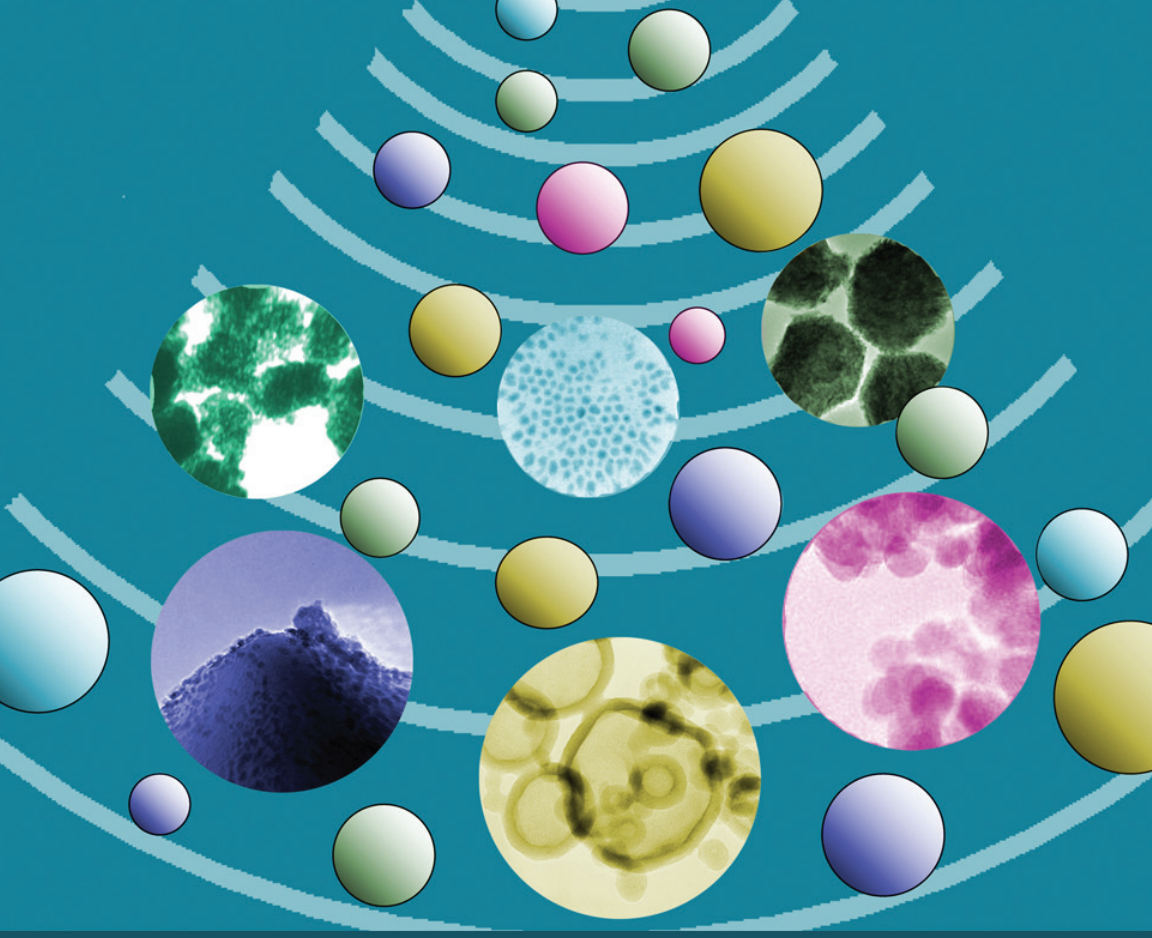

Cavitation

A Novel Energy-Efficient Technique for the Generation of Nanomaterials

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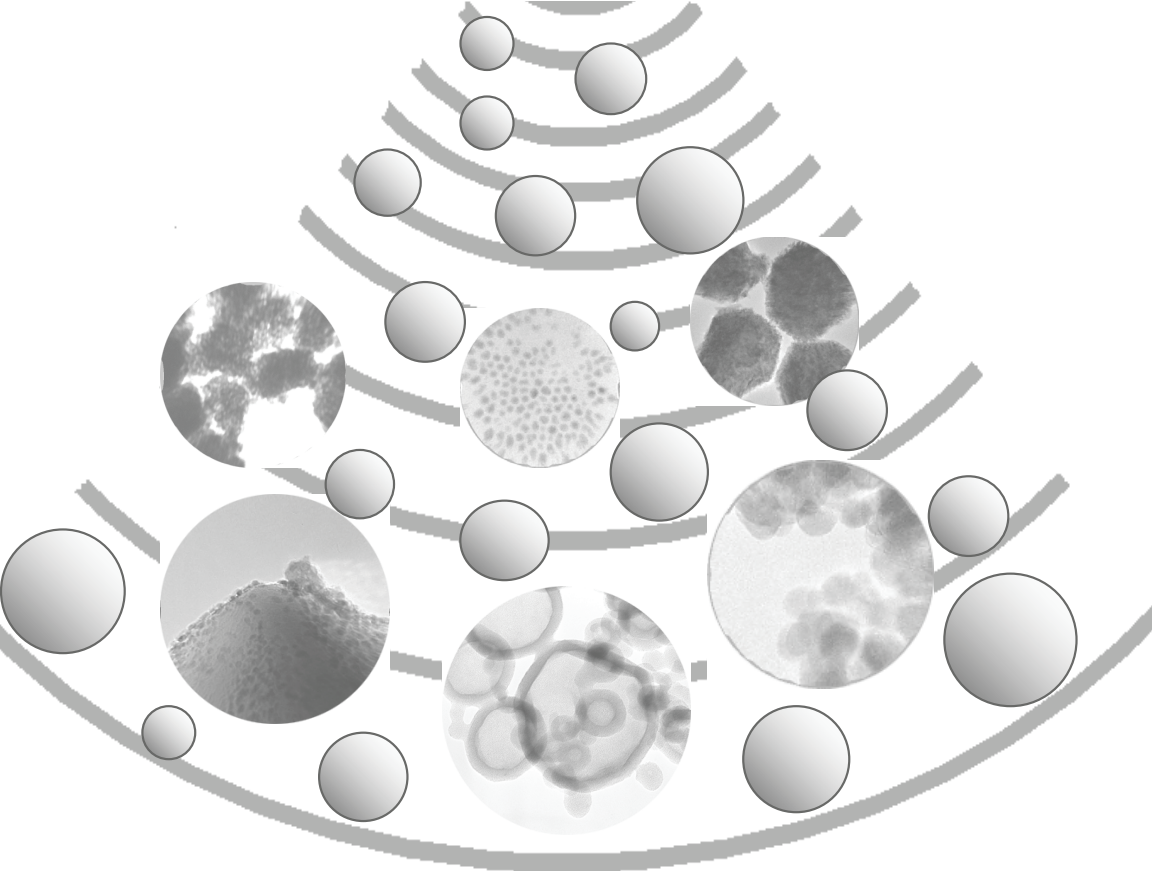
Sivakumar Manickam
Muthupandian Ashokkumar



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Pan Stanford Publishing

Published by

Pan Stanford Publishing Pte. Ltd.
Penthouse Level, Suntec Tower 3
8 Temasek Boulevard
Singapore 038988

Email: editorial@panstanford.com
Web: www.panstanford.com

British Library Cataloguing-in-Publication Data
A catalogue record for this book is available from the British Library.

Cavitation: A Novel Energy-Efficient Technique for the Generation of Nanomaterials

ISBN 978-981-4411-54-7 (Hardcover)
ISBN 978-981-4411-55-4 (eBook)

Printed in the USA

Contents

Foreword

It was an honor to be asked to provide the foreword for this book, and it is with great pleasure that I do so. *Cavitation: A Novel Energy-Efficient Technique for the Generation of Nanomaterials* is a timely survey of a field that is mature in parts but with new, ever more complex applications emerging at a consistent rate. It is edited by two colleagues, Professors Manickam and Ashokkumar, who have made their own seminal contributions but also collaborated with a wide range of others in pushing forward the field of "sonochemical materials science".

There is a constant demand for developing novel technologies to synthesize multifunctional materials and, perhaps more importantly, control their properties. Having used ultrasound in the synthesis of functional polymers and materials for the past 25 years or so, I have always appreciated the extreme, but useful reaction conditions generated by acoustic cavitation but it has been interesting to watch the many clever and inventive ways that have surfaced for producing a huge range of materials. Over recent years, sonochemistry has shown significant growth in a variety of fields, but none more so than in the preparation of functional bio- and inorganic materials covering length scales from the *nano-* to the *micro-*. Many of these are described in this book along with emerging methods that combine with great effect cavitation with other methods such as electrochemistry, photochemistry, or microwaves. In parallel, cavitation generated by hydrodynamic forces has also been shown to be useful.

The book contains chapters from a number of leaders in the field of application of cavitation to nanomaterial synthesis. These chapters will serve as an excellent introduction for those new to the area and a welcome review of applications for those more familiar with sonochemistry. It has something for everyone and will not only be beneficial to sonochemists and materials scientists, but also to many interdisciplinary scientists. It represents an excellent addition to the literature.

