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Engineering of Thermoplastic Elastomer with Graphene and Other Anisotropic Nanofillers

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Foreword

My whole career has been dedicated to pursuing the development of various types of functional nanoparticles and their nanoscale dispersion across multiple polymer matrices, from engineering to bio-based polymers. So, the content of this book is very close to my expertise.

The group, leading by Prof. Abhijit Bandyopadhyay, is well known to me through their high-quality work on processing and development of new generation engineering thermoplastic elastomers. Over the years, this group used various types of advanced nanofillers to modify the inherent properties of different types of elastomers using polymer nanocomposite technology.

Over the last few years, nanocarbons and related nanoparticles are becoming emerging fillers for the development of next-generation engineering polymer materials for a wide range of applications, from construction to biomedical. Therefore, this book has immediate relevance, interest, and importance owing to the trend in the plastic industry.

In this book, the authors tried to cover various characteristics of nanofillers and several types of processing techniques to disperse them in thermoplastic elastomers. The key to manufacturing a useful engineering thermoplastic elastomer nanocomposite for practical applications is to achieve the desired degree of dispersion of filler particles in a polymer matrix and tune the obtained composite properties as per the product requirement. I am thrilled to say that the authors very meticulously cover this aspect in this book.

Based on my knowledge in this field and going through the content of this book, I must say that this is an ideal book for postgraduate students, researchers, and polymer processing technologists who are interested in engineering thermoplastic

elastomers in general. I also believe this book will be beneficial for industry-based scientists and engineering, including product development managers who want to bring advanced elastomer-based products in the market.

Congratulations and all the best!

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Preface

Rubber is a unique class of polymer pact with some uncanny properties like high shock absorption, compressibility resistance, resilience, recoverable deformability along with low modulus and strength. High molecular weight, high chain entanglement density, and extremely low cohesive force of attraction among the segments are the keys to form a rubber, which during processing is mixed with several other ingredients (at least 10–12) to achieve the strange combination of properties. Vulcanization or chemical crosslinking (either sulphur- or non-sulphur-based) between the molecules of a rubber is thought to be the key that confers the true rubberiness, and once that is achieved, the rubber becomes a thermoset. However, in an era of sustainable development, a thermosetting polymer with zero recyclability and complex formulation is not a preferred choice indeed. The world is obsessed for polymers with "zero waste" technology—conventional rubber, being unfit to that, makes a way for the relatively new thermoplastic elastomers or TPE which by virtue of its inimitable molecular design has got the immense potential to replace conventional rubbers in many of its applications. Believing to that, the world has seen a steep rise in consumption of TPE of late and is also predicted to hold an even stronger ground in future. The exclusive molecular design of tri- or di-blocking of homopolymers developed though special living anionic polymerization imparts the essence of both thermoplastic and elastomeric properties combining both melt recyclability and recoverable elongation once the stress is lifted. TPE, representing a unique combination of hard and soft polymer segments alluring with high and low T_g s, respectively, inherits high cohesive strength, thus could avoid nearly all additional ingredients unlike rubbers, and emerges as an ideal "zero waste" future elastomer material. The good part is this elastomer could be tailor-made as and when, driven by the application demand.

Of late, the world has seen the development of many new TPEs with different monomers, block length, etc., befitting new as well as conventional applications. Alongside, nanotechnology has emerged as a promising new material technology for serving the human kind. Both isotropic and anisotropic nanomaterials have shown remarkable properties that could revolutionize the material world with advanced applications in optical, optoelectrical, and other relevant fields. The first

revolutionary work on polymer nanotechnology was reported by the Toyota Research Group in Japan nearly 30 years back, and since then different nanomaterials have been explored in a variety of thermoplastics and elastomers and yielded some good to exciting results in many of the cases. However, on critical review, anisotropic nanomaterials were found more effective on thermoplastics than on elastomers largely due to the inherent viscoelasticity and presence of huge number of ingredients in the latter. TPE, on the other hand, has been able to derive greater benefit of the anisotropic nanomaterials and, thus of late, has been considered as a better matrix than the conventional elastomer for exploration. The combination of TPE and anisotropic nanomaterials like clay, carbon materials, and graphene has yielded many exciting properties, befitting conventional as well as advanced applications. Acknowledging the progress of this important hybrid material technology for the past seven to ten years, an attempt has been made to tot up important outcomes, and analyse and predict the future applications. We believe this book would serve as an important document for the readers for awareness and knowledge enhancement.

