

**Journal of**

# **Pyrotechnics**

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FIREWORKS - PYROTECHNIC SPECIAL EFFECTS - PROPELLANTS & ROCKETRY - CIVILIAN PYROTECHNICS

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# Keyword Index

The following list of keywords refers to articles that have appeared in Issues 1–20 of the *Journal of Pyrotechnics*. The numbers are paired. The first number is the Issue Number. The second number is the page number where the article begins. For example, 10-17 means Issue 10, page 17. See the list of Tables of Contents for article titles and beginning page. We hope that you find this list useful. For full abstracts, refer to the JPyro Web Site: <http://www.jpYRO.com>. Also see list of authors.

Most entries have words in their common usage form (e.g., Black Powder not powder, black) or as related to a major topic (e.g., rocket motor) with some exceptions. We have incorporated many cross references to assist in finding topics of interest.

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02-09-05

## Editorial Policy

Articles accepted for publication in the *Journal of Pyrotechnics* can be on any technical subject in pyrotechnics. However, a strong preference will be given to articles reporting on research (conducted by professionals or serious individual experimenters) and to review articles (either at an advanced or tutorial level). Both long and short articles will be gladly accepted. Also, responsible letters commenting on past Journal articles will be published, along with responses by the authors.

## Author List for *Journal of Pyrotechnics*, Issues 1 to 20

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## Future Events Information

If you have information concerning future—explosives, pyrotechnics, or rocketry—meetings, training courses or other events that you would like to have published in the *Journal of Pyrotechnics*, please provide the following information:

Name of Event

Date and Place (City, State, Country) of Event

Contact information — including, if possible,

    name of contact person

    postal address

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    web site information

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# Author's Guide for Full Articles

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Also See Guidance for Authors of Book Reviews, Comments and Short Articles

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## Scope

Articles accepted for publication need to address technical aspects of pyrotechnics, including fireworks, pyrotechnic special effects, propellants & rocketry, and civilian pyrotechnics. The Journal is “dedicated to the advancement of pyrotechnics through the sharing of information”. This is accomplished with a mix of different types of articles; however, most fall into two areas. One area is reports on research conducted by both professional scientists and individual experimenters. The other area is reviews of various technical and craft areas of pyrotechnics, some at an advanced level and others at a tutorial level.

## Submission

Submissions should be made directly to the publisher at the address below. Upon receipt of an article, the author will be sent an acknowledgment and a tentative publication date. For specific requests regarding editors, etc. please include a note with that information. Preferably the text and graphics will be submitted electronically or on a 3-1/2" diskette or CD in IBM format with a print copy as backup. The Journal is currently using Microsoft Word, which allows for the import of several text formats. Graphics can also be accepted in several formats. Please also inform us if any materials need to be returned to the author.

## Style

- The Journal of Pyrotechnics has adopted the ACS Style Guide [ISBN 0-8412-3462-0]. It is not necessary that authors have a copy.
- General information:
  - The first time a symbol, abbreviation, or acronym is used, it is to be written in full to define it [e.g., heat of reaction ( $\Delta H_r$ ) or potassium nitrate ( $\text{KNO}_3$ )].
  - Avoid slang, jargon and contractions.
  - Use the active voice when possible.

- Use of the third person is preferred; however, first person is acceptable where it helps keep the meaning clearer.

## General Format

- Title
- Authors' names, including an affiliation for each author and an address for at least the first author.
- A short abstract (An abstract is a brief summary of the article, not a listing of areas to be addressed.)
- Keywords — 4 to 10 to be used in a reference database: However, multi-word names and phrases constitute only one keyword (e.g., potassium nitrate and heat of reaction are each one word).
- Use SI units for measurements. If English units are used, please provide conversions to SI units.
- Every figure (including photographs and graphs) must be referred to in the text. All figures are to be numbered with Arabic numerals in the sequence in which they are cited. Every figure is to be accompanied by a caption. Figures will be printed in black and white. Place figures at the end of the text or as separate files. For graphs, please also submit “raw” X–Y data.
- Every table must be referred to in the text. Tables are to be numbered with Arabic numerals in the sequence in which they occur. Every table is to begin with a caption that explains in detail the contents of the table. Footnotes to a table should be indicated by lower-case letters in parentheses and typed directly under the table.
- Footnotes in the text are to be avoided.
- Acknowledgement of financial support, advice or other kinds of assistance should be made at the end of the paper under the heading “Acknowledgements”.
- It is the responsibility of the authors to assure the accuracy of references. References cited in the text are numbered sequentially in the order in which they are cited in the text, The