Gareth J. Price
Professor of Chemistry
University of Bath, UK

Preface

Nanomaterials and their end products have started occupying the pinnacle position of consumer markets. At this juncture it becomes vital to consider the processing means through which naomaterials are generated. Especially, energy efficacy is the foremost concern while dealing with the processing of nanomaterials regardless of the scale of operation. Conventionally a gamut of top-down and bottom-up techniques are explored to obtain these nanomaterials. One of the green chemistry principles underlines the need for unusual energy sources to generate nanomaterials. Utilizing the energy from the collapse of cavitation bubbles, generated either by ultrasound or hydrodynamic forces, for the generation of nanomaterials is a merit to consider in this "green chemical processing era".

The past decade has witnessed the development of a wide range of nanomaterials using cavitation. A step forward is the coupling of cavitation with other techniques such as microwave, photochemistry, and electrochemistry, which have seen innumerous advantages in the generation of nanomaterials. In many instances, nanomaterials are attained with unique morphologies, a reduction in size, and narrow size distribution. While a few currently available books deal with the fundamental aspects of cavitation and sonochemistry, there is no book devoted specifically to the technologically important nanomaterials obtained by cavitation. This stimulus made us think about it, and we ended up editing this book. The chapters have been contributed by leading researchers working on utilizing cavitation for the generation of nanomaterials. This book will be most useful to those who explore cavitation for the facile synthesis of diverse nanomaterials. Some fundamental aspects of cavitation have been discussed only to a certain extent, as the core theme of this book is to understand the nanomaterials generated by cavitation.

In Chapter 1, Prof. Manickam, Dr. Tang, and Prof. Ashokkumar have discussed newly emerging multifunctional nanomaterials and the preparative strategies using ultrasound, where a clear evidence for the proper selection of ultrasonic parameters for the formation of nanomaterials has been revealed. Dr. Okitsu in Chapter 2 has

reviewed the role of sonochemical method in the synthesis of metal nanoparticles with precise control in size, shape, and structure. Dr. Anandan and Prof. Ashokkumar have focused in Chapter 3 on the ultrasonic synthesis of monometallic and bimetallic nanostructured materials with unique properties as well with their applications. Prof. Yu and coworkers have examined the recent advances in nanostructured metal oxides obtained using sonochemistry and ultrasonic spray pyrolysis methods in Chapter 4.

In Chapter 5, Prof. Pandit and coworkers have analyzed synthesizing nanomaterials using an alternative form of cavitation, that is, hydrodynamic cavitation. In this chapter, it is clearly shown that the control of the size of nanomaterials is possible using experimental parameters such as pump discharge pressure, liquid flow rate, and the design of the orifice plate employed. Moreover, they have shown the importance of this technique for obtaining hard, brittle, rubbery, and highly crystalline materials. Prof. Pollet and colleagues (Chapter 6) have discussed the concept of fabricating nanomaterials by combining power ultrasound and electrochemistry. More importantly, they have investigated the generation of intriguing nanostructures using this unique and combined methodology. Prof. Cravotto and Dr. Boffa (Chapter 7) have shed light on another hybrid technique, namely, a combination of ultrasound and microwaves and discussed the synergistic effects in the preparation of various nanomaterials.

Dr. Francesca's group (Chapter 8) has looked into the application of ultrasound technique in synthesizing and functionalizing micro-nanopolymeric materials for the microencapsulation of various bioactive agents. Prof. Gedanken and coworkers (Chapter 9) have discussed the principles behind the sonochemical process in embedding the nanoparticles onto textiles and discussed the advantages of this method compared with other coating techniques. Dr. Sonawane and coworkers (Chapter 10) discussed the generation of nanocomposites assisted by ultrasound via in situ emulsion polymerization. Dr. Ekaterina and Dr. Shchukin (Chapter 11) have provided the conceptual solutions for the controlled sonochemical fabrication of mesoporous surfaces and metal sponges. Following this, Dr. Yasui and Dr. Kato (Chapter 12) have provided a detailed discussion on the numerical simulations of nucleation and aggregation of $BaTiO_3$ crystals under ultrasound conditions. Finally, Prof. Ashokkumar and Prof. Manickam (Chapter 13) have discussed

the issues on the development of large-scale ultrasound reactors besides future perspectives.

We sincerely thank all the contributors of the chapters as well the reviewers for their excellent contributions towards the successful completion of this book. We trust that this book will be extremely beneficial to researchers involved in the exploitation of cavitation for the generation of nanomaterials for different technological applications.

Sivakumar Manickam
Muthupandian Ashokkumar
Summer 2014