SMART COATINGS

FUNDAMENTALS, DEVELOPMENTS, AND APPLICATIONS

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This book focuses on fundamentals, technology, synthesis, and characterizations and applied techniques from a practical point of view of coatings. The first three chapters offer a rigorous review of the application of these coatings to corrosion protection in various aerospace and oil and gas industries, and the subsequent chapters present a quick critical review of the state-of-the-art protection techniques of these coatings to novel biomedical applications such as clinical translations and tissue-engineered materials. Environmental, ergonomics, and aesthetic aspects and future perspectives are also explained at the end.

Features:

• Explores the synthesis and application techniques of novel smart coatings in various research areas
• Presents a concise, critical, and state-of-the-art review of existing research on various types of smart coatings
• Ascertains the different mechanisms associated with the stimuli response of smart coatings
• Includes an exclusive chapter on real-time applications in the biomedical field
• Covers self-healing, self-cleaning, pH balance, early corrosion detection, and triggering mechanisms

This book is aimed at researchers and graduate students specifically in smart coatings and thin films and corrosion, including chemical, materials science engineering, industrial and manufacturing engineering, and nanotechnology.
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Preface

“What is the greatest gift to human society in the 21st century?” Of course, the “Materials”. The word “Materials” serves diverse choices of constituents ranging from engineering materials such as wood (naturally occurring composite) and conventional steel to functional nanomaterials (or thin films) in micro-electro-mechanical systems (MEMS) and nano-electro-mechanical systems (NEMS) devices. However, one common question to pose at this juncture is: With ever increase in miniaturization and automation, do these materials have the potential to solve the great and pressing problems of society? And if the answer to the above question is “Yes”, is it possible to make them auto-responsive when the need arises? The surface functionalization of materials via “Smart Coatings” is the answer to the latter one. These smart coatings auto-respond to the changes occurring around the surrounding environment (in both automatic and external triggering modes) and prevent external damage to the underlying material. For instance, stimuli-responsive smart coatings can detect the corrosion events occurring in metals at their early stages and take the preventing measure. Owing to their excellent self-healing, self-cleaning, and sensing characteristics, these smart coatings find a unique niche in widespread surface functionalization applications, thus a topic of systematic and considerable research.

Although these smart coatings have been researched for the past 3–4 decades, their practical applications on the commercial scales are still far from industrial acceptance. When Dr. Deshpande put forth this idea of writing a book on “Smart Coatings”, the immediate thought that came to my mind was the applicability and advances in these coatings for the diverse range of applications. Keeping this in view, we are pleased to present the book *Smart Coatings: Fundamentals, Developments, and Applications* to the materials science and coatings community. While reviewing the articles for this book, we have noticed that more emphasis was given on the synthesis and applying techniques previously, and advancement in the field with the current issues is seldom reported. In view of this, the present book provides significant insights about the current issues, various advancements and diverse range of applications in particular, and synthesis and applying (deposition) techniques in general.

The organization of chapters and their subsequent contents is made so that it will provide a comprehensive review of the applications of smart coatings in various sectors starting from fundamentals to recent advancements in the field. For instance, each chapter of the present book begins with a general introduction followed by a strong motivation that helps the scientist, researchers (research scholars also), and academician to understand the importance and depth of the subject from various applications’ viewpoints, while the current issues/challenges and future perspectives based on the authors’ own views are outlined in the last part of the chapters. The purpose of including challenges and future scope is to guide the research community about the current hurdles faced during the applications
of these coatings in various sectors such as automobile, marine, defence, biomedical (i.e., medical implants), and clinical translations. This also pinpoints some important open questions in the field that can be addressed in future and open up new pathways to tailor the multifunctionality in these coatings. Towards this end, the authors have profoundly reviewed the articles till June 2021.

The first chapter provides a general overview of the coatings, their historical developments, and recent advancements from various applications’ viewpoints. The current issues in the present coatings technologies are outlined, thus paving a motivation for stimuli-responsive smart coatings. Different stimuli-response mechanisms are highlighted in the middle, followed by recent advancements. Following this, the second chapter presents a brief overview of the electrochemical aspects of corrosion in metals (and alloys) in general and its prevention strategies via surface functionalization in particular. A complex mathematical treatment related to the kinetics of corrosion is avoided. Rather more emphasis is given to corrosion prevention by smart coatings. Chapter 3 of this book addresses the applicability of these coatings in the automobile, aerospace, and defence sectors. This chapter starts with the advancements in conventional materials and respective surface preparation strategies. Water-soluble and UV-curable smart coatings with their multifunctional characteristics and related triggering mechanisms are highlighted in the middle. Finally, optimization of process parameters by synthesis and applying techniques of these coatings for the mentioned applications is outlined. Subsequently, Chapter 4 connects the real-time applications in biomedical fields to various triggering mechanisms offered by these coatings. The shape memory alloys/polymers and nanobioceramic smart coatings for bio-implant applications are briefly outlined on this front. Following this, Chapter 5 provides significant insights into challenges related to applying these coatings in clinical translations. Towards this end, the release mechanisms such as active triggering and triggered release are outlined with current challenges and future perspectives. Chapter 6 highlights the synthesis, applying techniques, and triggering mechanisms related to smart switchable coatings from a marine and medical applications viewpoint. The surface functionalization via switchable smart coatings is of paramount importance in water/oil repellent applications in marine industries and controlled drug delivery at therapeutic sites in medical sectors. Such unique aspects of smart coatings are explored in Chapter 6. Finally, Chapter 7 gives closure and sheds light on the environmental aspects, followed by a general discussion on the challenges related to the enhancement in multifunctionality of smart coatings. All the chapters are organized concisely, and the attempts are made to provide succinct information about every aspect.

We believe that the present book would be helpful to the scientists, researchers (research scholars), and academicians from diverse research backgrounds such as biomedical science, civil and structural engineering, mining and marine engineering, metallurgy engineering and materials science, mechanical engineering, and nanoscience and nanotechnology. Note that the explanations and expressions in this book are the author’s views based on expertise in the field. However, readers are also encouraged to have a detailed look (if they want) at the cited