Review of:

Pyrotechnic Chemistry

K. & B. Kosanke, N. Kubota, B. Sturman, C. Jennings-White, T. Shimizu, et al.

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This is a collaborative work by many authors, resulting in many distinct writing styles between the various chapters; nevertheless the book provides a superb overview of the chemistry of pyrotechnics and various tangentially related topics. Given the stellar curricula vitae of the contributors, it is no surprise that this work is both technically excellent and extremely interesting to anyone with any degree of curiosity regarding pyrotechnic chemistry. While the preface discloses that this text is written at "an introductory to intermediate level" the more extensive one's background in the field, the greater the appreciation for the material will be. It is, indeed, as promised, accessible to both novices and appreciated by fairly advanced students of this subject. The book consists of nineteen chapters and is extensively, if not exhaustively referenced, providing a guide to further source material for those readers desirous of more advanced treatments of the various topics discussed in each chapter.

The first chapter, an Introduction, by David Dillehay, provides a brief history of both pyrotechnics and other energetic materials. It offers both background information and definitions. The eminent Takeo Shimizu wrote the second chapter, which discusses the Chemical Components of fireworks. More than simply a list, Shimizu provides a practically focused "chemical handbook" of the compounds' chemical and physical properties, the history of their use and the applications for each, as well as a brief introduction to the types of chemical reactions in which these materials are used. The compounds are reviewed by classes, according to function: oxidizers, coloring agents, fuels, dyes, other agents, and binding agents. I particularly enjoyed the discussions of organic fuels and charcoals.

Barry Sturman, in Chapter Three, provides an Introduction to Chemical Thermodynamics. This chapter is, of necessity, more technical, though the author successfully avoids making the material so abstruse as to be useful to only the expert. The physics naturally leads into a basic approach to classic pyrotechnic reactions and an introduction to chemical stoichiometry. The tendencies of pyrotechnic reactions to proceed are approached through a very well written discussion of the concepts of enthalpy and entropy as the first law of thermodynamics is explained. The second and third laws follow. Then, in a most lucid summary, the application of the laws of thermodynamics to pyrotechnics is provided. I compliment the author on one of the most useful explanations of the basic processes of physical chemistry that underlie all that we do in pyrotechnic chemistry. This reviewer would advise the novice reader to explore further source material as needed, should this somewhat more technical chapter be found challenging. If read for concept, rather than detail, however, it helps ground the novice reader in these most essential concepts.

Ken and Bonnie Kosanke contribute the Fourth Chapter on Pyrotechnic Ignition and Propagation and Chapter Five on Control of Pyrotechnic Burn Rate. The fourth chapter is a very interesting treatment of a topic more often assumed to be understood than *actually* understood. The authors are to be commended for including this material. The fifth chapter provides a very practical approach to pyrotechnic problem solving and explains why compositions behave in the manner that they do. Both compounding and particle size are discussed.

Ian von Maltitz, who has, in addition, written a superb textbook on the subject, contributes Chapter Six on Black Powder. No discussion of pyrotechnic chemistry could be considered complete without addressing, in detail, this most seminal pyrotechnic composition. Having had the advantage of reading the full textbook, the reviewer finds that the distilled discussion in this textbook more than meets the needs for a pyrotechnic chemistry book. Again, the reader desir-

ing more detailed information would be well served by reading von Maltitz' full length book on this subject.

Chapter Seven, by the Kosankes, discusses Pyrotechnic Primes and Priming. Many an excellent star has been "blown blind" for failure to provide an adequate prime. Also, the use of dark primes in color changing stars is discussed. Both technical and practical information is provided.

Mike Wilson and Ron Hancox contributed Chapter Eight on Pyrotechnic Delays and Thermal Sources. This technical material may be of less direct use to most pyrotechnists, but, the discussion of this topic is both well written and serves to expand the reader's knowledge of this subject. It affords the reader a good understanding of basic behaviors of these pyrotechnic systems and compositions.

More in keeping with perhaps the most crucial element of pyrotechnic chemistry after Black Powder, The Chemistry of Colored Flames, Chapter Nine, is written by the Kosankes. This critically useful material begins with a brief discussion of the physics of visible light and proceeds to apply this basic material to a very detailed and cogent discussion of the basics of producing pyrotechnic colored flames. Emitter species, chlorine donors, the role of flame temperature, and the use of various fuels are reviewed. This is simply a superb contribution to this extremely broad field of pyrotechnic chemistry. It is a most useful chapter and greatly enhances the value of this textbook.

Chapter Ten on Illuminants, by Dillehay, naturally follows. Again, this material is of less direct application for many pyrotechnists, but nevertheless provides a useful treatment of the subject of pyrotechnic flashes, flares, and illuminants, often used to good effect in displays.

Propellant Chemistry by Naminosuke Kubota is the subject of Chapter Eleven. Composite propellants and Black Powder propellants are discussed. Combustion kinetics and chemistry are then reviewed.