numbers should be enclosed in square brackets and written as superscripts after their reference (i.e., “Smith<sup>[1]</sup> states”; or “the research<sup>[2,3]</sup> shows”). References are to be listed in numerical order at the end of the manuscript under the heading “References”. The full citation, including author, title of book or article, publisher for books or journal title plus volume number for journals, year of publication, pages cited, etc. is to be provided. Examples:

- 1) A. E. Smith, *Pyrotechnic Book of Chemistry*, XYZ Publishers, 1993, [p nn–nn (optional)].
- 2) A. E. Smith, R. R. Jones, “An Important Pyrotechnic Article,” *Pyrotechnic Periodical*, Vol. 22, No. 3 (1994) [p n–n, (optional)].

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The *Journal of Pyrotechnics* is refereed. However, the editing style is friendly, and the author makes the final decision regarding what editing suggestions are accepted.

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Last Updated June 2004.

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# Author's Guide for Communications: Short Articles, Comments and Book Reviews

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## Guidance for Authors of Book Reviews, Comments and Short Articles

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### Style Guide

The *Journal of Pyrotechnics* has adopted the *ACS Style Guide*. It is not necessary that authors have a copy as we will suggest changes that are needed.

### Manner of Submission

Submissions should be made directly to the publisher. Upon receipt of an article, the author will be sent an acknowledgment. Preferably the text and graphics (if there are any) will be submitted electronically or on a diskette (3-1/2) or CD in IBM format with a printed copy as backup. However, because of the short nature, handwritten or typed comments are also acceptable. The Journal currently uses Microsoft Word for

Windows, which allows for the import of several text formats. Graphics, if there are any, can be accepted in several formats. Please also inform us if any materials need to be returned to the author.

### General Writing Style

- The first time a symbol is used, it is preferred to write it out in full to define it [e.g., enthalpy of reaction ( $\Delta H$ ) or potassium nitrate (KNO<sub>3</sub>)].
- Avoid slang, jargon, contractions, and abbreviations.
- Use of the active voice is preferred.
- The use of third person is preferred; however, particularly for comments on previous articles, first person is acceptable.

## Format

### Book Reviews

- For the book, provide its full title, name(s) of author(s), publisher, location of publisher (city, state, country), year of publication, ISBN [number usually found on the back of the title page].
- Usually, the author of the book will be sent a copy of your Review and allowed to respond if they so choose.
- Follow information in the “Short Articles” section to the extent that it applies.

### Comments

- These are usually comments on an article that appeared in an earlier issue of the *Journal of Pyrotechnics*. They can be in the form of a letter directed to either the editor or the author.
- The author of the article will be sent a copy of your Comments and allowed to respond, if they so choose.
- Follow information in the “Short Articles” section, to the extent that it applies.

### Short Articles

- In addition to the author's name, please include an affiliation and an address for at least the first author when there are multiple authors.
- A short abstract at the start of the article is optional. (An abstract is a brief summary of the article, not a listing of areas to be addressed.)
- Optionally, the author can include a few keywords to be used in a reference database. Multi-word names and short phrases are acceptable (e.g., potassium nitrate and enthalpy of reaction).
- Use of SI units is preferred. If English (or Imperial) units are used, please provide a conversion to the appropriate SI units (e.g., 1 inch equals 25.4 mm).
- Figures, Graphs and Photos are numbered consecutively. For submission, place them at the end of the text or as separate files. For graphs, please also submit “raw” X-Y data.

