Drohammer Test Investigations on Some Inorganic and Organic Azides

Thomas M. Klapötke* and Claudia M. Rienäcker

Department of Chemistry, Ludwig-Maximilians-University Munich, Butenandtstr. 5-13 (Building D), D-81377 Munich (Germany)

Summary

A specific drohammer test apparatus for measuring the maximum absolute acoustic level was designed and installed. In this contribution we report the results of the testing of six different explosives. All used substances, which are silver azide, lead azide, cyanuric triazine, 1,3,5-trinitro-2,4,6-triazidobenzene (TNTA), 1,3-dinitro-2,4,6-triazidobenzene (DNTA) and 1,3,5-trinitro-2-monoazidobenzene (TNMA), contained at least one azide group.

1. Introduction

Due to the use and preparation of explosive materials in our group, especially azides and nitro compounds, it was useful to build a drohammer test apparatus to investigate the impact sensitivity of the compounds with the possibility of measuring the acoustic levels of explosions. Various drohammers are in use by different institutions and companies in order to investigate the safety characteristics of commercial and military explosives. Variables are the drop mass and its altitude. In our case the drohammer had always the same height, but it was possible to choose between two different weights (5 kg and 250 g).

2. Drohammer Test Apparatus

A schematic diagram of the drohammer is shown in Figure 1. The apparatus is based on a 600 kg concrete block, on top of which a replaceable polished steel plate (T 316 SS) for the samples was fixed. A 60 cm height metal frame contains the drohammer release mechanism, the light barrier and a sledge with roller bearings for the drohammer. A small box beside the block contains the electronic devices like the light barrier control and trigger delay. The distance between the microphone (from “Beyerdynamic”, model M101 N(C)) and the impact area was fixed to 140 cm and the drop height was 52 cm (see Figure 1). For all experiments, the Hewlett-Packard HP VEE software, version 4.01 (1997) was used. Two programs have been developed based on this program, one for recording the measurements and the other for the interpretation of the data.

The acoustic level operating the drohammer without explosion was 119 dB (zero value) which was significantly lower than the obtained values of 140–150 dB with test substances (logarithmic scale, cf. Eq. (1)).

3. Sample Preparation

All substances used, such as silver azide, lead azide, cyanuric triazine, 1,3,5-trinitro-2,4,6-triazidobenzene (TNTA), 1,3-dinitro-2,4,6-triazidobenzene (DNTA) and 1,3,5-trinitro-2-monoazidobenzene (TNMA) were synthesized by literature methods. The samples for the impact test were dried at 50°C in an oven over night and placed between two sheets of sandpaper (180 grit).

4. Experiments

The samples (10–40 mg, see Table 1) were loaded between two sheets of sandpaper (180 grit, covered area ca. 0.25 cm²) which were placed directly onto the steel plate (polished stainless steel, T 316 SS) in the impact area. The drohammer impact surface (cylinder with flat round surface, d = 15 mm) also consisted of polished stainless steel (T 316 SS). For data collection the following parameters were used (for software see above): scan rate: 200 000; no. of scans: 65536; range of voltage: ±1.25 V. The drohammer was finally released from a safe place outside the room with a remote control.

5. Results

5.1 Physical Background

To interpret the measured data it was necessary to adjust the specific data of the microphone used by applying the following physical equations:

* Corresponding author; e-mail: tmk@cup.uni.muenchen.de
Figure 1. Drop hammer test apparatus.

Table 1. Average values of max. abs. acoustic level in [dB] for different chemical substances and different amounts

<table>
<thead>
<tr>
<th>Substance</th>
<th>Amount [mg]</th>
<th>Average value of max. abs. acoustic level [dB]</th>
</tr>
</thead>
<tbody>
<tr>
<td>silver azide AgN₃</td>
<td>35</td>
<td>149.75</td>
</tr>
<tr>
<td>lead azide Pb(N₃)₂</td>
<td>40</td>
<td>147.84</td>
</tr>
<tr>
<td>cyanuric triazide (N₃CN)₃</td>
<td>10</td>
<td>140.09</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>148.72</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>152.28</td>
</tr>
<tr>
<td>1,3,5-trinitro-2-monoazidobenzene (TNMA)</td>
<td>10</td>
<td>141.06</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>149.58</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>151.96</td>
</tr>
<tr>
<td>1,3-dinitro-2,4,6-triazidobenzene (DNTA)</td>
<td>10</td>
<td>147.61</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>151.24</td>
</tr>
<tr>
<td>1,3,5-trinitro-2,4,6-triazidobenzene (TNTA)</td>
<td>10</td>
<td>146.28</td>
</tr>
</tbody>
</table>

