

Preface

In recent years sol-gel technology has become a hotbed for state-of-the-art developments in many diverse fields due to the accessibility of advanced materials with ‘tailor-made’ functionalities through inexpensive and environmentally viable processing routes. The focus of this book is on the use of such technologies and the resultant materials for applications in the energy, environmental and electronic sectors specifically providing a unique perspective. The current book comprises a broad scope encompassing basic knowledge, as well as high-level research advancements with the potential for commercialization and industrial use. Taking an integrated approach, a wide range of topics are covered, from electronic materials, photocatalysts, sensors and optics, to aerogels and materials for energy storage and conversion, consequently showcasing the combined use of chemistry, physics, materials science and engineering in the search for solutions to some of the most challenging issues of our time.

One of the reasons for the continued advancement of sol-gel technology is the ease of control of the nanoarchitecture of the resultant materials and the plethora of different material constructs which can be developed. The opening chapter focuses on introducing the core activities involved in sol-gel processing including the formation, ageing and drying of wet gels, with a particular focus on preparation of aerogels.

An important application of sol-gel processing in the area of electronics is outlined in Chap. 2, which presents an exploration of the full potential of this technology with regard to the preparation of high-performance varistors. Sol-gel methods can be easily integrated with any varistor processing method and examples of this and the advantages accrued are discussed. A detailed literature survey on the preparation, properties and advantages of sol-gel derived ZnO varistors is included along with recent work on the numerous sol-gel ceramic-polymer varistors.

Sol-gel technology has now reached a mature stage in the field of coatings for optics and photonics. Recent achievements in sol-gel derived functional optical coatings, specifically those dealing with reflection and anti-reflective phenomena such as photonic crystals and anti-reflective coatings are discussed in Chap. 3. Additionally, chemical strategies to modify the optical properties of sol-gel coatings

are described together with a critical analysis of various liquid deposition techniques.

Chapter 4 evaluates the role of sol-gel modified unicellular microalgae, diatoms, in numerous environmental applications such as catalysis, separation science, filtration and emerging nanotechnologies. Much of the work presented in this chapter highlights the influence and importance of diatom species on the properties of sol-gel coated diatoms or diatom replicas.

The development of a diverse range of chemical sensors derived from sol-gel processing technology for a large range of applications, including determination of gases, forensic analysis and biosensing are reported in Chap. 5. The adaptability of the sol-gel process for the tailoring of material properties is key to the development of such a variety of sensors. The chapter also includes a discussion on the use of sol-gel films in sensor configuration to allow more flexibility.

In recent years, cathode materials prepared through sol-gel processing have exhibited improved electrochemical performance in rechargeable Li-ion batteries. Furthermore, some of the major drawbacks of current generation Li-ion battery cathodes have been efficiently alleviated by sol-gel technology processes. Chapter 6 outlines the synthesis, preparation and processing of these cathode materials in addition to some relevant modification procedures.

Sol-gel technology for the environmental-based application of developing an alternative to chromium-based corrosion control materials is the focus of Chap. 7. As well as the principles underlying the chemistry of the materials investigated, recent advances in the trends for preparing such corrosion protection systems are also presented. A number of strategies including sol-gel film design, introduction of nanoparticles, application of organic polymers and application of corrosion inhibitors are explored.

Due to its high specific surface area, excellent electrical and mechanical properties along with very good chemical stability, graphene is an ideal candidate for next generation energy devices. Chapter 8 gives an overview of the recent research on graphene incorporated sol-gel materials for energy conversion and storage applications including supercapacitors, solar cells, Li-ion batteries and fuel cells.

Chapter 9 details the preparation and applications of nanocrystalline titanium dioxide (TiO_2) via sol-gel processing. The various crystal forms of TiO_2 are presented and their application as photocatalysts is discussed.

In the final chapter, an overview of lanthanum phosphate (LaPO_4) derived from sol-gel processes is given. Properties such as hydrophobicity, metallophobicity, low thermal conductivity and machinability make LaPO_4 an ideal material for use in coating applications. A detailed case study of LaPO_4 nanocoating preparation and characterization is also included in this chapter.

The obvious strength of the sol-gel method lies in its inherent adaptability and flexibility while maintaining the integrity and consistency of the materials produced. The versatility of the method, as shown throughout this book, lies in the ease of integration of sol-gel technologies with other forms of processing, allowing multidisciplinary approaches to occur with very little effort. The application of sol-gel technologies to some of the work discussed is still at a relatively early stage

of development and as such some authors highlight possible limitations to the commercialization of such methods in their respective fields. However, they also suggest strategies to overcome these perceived limitations in the future, thus allowing full commercialization and the benefits of such advancements to be felt by society at large.

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