- Tables are numbered separately from figures, graphs and photos.
- References cited in the text will be referred to by number, i.e., “Smith[1] states”; or “the research[2,3] shows ...” In the reference section, they will be ordered by usage and not alphabetically. A full citation is preferred, including author, title of book or article, publisher for books, title of publication plus volume for journals, and year of publication. Reference to specific pages is optional, but encouraged. The citation that includes the pages in the Journal makes it easier if someone wishes to read the original source material. If multiple pages in an article or book are cited, they should be referenced like in example 3. Examples of citations:

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- 1) A.E. Smith, R.R. Jones, “An Important Pyrotechnic Article”, *Pyrotechnic Periodical*, Vol. 22, No. 3 (1994) [p n–n optional].
- 2) A.E. Smith, “Excellent Article on Pyrotechnics”, *Pyrotechnic Journal*, Vol. 100, No. 5 (1995) pp 6–35. [a] p 9; [b] pp 5; [c] Tables on pp 30–35.

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# Pyrotechnic Reference Series

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  - **Lecture Notes for Pyrotechnic Chemistry**
  - **Lecture Notes for Fireworks Display Practices**
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**Illustrated Dictionary of Pyrotechnics**

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Many areas of applied pyrotechnics, fireworks in particular, suffer from a lexicon that contains many specialized terms, is poorly documented, and about which there is much disagreement. For example, what you call *glitter*, others still call *flitter*, and vice-versa; your *separation distance* may be someone else's *setback*. As a result, effective communication is made more difficult than necessary. Having an extensive dictionary of terms will not instantly solve such communication problems, but it can help, especially over time. Unfortunately, until now such a dictionary has not been available.

The *Illustrated Dictionary of Pyrotechnics* [ISBN-1-889526-01-0] is 130 pages in length, 8½" by 11", and it has a durable binding. There are more than 1200 entries, 130 figures and illustrations, and 50 short tables. It includes scientific and craft terms from fireworks, explosives, rocketry and pyrotechnic special effects.

In addition to the principal authors, eight individuals with expertise from each of the technical areas addressed, reviewed and contributed to the development of the dictionary. Most entries go well beyond merely defining a term; many terms are explained using examples, data, and/or illustration. Accordingly, the dictionary should be both authoritative and easy to comprehend.

**Excerpts from review by L. Homan for the *Western Pyrotechnic Association Newsletter*, March, 1995.**

*"A dictionary is undoubtedly the most daunting of literary tasks, only for the most motivated and knowledgeable. In this case the selection of terms is somewhat eccentric, as any beginning project must be, including technical terms of little value to the average pyrotechnician. The content might form the basis for a game of knowledge amongst a group of fire-*

*works enthusiasts, see who can find a term which someone else in the group does not know. The dictionary is very readable, being clearly laid out and not too specific or complicated, giving good meanings yet stopping short of excessive explanations... The individual reader will have to gauge his own level of need, the less you understand it, the more useful it is, I suggest a sneak preview... This new dictionary is very well done, worth the reasonable price for most, but I wouldn't steal it."*

**Excerpts from review by R. Winokur for *American Fireworks News*, No. 163, April, 1995.**

*"The content of this volume is eclectic in the extreme. It contains entries on all aspects of fireworks, from regulatory definitions to Italian and Japanese shell making. It also contains a large variety of terms used in rocketry which are not normally seen in the fireworks literature. In addition there are many terms taken from high explosive science and technology, and some from stage and movie special effects. To illustrate the eclectic nature of this volume one only has to open the pages at random. For example, on pages 74 and 75 we find "M-80" defined: "One type of small but powerful exploding device...". In the next entry we find "Mach Diamonds: Diamond shaped features exhibited by the exhaust plume of rocket motors and engines"... Several entries later we find "Magnesium, Magnalium, Magnesium carbonate and Magnus Force". Terms are sometimes grouped together based on their being closely related in definition rather than strictly alphabetically. For example, the terms "Color Purity, Color Species and Color Spectrum come before Colored Heart and Colored Smoke". Although this is unusual in a dictionary, it is an extremely functional aspect of the volume. The entries are usually considerably more than brief definitions. On average an entry is composed of a short paragraph or more, and often includes one or more illustrations in the form of diagrams, drawings and graphs. In some instances a series of closely related entries may take up several pages. For example, if one searches for the term Mortar, the following entries are found Mortar (fireworks), Mortar (special effects), Mortar Burst, Mortar Length, Mortar Organization, Mortar Placement, Mortar Plug, Mortar Rack, Mortar Racks - Dense-Pack, Mortar Strength, and Mortar Trough. These eleven entries take about 2½ pages and contain a wealth of information on structure, physical properties, composition, safety, and function of mortars..."*

