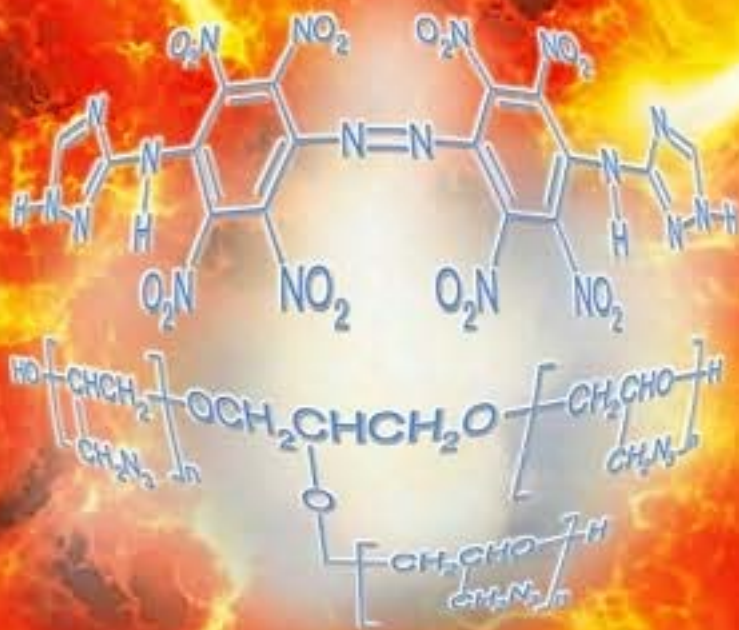


Jai Prakash Agrawal

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*Jai Prakash Agrawal*

**High Energy Materials**

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*This book is dedicated to my revered spiritual teacher  
His Holiness Sri Sri Ravi Shankar  
Founder, Art of Living and  
The International Association for Human Values*

## Foreword

There are several books dealing with explosives, propellants and pyrotechnics, but much of the latest information on High Energy Materials (HEMs) of recent origin is scattered in the literature as research/review papers. This book is the first of its kind in which the knowledge on materials hitherto accumulated over the past 50 years in the literature has been carefully blended with latest developments in advanced materials, and articulated to highlight their potential from the point of view of end-use.

This book contains six chapters. While chapter one of this book introduces the subject in terms of salient/fundamental features of explosives, additional requirements for military explosives and their applications (military, commercial, space, nuclear & others), chapter 2 highlights the status of current and futuristic explosives in the light of their special characteristics. In addition, the future scope of research in this field has also been brought into focus in this chapter.

Chapter 3 essentially covers the important aspects of processing & assessment of explosives & their formulations. The propellants which are extensively used for various military & space applications are described in chapter 4. The major portion of this chapter is devoted to different aspects of high performance & eco-friendly oxidizers (ADN & HNF), novel binders such as butacene, ISRO Polyol and other state-of-the-art energetic binders [GAP, NHTPB; poly (NiMMO), poly (GlyN), etc.], energetic plasticizers (BDNPA/F, Bu-NENA, K-10, etc.) along with other ingredients which are likely to play a crucial role in augmenting the performance of futuristic propellants for various missions. The inhibition of rocket propellants & insulation of rocket motors along with their recent developments are also included in this chapter. Pyrotechnics which form an integral part of explosive and propellant related missions are discussed in chapter 5 whereas Explosive & Chemical safety which is of vital importance to all those working in the area of High Energy Materials (HEMs) is dealt in chapter 6.

Dr. J. P. Agrawal, who is an internationally acknowledged explosive & polymer scientist of repute, is a great writer with a large number of research publications to his credit. His rich experience and the international knowledge in High Energy Materials written in the book are valuable assets for the new generation of High Energy Materials scientists and rocket technologists.

This book is the most comprehensive review of modern High Energy Materials and encompasses their important aspects with special reference to their end-use/applications. The language in the text is very lucid and easy to understand. The readers and researchers will be immensely benefitted by the book.

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## Preface

A new term 'high energy materials' (HEMs) was coined by the explosives community for the class of materials known as explosives, propellants and pyrotechnics in order to camouflage research on such materials. In other words, HEMs is a generic term used for this class of materials. HEMs, although generally perceived as the 'devil' during war and considered as an 'evil' during handling, transportation and storage, have proved to be an 'angel' due to their tremendous impact on the economy and industries and their innumerable applications in almost all walks of life. There are several books devoted to explosives, propellants and pyrotechnics but most of these either discuss their science in general or concentrate on some specific topic. Also, none of these books deals with recent developments in detail. While a number of excellent reviews have been published to bridge this knowledge gap, there is still no single text available in the literature on the subject, embedded with recent advances and future trends in the field of HEMs. This book, entitled 'High Energy Materials: Propellants, Explosives and Pyrotechnics' is a text which covers the entire spectrum of HEMs, including their current status, in a single volume and its objective is to fill this gap in the literature.

The modus operandi of this book is: (i) to provide the current status of HEMs which have been reported in the form of research/ review papers during the last 50 years but are scattered in the literature; (ii) to explore the potential of recently reported HEMs for various applications in the light of additional requirements in the present scenario, that is, cost-effectiveness, recyclability and eco-friendliness; (iii) to identify the likely thrust areas for further research in this area. Thus, the information on HEMs reported during the last 50 years but scattered all over the literature, will be readily available to researchers in a single book. Further, the level at which chemistry is pitched in this book is not as high as in many specialized books focused on a particular aspect of HEMs. Readers interested in better understanding and details of nitration chemistry are referred to the book 'Organic Chemistry of Explosives' (J.P. Agrawal and R.D. Hodgson) which provides detailed information on various synthetic routes for a wide range of HEMs and the chemistry involved. By including Chapter 1 on 'Salient Features of Explosives' and Chapter 6 on 'Explosive and Chemical Safety' along with chapters on Explosives, Propellants and Pyrotechnics, this book will certainly be of interest to both professionals and those with little or no background knowledge of the subject.

This book is split into six well-defined chapters: Salient Features of Explosives, Status of Explosives, Processing and Assessment of Explosives, Propellants, Pyrotechnics, and Explosive and Chemical Safety. Further, the book includes an exhaustive bibliography at the end of each chapter (total references cited are more than 1000). It also provides the status of HEMs reported mainly during the last 50 years, including their prospects for military applications in the light of their physical, chemical, thermal and explosive properties. The likely development areas for further research are also highlighted. Accidents, fires and explosions in the explosive and chemical industries may be eliminated or minimized if the safety measures described in this book are implemented.

I hope that this book will be of interest to everyone involved with HEMs irrespective of their background: R&D laboratories, universities and institutes, production agencies, quality assurance agencies, homeland security, forensic laboratories, chemical industries and armed forces (army, navy and air force). This book will also be of immense use to organizations dealing with the production of commercial explosives and allied chemicals.

To sum up, I have endeavored to bring about a refreshing novelty in my approach to the subject while writing this volume and tried my best to include all relevant information on HEMs which could be of interest to military as well as commercial applications. However, it is just possible that a few interesting HEMs or some relevant information might have been overlooked unwittingly, for which I apologize. Readers are requested to inform me or the publisher about such omissions which would be greatly appreciated and included in the next edition of this book.

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