional materials. In addition, several critical issues and suggestions for future work are comprehensively discussed in this book with the hope that the book will provide a deep insight into the state of the art of "Polymer Gels." We express our sincere thanks to all the authors, who have contributed their extensive experience through their work for the success of this book. We would also like to thank Swati Meherishi and the rest of the team at Springer for invaluable help in the organisation of the editing process.

Cranfield, UK — Vijay Kumar Thakur, Ph.D.
Shimla, India — Manju Kumari Thakur, M.Sc., M.Phil., Ph.D.

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Dr. Vijay Kumar Thakur, Ph.D. prior to commencing in the School of Aerospace, Transport and Manufacturing at Cranfield University, he was working as a Staff Scientist in the School of Mechanical and Materials Engineering at Washington State University, USA (2013–2016). Some of his other prior significant appointments include being a Research Scientist in Temasek Laboratories at Nanyang Technological University, Singapore (2009–2012), and a Visiting Research Fellow in the Department of Chemical and Materials Engineering at LHU, Taiwan. He did his postdoctoral study in Materials Science and Engineering at Iowa State University and received his Ph.D. in Polymer Chemistry (2009).

In his academic career, he has published more than 100 SCI journal research articles in the field of chemical sciences/materials science and holds one US patent. He has also published 33 books and 35 chapters on the advanced state of the art of polymer science/materials science/nanotechnology with numerous publishers. His research interests include the synthesis and processing of bio-based polymers, composites, nanostructured materials, hydrogels, polymer micro-/nanocomposites, nanoelectronic materials, novel high dielectric constant materials, engineering nanomaterials, electrochromic materials, green synthesis of nanomaterials, and surface functionalization of polymers/nanomaterials. Application aspects range from automotive to aerospace, energy storage, water purification, and biomedical fields.

He is an editorial board member of several international journals, as well as a member of scientific bodies around the globe. Some of his significant appointments include Associate Editor for *Materials Express* (SCI), Advisory Editor for *SpringerPlus* (SCI), Editor for *Energies* (SCI), Editor for *Cogent Chemistry* (SCI), Associate Editor for *Current Smart Materials*, Associate Editor for *Current Applied Polymer Science*, Regional Editor for *Recent Patents on Materials Science* (Scopus), and Regional Editor for *Current Biochemical Engineering* (CAS). He also serves on the Editorial Advisory Board of *Polymers for Advanced Technologies* (SCI) and is on the Editorial Board of *Journal of Macromolecular Science, Part A: Pure and Applied Chemistry* (SCI), *International Journal of Industrial Chemistry* (SCI), *Biointerface Research in Applied Chemistry* (SCI), and *Advances in Natural Sciences: Nanoscience and Nanotechnology* (SCI).
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