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## **Lecture Notes for Pyrotechnic Chemistry**

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*Lecture Notes for Pyrotechnic Chemistry* [ISBN-1-889526-16-9], revised and enlarged in early 2005, contains the class notes for a three-day course on the Pyrotechnic Chemistry. The Course Notes assume only minimal levels of understanding of Chemistry and Pyrotechnics. Each 8½×11" page contains a pair of viewgraphs from the course lectures. The over 440 viewgraphs include many illustrations and tables. Each viewgraph of text is complete enough for the reader to be able to understand the subject being discussed. Following is the outline of topics:

- I Basic Chemical Principles
- II Pyrotechnic Chemistry, Ignition and Propagation
- III Pyrotechnic Primes and Priming
- IV Factors Affecting Burn Rate
- V Aspects of Pyrotechnic Burning
- VI Physical Basis for Colored Light Production
- VII Chemistry of Colored Flame
- VIII Chemistry of Sparks, Glitter and Strobe
- IX Pyrotechnic Smoke and Noise
- X Approaches to Formulation Development
- XI Pyrotechnic Sensitivity
- XII Pyrotechnic Hazard Management

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## **Lecture Notes for Fireworks Display Practices**

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The *Lecture Notes for Fireworks Display Practices* [ISBN-1-889526-03-7] contains class notes from a week-long course on practical and safety aspects of performing fireworks displays. Each 8½×11" page contains a pair of viewgraphs from the course lectures. The 440 viewgraphs include many photographs and tables. Each viewgraph of text is complete enough for the reader to understand the subject being discussed. **Revised 02/05.**

- I. **Elements of Hazard Management for Fireworks**
- II. **Fireworks Construction, Operation, and Characteristics**
  - Aerial Shell Components and Manner of Functioning
  - Aerial Shell Malfunctions
  - Typical Performance Characteristics
  - Other Fireworks Types

### **III. Fireworks Display Safety**

- Display Site Requirements
- Fireworks Display Equipment
- Mortar Placement
- Chain-fusing Techniques
- Making Repairs to Fireworks
- Ground and Low-level Fireworks
- Manual Display Procedures
- Setup of Electrically Fired Displays
- Techniques for Electric Firing

### **IV. Fireworks Transportation and Storage Requirements**

- Fireworks Sensitivity to Accidental Ignition
  - Pyrotechnic Combustion
  - Sensitivity Indicators
  - Fireworks Sensitivity
  - Fireworks with Electric Igniters
  - Storage Considerations
- Blast and Thermal Effects from Fireworks

### **V. Fireworks Display Design**

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## **Pyrotechnic Chemistry**

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*Pyrotechnic Chemistry* [ISBN: 1-889526-15-0] is a hard cover book on the chemistry of pyrotechnics. The book was authored by a collection of 13 renowned pyrotechnic researchers from around the world. It contains over 400 pages in a large 8½ × 11" format.

This text is written at an introductory to intermediate level. As such it is intended for readers with limited prior knowledge of chemistry or limited knowledge regarding specific areas of applied pyrotechnics. One goal of this text is to provide an extensive list of references, thus directing readers to sources of additional information.

The Table of Contents is extensive, running to 9 pages with approximately 600 entries. Because of the extensive table of contents, this text has not been provided with an index. It is suggested that readers wishing to research a specific topic first consult the list of chapters to find the one most relevant to the topic of interest, and then consult the detailed table of contents to locate the page number(s) of the section(s) addressing that topic.