Kolkata, India

Abhijit Bandyopadhyay
Poulomi Dasgupta
Sayan Basak

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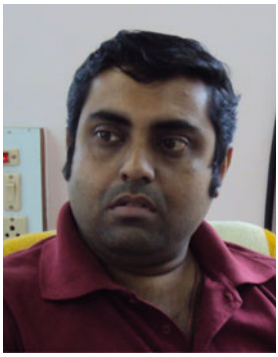

Dr. Abhijit Bandyopadhyay is presently working as Full Professor in the Department of Polymer Science and Technology, University of Calcutta, along with as Technical Director in South Asia Rubber and Polymers Park (SARPOL), West Bengal. He did his B.Sc. (Chem. Hons.) from the University of Calcutta securing first class in the year 1997 followed by B.Tech. and M.Tech. in polymer science and technology from the University of Calcutta in the years 2000 and 2002, respectively, with first class, and subsequently completed Ph.D. in the year 2005 in polymer nanocomposites from Rubber Technology Centre, IIT Kharagpur. Before joining the University of Calcutta in November 2008, he worked as Assistant Professor in Rubber Technology Centre, IIT Kharagpur, during 2007–2008. He has published 90 papers in high-impact international journals and 3 books and has filed two Indian patents so far. He has successfully handled many funded research projects and did consultancies for renowned companies like Exide Industries Ltd., Phillips Carbon Black Ltd., etc. He is Fellow of the International Congress for Environmental Research (since 2010), Associate Member of Indian Institute of Chemical Engineers and Life Member of Society for Polymer Science, Kolkata Chapter, and Indian Rubber Institute, respectively. He is Editorial Board Member of two international journals. He has more than 12 years of teaching and research experience. He has been awarded Young Scientist Award by Materials Research Society of India, Kolkata Chapter, in 2005 and Career Award for Young Teachers by All India Council for Technical Education,

Government of India, in 2010. His research areas include polymer nanocomposites, reactive blending, adhesion, polymer hydrogel in drug delivery, waste polymer composites, green polymer composites, and hyperbranched polymers. He has successfully supervised 11 research students for their doctorate degree so far, and 4 more are presently working under him.

Ms. Poulomi Dasgupta completed her graduation with Chemistry (Hons.) from Vidyasagar College, Kolkata, in 2013. She subsequently received her B.Tech. (2016) and M.Tech. (2019) degrees at the Department of Polymer Science and Technology at the University of Calcutta. She was awarded gold medal from the University of Calcutta (during B.Tech.). She was a recipient of GATE fellowship, AICTE, Government of India, during M.Tech. Prior to joining M.Tech., she worked with Indag Rubber, Himachal Pradesh, as R&D Executive. Currently, she is associated with TCG Lifesciences (Chembiotek Research International) as Research Chemist. Her area of research was based on "development of thermo-responsive self-healable elastomeric compound and its characterization".

Mr. Sayan Basak has completed his B.Tech. from the Department of Polymer Science and Technology, University of Calcutta, India (2015–2019), and is currently pursuing his Ph.D. from the School of Polymer Science and Engineering, University of Akron, USA (2019–2024). His undergraduate research interest, along with his present research domain, revolves working with thermoplastic elastomers and multi-component polymer systems, thereby prospecting into new materials to develop smart polymer materials for new-age applications. Apart from being a budding technologist, he loves to spend his time creating content, which is supported by the Society of Plastic Engineers, The Times of India, and Medium on sustainability, recyclability, and green chemistry.

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