## **Review of:**

## The Chemistry of Explosives

Jacqueline Akhavan RCS Paperbacks [ISBN 0854046402] 2004

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Authors of introductory-level books in technical fields face a formidable challenge: they must strike an appropriate compromise between the needs of relatively uninformed students and the expectations of experts in the field. For subject matter as broad and complex as chemistry or explosives, it is practically impossible to satisfy both students and experts with a 170-page paperback book. This is the challenge facing Jacqueline Akhavan and the second edition of her book The Chemistry of Explosives, which is part of the RSC (i.e., Royal Society of Chemistry) Paperback series of inexpensive introductorylevel texts for selected topics in chemistry. It therefore is not surprising that Akhavan's The Chemistry of Explosives fails to meet the challenge. What is surprising is that the author made only trivial changes in the second edition and that clear errors pointed out by reviewers of the book's first edition were addressed superficially or not at all. Although I have to acknowledge that the book probably provides much of what the author and publisher intend to provide -i.e., a clear, readable introduction to a selected topic in chemistry that should appeal to the general chemist - the persistence of known errors is disturbing and I would not recommend this book to people who want a technically accurate introduction to the subject.

There is very little difference between the first and second editions of this book. In fact, most pages are completely unchanged, and it is possible to spot most changes by doing page-bypage comparisons of the two editions. The first edition has 158 pages, not counting bibliography and index. The second edition has 164 pages. Three of the additional pages (pages 15–17) were used in Chapter 1 for a small section entitled "Recent Developments" and two more (pages 45– 46) appear in Chapter 2. These five pages describe a small number of newer explosives (e.g., NTO, TNAZ, nitrocubanes) and very briefly mention the topics "Insensitive Munitions" and "Pollution Prevention". The final new page was added to Chapter 5 as part of an effort to correct the discussion about "Force and Pressure of Explosion" (pages 100–102).

The first edition of this book was reviewed in the *Journal of Pyrotechnics* (No. 10, Winter 1999) by Ken Kosanke and Barry Sturman. Both reviewers, who are well respected for their broad knowledge of pyrotechnics, chemistry and physics, identified a number of technical errors. The author was made aware of these errors by the Journal of Pyrotechnics Editor. A few of the errors were corrected. Efforts were made to correct a few other errors, but these efforts weren't always successful. Two errors were addressed by adding superficial parenthetical remarks or footnotes, but most of the errors were not corrected. For example:

Page 1 still perpetuates the legend of Berthold Schwartz, who is credited with playing a major role in the adoption of Black Powder in Europe. The parenthetical comment that "many dispute his existence" only superficially addresses the comments in Sturman's review of the first edition. Why didn't Akhavan use the information provided by Sturman as an opportunity to develop a more accurate (and more interesting!) story about the adoption of gunpowder in Europe?

Page 51 now uses a value for atmospheric pressure (Equation 3.2 on page 51) that is more reasonable ( $9.869 \times 10^{-2}$  N mm<sup>-2</sup>), but it still is not the universally accepted pressure for 1 atm:  $10.13 \times 10^{-2}$  N mm<sup>-2</sup> (i.e., 101.325 kPa).

Page 61, Table 3.3, line 9 still indicates that deflagrating explosives are "not affected by strength of container". This is incorrect and should be obvious in light of line 8, which states that "rate of burning increases with increasing ambient pressure". Moreover, isn't confinement in a strong container one of the ways deflagration can convert to detonation (line 11)?

Page 64, Figure 4.1 still incorrectly identifies the thermal run-away (or critical) temperature as the ignition temperature of a pyrotechnic material.

Page 70 still states "Almost all explosive trains contain a primary explosive as the first component". This is surprising in light of Kosanke's reminder that the blasting cap, which is one of the most common explosive trains in use, typically contains an ignition and/or delay charge before the primary explosive component.

Page 73 still states "The amount of chemical energy H generated by the decomposition of an explosive will give information on the sensitivity of the explosive... a high value of H will result in a more sensitive explosive." This is incorrect, and it should be obvious from Table 5.12 (page 87). No correction was made, even though this inconsistency was explicitly pointed out in Kosanke's review of the first edition.

Page 81 still states that the "heats of formation for a reaction containing explosive chemicals can be described as the total heat evolved when a given quantity of a substance is completely oxidized in excess amount of oxygen..." This is not true.

Page 100-102 contains a revised discussion of "Force and Pressure of Explosion". Although the discussion was expanded by nearly a page, it still appears to equate F to both PV and nRT, which should be familiar to all readers as parts of the ideal gas equation. Akhavan also calls Fthe "force constant". Many chemistry and physics students (as well as their teachers) will be confused by this section because both PV and nRT have units of "work" (i.e., force times distance) or "energy" (e.g., Joules). And force constants normally are associated with Hooke's law, not the PV term from the ideal gas law. Rather than using the term 'force' to describe F, it would have been better to use another term. Rudolf Meyer's book *Explosives* (3<sup>rd</sup> Ed, VCH, 1987, page 316) uses the term "specific energy", which for explosives is "defined as its working performance per kg, theoretically calculated from the general equation of state for gases: f = pV =nRT, where p is the pressure, V is the volume, n is the number of moles of the explosion gases per kg, R is the ideal gas constant, and T is the absolute temperature of the explosion". If the terms 'force' and 'specific energy' are used interchangeably by experts in the field (which appears to be the case from both Meyer's book and Akhavan's book), it should be explained why explosives experts use the term 'force' differently than most chemists and physicists.

Page 161, Table 8.7 still lists silicon tetrachloride and ammonia vapor as a pyrotechnic composition. Why? Pyrotechnic compositions are fuel-oxidizer mixtures, which give off light, evolve heat, produce fogs or smoke, or give acoustic effects. The reaction of silicon tetrachloride with ammonia is not a redox reaction. The mixture therefore is not a pyrotechnic composition, even though the reaction is capable of generating lots of heat and smoke.

Page 162 still states that  $SrCl^+$ ,  $BaCl^+$  and  $CuCl^+$  are the light emitters generated by pyrotechnic mixtures, even though it is widely accepted that the light emitters are neutral molecules. The footnote at the bottom of page 162, which states "other researchers believe that there is no charge on these molecules", may be a response to comments in Sturman's review. Whatever the case, it's both surprising and unfortunate that Akhavan did not use the information provided by Sturman to research and provide a more accurate description of colored light-generation by pyrotechnic compositions.

## Other areas for improvement:

There is no mention of recent efforts to develop nitrogen-rich or solid all-nitrogen compounds as explosives. Karl Christe's recent work is particularly elegant and simple. It could be used to illustrate and explain many points, and the fact that it still is a "work in progress" should be interesting to most students.

The line formula for lead azide is  $Pb(N_3)_2$ , not  $PbN_6$  (page 22).

Page 26 states "the molecular structure (of RDX) breaks down on explosion leaving momentarily, a disorganized mass of atoms. These recombine..." At one time, this mechanism was widely accepted, and it might still be believed by some people in the field. However, enough is now known about rapid chemical reactions to conclude that explosives probably don't just make a mass of atoms that then recombine.

Page 24, reactions 2.2 and 2.3, describe reaction schemes for decomposition of lead azide. These reactions are pure speculation by the author and they don't belong in the book. (Decomposition of a neutral solid into ions?)

The organic chemistry in this book is very weak. The author should have consulted with an organic chemist regarding mechanisms for organic transformations. Did an organic chemist proof-read the book? Reaction 7.6 (page 125) has some unreasonable intermediates. Reaction 7.21 (page 140) invokes the "lasso mechanism", which most organic chemistry students are discouraged from using.