## List of Book Chapters and Authors

- 1 Introduction to Pyrotechnic Chemistry
- 2 Chemical Components of Fireworks Compositions
- 3 An Introduction to Chemical Thermodynamics
- 4 Pyrotechnic Ignition and Propagation: A Review
- 5 Control of Pyrotechnic Burn Rate
- 6 Our Present Knowledge of the Chemistry of Black Powder
- 7 Pyrotechnic Primes and Priming
- 8 Pyrotechnic Delays and Thermal Sources
- 9 The Chemistry of Colored Flame
- 10 Illuminants and Illuminant Research
- 11 Propellant Chemistry
- 12 Principles of Solid Rocket Motor Design
- 13 Pyrotechnic Spark Generation
- 14 Glitter Chemistry
- 15 Strobe Chemistry
- 16 A Study of the Combustion Behaviour of Pyrotechnic Whistle Devices (Acoustic and Chemical Factors)
- 17 Sensitiveness of Pyrotechnic Compositions
- 18 Hazardous Chemical Combinations: A Discussion
- 19 Assessing the Risks — Suggestions for a Consistent Semi-Quantified Approach

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### Review of: Pyrotechnic Chemistry

Bernard E. Douda

Crane Division, Navel Surface Warfare Center

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*Pyrotechnic Chemistry* is the fourth in the Pyrotechnic Reference Series produced by the publisher of the *Journal of Pyrotechnics*. It is composed of nineteen stand-alone presentations each authored by pyrotechnic experts in their specialty area.

There are chapters dealing with pyrotechnic materials, thermodynamics, ignition and propagation, burning rate control, black powder, primes and priming, delays and thermal sources, illuminants, solid rocket motor design, spark generation, whistle devices, and the chemistry of colored flames, propellants, glitter, and strobes. Safety aspects are addressed in chapters dis-

cussing composition sensitiveness, hazardous chemical compositions, and risk assessment.

One advantage of a compilation of this sort is that it makes it convenient for the reader to find information across a wide range of pyrotechnic topics. The extensive Table of Contents makes this possible. The book contains a large number of figures and tables to support the text material. There are many examples of application of the information to pyrotechnic practical situations. For the most part, this book addresses the topics thoroughly but perhaps in some cases not to the degree that one would find in a textbook.

The compilation format provided the opportunity for each of the authors to address their topic to a degree sufficient to relate all aspects of their topic to practical pyrotechnics. They accomplished this by providing the underlying theory, the relevant equations, illustrative figures, and tables of supporting data. The result of this is that some chapters are much larger than others.

Another important characteristic of this book is that it addresses many pyrotechnic safety issues in chapters dedicated to this purpose. Not only were the authors able to point out safety concerns with material incompatibilities throughout their individual topics but also they prepared three chapters dedicated to sensitivity of pyrotechnic compositions, hazardous chemical combinations, and risk assessment.

Each chapter includes a set of its own references. These will be valuable to those wishing to explore a subject further. The book is easy to read. The topics are presented in an informative and educational manner. This book not only addresses topics related to fireworks but also addresses topics relevant to military pyrotechnics. It complements other pyrotechnic reference books and will serve as a valuable addition to one's library.

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- **Selected Publications of Dr. Takeo Shimizu,**
  - Part 1. From IPS (1985–1994)**
  - Part 2. Translated Articles**
  - Part 3. Studies on Colored Flame Compositions of Fireworks**
  - Part 4. The Design Criteria for Chrysanthemum Shells**

## Selected Pyrotechnic Publications of K. L. & B. J. Kosanke, Parts 1–5

The following five books are collections of articles that originally appeared in a variety of pyrotechnic publications. The articles were reformatted into a 2-column, 8½×11" format.

### Part 1 (1981–1989) [ISBN 1-889526-05-3]

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#### Table of Contents:

Physics, Chemistry & Perception of Colored Flames,  
Part 1: Physics  
Taming Triangle Diagrams  
Festival Ball Comets  
Physics, Chemistry & Perception of Colored Flames,  
Part 2: Chemistry  
An Idea for Small Shows  
Electrical Firing of Musically Choreographed  
Aerial Fireworks Displays  
Sizzling Colored Comets  
HDPE Mortars for Electrically Fired Displays  
Economics of Plastic Shell Construction  
An Evaluation of "Pyro-Flake" Titanium for Use in  
Fireworks  
RAP Shell Assembly Techniques  
Destructive Testing and Field Experience with  
HDPE Mortars  
Understanding Product Liability (Parts 1 and 2)  
Japanese Shell Break Radii  
CMC — Its Properties and Uses