Kubota's Chapter Twelve, Principles of Solid Rocket Motor Design, is, in and of itself, practically a monograph on this subject. This chapter can be read at either of two levels: the reader conversant with physics will be provided sufficiently detailed technical information to apply the material provided to designs of independently conceived rocket motor systems, while the amateur will still be able to read the chapter to gain an understanding of exactly how rocket motors are designed and how they function. Detailed discussions of exhaust gas momentum and aerodynamics lead to a discussion of the thermodynamics of thrust generation. Mass balance, thrust, specific impulse and topics related to the pressure sensitivity of burn rates and motor function are discussed. Propellant grain variants are reviewed and the effects of various grain designs on thrust generation are covered in a very practical manner, with superb accompanying illustrations. Propellant selection and the effects of reaction products are briefly addressed. Motor case and nozzle design are presented in a fairly lucid, though brief discussion. Igniter design and selection of materials are reviewed. This critical issue has not been as well addressed in other solid rocket motor articles and its inclusion is a welcome addition. Motor combustion phenomena are reviewed. The chapter concludes with a practical exercise: the application of the various principles previously discussed to the construction of a two-stage motor. Overall, this is a superbly well-written chapter. It makes some very abstruse material understandable to a wide range of readers. The author has done an exemplary job in writing the most complete though concise presentation of solid rocket motor design that this reviewer has seen.

Chapter Thirteen, by the Kosankes and by Clive Jennings-White, on Pyrotechnic Spark Generation provides an articulate discussion of a topic as important as colored flames. Indeed, the production of gold and silver sparks and their variations constitute an effect as responsible for the "oohs and aahs" uttered by the spectators at displays as any effect achieved. Both charcoal and metal spark effects are reviewed. Jennings-White follows in Chapter Fourteen with a discussion of Glitter Chemistry. While this is an easy effect to appreciate, the chemistry behind glitter is the subject of much debate and is extraordinarily complex. The author provides a rational discussion of the leading theories put forward by various proponents as to the nature of the chemistry behind the glitter effect so many of us enjoy. Colored glitters are also briefly discussed. Together, these two chapters

afford one of the best reviews of these related topics that I have read.

Strobe Chemistry is the subject of Chapter Fifteen, also by Jennings-White. Again, this is an easy effect to compound and to produce and a rather difficult topic to understand in detail. A simplification of light and dark phase reactions more than adequately makes this topic accessible to readers of any and all levels of chemistry knowledge. While an expanded discussion of colored strobe effects and chemistry would have been appreciated in this textbook, the references noted in the bibliography offer access to this related topic. Overall, this discussion, while brief, is both fascinating and important.

Whistle Devices provide the topic for discussion in Chapter Sixteen, by Mike Podlesak and Mike Wilson. Whistles are ubiquitous in pyrotechnics: in drivers, ground devices, consumer and display items, and in rockets. A discussion of the fuels so crucial to providing these oscillating reactions and their use in pyrotechnics is offered. Whistle combustion chemistry is reviewed in a manner at once extremely technical and fascinating to almost any reader. Additional discussion regarding the use of these compositions in pyrotechnic rockets would be useful, but the basics of whistle compositions suffice for the purposes of this textbook.

From a safety perspective, there is, perhaps no more vital topic than that discussed by Dave Chapman in Chapter Seventeen: the Sensitiveness of Pyrotechnic Compositions. Tests for sensitivity and a discussion of the different nature of friction, impact, and temperature sensitivity are discussed. Implications for transportation are provided. A few specific compositions and related accidents are also discussed. This is a very practical chapter and the authors are to be commended for its inclusion.

Clive Jennings-White and Ken Kosanke review Hazardous Chemical Combinations in Chapter Eighteen. The authors provide a detailed discussion of dangerous chemical combinations, discussions of the hazards produced, and a basic chemical rationale for why these particular compositions are so hazardous. Chlorates and powdered metals (aluminum, magnesium, zinc, and magnalium) are reviewed in detail. The reviewer suggests that inclusion of phosphorus related compositions would be useful in a future edition, as would a more focused discussion of the hazards associated with various specific flash compositions. Nevertheless, the information provided in this chapter is most useful.

Tom Smith's concluding Chapter Nineteen, on Assessing the Risks, provides a safety-oriented and practical approach to those contemplating working with pyrotechnic compositions and devices. It is a well-written and most suitable conclusion to this text. The basic statistics of risk assessment are provided, so that the reader may make more mathematically informed and rational decisions. Both qualitative and quantitative risk assessments are addressed.

Overall, this is a most satisfactory endeavor. The Pyrotechnic Chemistry textbook offered by these authors through the Journal of Pyrotechnics is at once useful and fascinating. Its various topics differ in degree of complexity and will appeal to a wide range of readers. While no single textbook can completely cover this broad range of associated and collected topics, this reviewer feels that the Pyrotechnic Chemistry book is an excellent basic and reference text (thanks to its exhaustive bibliography) and is worthy of inclusion in any reader's pyrotechnic library. I enthusiastically recommend this book and offer my congratulations to its contributing authors and editors on a job well done.