Reduction of Shell Ignition Failures  
Determination of Aerial Shell Burst Altitudes  
Pyrotechnic Spark Generation  
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Measurements  
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Shimizu Aerial Shell Ballistic Predictions  
(Pts 1–2)  
Hazard Data for Chemicals Used in Pyrotechnics  
Burn Characteristics of "Visco" Fuse  
Saran Resin — Its Properties and Uses  
Pyrotechnic Fuse Burn Rates  
A Collection of Star Formulations  
Production of Benzoate Color Agents  
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Dautriche - Shock Tube Measurement of High  
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Fireworks and their Hazards  
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Explosive Limit of Armstrong's Mixture  
Aerial Shell Drift Effects: A) The Effect of Long Mortars, B) The Effect of Capsule-Shaped Shells  
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Some Measurements of Glitter  
Lift Charge Loss for a Shell to Remain in Mortar Configuration and "Over-Load" Studies of Concussion Mortars  
Quick Match: A Review and Study  
Pyrotechnic Primes and Priming  
Dud Shell Risk Assessment: NFPA Distances  
Dud Shell Risk Assessment: Mortar Placement  
Performance Test of Civil War Black Powder  
Caution: Very Fast "Black Match"  
Peak In-Mortar Aerial Shell Acceleration

Firing Precision for Choreographed Displays  
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Mortar Separations in Troughs and Drums  
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**Selected Pyrotechnic Publications of  
Dr. Takeo Shimizu,  
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A collection of previously published technical papers that appeared in *Proceedings of the International Pyrotechnics Seminars* from 1985–1994. The articles have been reformatted into a 2-column, 8½×11" format. [ISBN 1-889526-08-8]

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Ballistics of Firework Shells  
An Example of Negative Explosives: Magnesium Sulfate/Magnesium Mixture  
The Effect of Hot Spots on Burning Surface and Its Application to Strobe Light Formation with Mixtures that Contain No Ammonium Perchlorate  
The Surface Explosion of Pyrotechnic Mixtures  
Stabilizing Firework Compositions:  
I. Minimum Solubility Law to Foresee the Degeneration  
II. A New Chemical Method of Magnesium Coating Burning Rate and Grain Size of Component Materials of Pyrotechnic Mixtures

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**Selected Pyrotechnic Publications of  
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A collection of previously published technical papers that appeared in various publications between 1978 and 1995. These articles were translated into English and reformatted into a 2-column, 8½×11" format. [ISBN 1-889526-10-X]

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    ity of Compositions  
Study on the Reaction Mechanism of Black  
    Powder and Its Applications  
Detection of Underwater Blasting Using  
    Electrical Noise

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**Selected Pyrotechnic Publications of  
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Part 3. Studies on Colored  
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A series of seven articles that originally appeared in the *Journal of Industrial Explosives*. The articles were translated from Japanese by Dr. Shimizu. The articles have been formatted into a 2-column, 8½×11" format. [ISBN 1-889526-11-8]

**Table of Contents:**

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    Measurement of Flames  
Part II. Temperature Measurement of Flames by  
    Means of Line-Reversal Method  
Part III. On Backgrounds of Color Flame  
    Spectra  
Part IV. On Flame Spectra of Red, Yellow and  
    Green Color Compositions  
Part V. On Flame Spectra of Blue Color  
    Compositions  
Part VI. On Flame Spectra of Metal Aluminum  
    Composition  
Part VII. On Composition Series for Practical Use

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**Selected Pyrotechnic Publications of  
Dr. Takeo Shimizu,  
Part 4. The Design Criteria for  
Chrysanthemum Shells**

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This is Dr. Shimizu's PhD thesis that was translated from Japanese by Dr. Shimizu. The articles have been formatted into a 2-column, 8½×11" format. [ISBN 1-889526-14-2]

**Table of Contents:**

1. Preface  
2. Construction of Chrysanthemum Shells  
3. Problems in Designing Chrysanthemum Shells  
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    Preparation and Preliminary Calculations  
5. Supplemental Experiments: Measurement of  
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    the Normal Atmosphere  
6. The Formulae for Calculating the Velocity of  
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