Figure 2. Results (max. abs. acoustic pressure level) of the drophammer tests for AgN₃ and Pb(N₃)₂.
acoustic intensity, $I$: acoustic energy, which hits one square metre per second; unit [W/m$^2$].

acoustic level, $L'$:

$$L' = 10 \cdot \lg \left( \frac{I}{I_0} \right), \text{ unit [dB]} \quad (1)$$

$$I_0 = 10^{-12} \text{ W/m}^2$$

absolute acoustic pressure level, $L$:

$$L = 20 \cdot \lg \left( \frac{p}{p_0} \right), \text{ unit [dB]} \quad (2)$$

$$p_0 = 2 \times 10^{-5} \text{ Pa}$$

specific data of the used microphone:

$$1.0 \text{ mV} \not\sim 0.769 \text{ Pa} \quad (3)$$

The Eqs. (1)–(3) were implemented into the interpretation program to analyze the maximum values of voltage, pressure level and absolute acoustic level for each measured explosion.

5.2 Experimental Results

Table 1 shows the experimental results. For each substance and each amount 5 to 40 drophammer tests were carried out. The average values (⊙) of the above defined acoustic levels are shown.
Figure 5. Results (max. abs. acoustic pressure level) of the drophammer tests for 1,3-dinitro-2,4,6-triazidobenzene.

Figure 2 shows the max. abs. acoustic pressure level diagrams of silver and lead azide. The average value for silver azide is higher than the one for lead azide, although the amount is lower. This indicates that AgN₃ is a more powerful substance under the test conditions applied in this study than is Pb(N₃)₂ which is in accord with the literature(9).

Cyanuric triazide, (N₃CN)₃, seems to be a much more powerful explosive than silver or lead azide. An explosion of 20 mg (N₃CN)₃ has nearly the same acoustic level as generated from 40 mg of Pb(N₃)₂ or 35 mg of AgN₃.

The higher variation of the acoustic pressure level at an amount of 10 mg is normal, because of the higher absolute weight deviation, which is more dramatic in small amounts than in higher ones. The results of the explosion tests for cyanuric triazide in the amounts 10, 20 and 30 mg are shown in Figure 3.

Beside the more inorganic compounds described above we also tested some organic nitroazide compounds. But even the weakest of these organic explosives has a higher acoustic level than AgN₃ or Pb(N₃)₂. The order of the acoustic level is TNMA < DNTA < TNTA, but the values for DNTA and TNTA are very similar. Figure 4 shows the results for 1,3,5-trinitro-2-monoazide, Figure 5 for 1,3-dinitro-2,4,6-triazidobenzene and Figure 6 a comparison for TNMA, DNTA and TNTA for 10 mg substance.

Figure 6. Results and comparison (max. abs. acoustic pressure level) of the drophammer tests for TNMA, DNTA and TNTA for 10 mg substance.

6. Conclusions

The designed drophammer apparatus has been claimed to be a very useful tool for research purpose and the handling sensitivity. The values of the measured max. abs. acoustic levels provide a valuable quantitative scale for the explosives to generate acoustic pressure levels under the drophammer stimuli. Even the weakest of the investigated organic explosives (TNMA) shows a higher acoustic level than AgN₃ or Pb(N₃)₂. However, it is not clear whether the acoustic level can be directly correlated to the detonation power. Nonetheless, as already mentioned in the literature(10), the drophammer impact test is easy to carry out, but the results from different research laboratories are sometimes not easily comparable. However, the method provides a relatively easy and straight-forward technique to qualitatively screen the reaction power of different explosives under this investigation.
7. References

(1k) T. M. Klapötke and T. Schütt, Main Group Metal Chemistry, 22, 357 (2000).
(3) A. Stettbacher, Z. Ges. Schieß-Sprengstoffwesen, 11, 34, 147 (1916).
(8) http://iva.uni-ulm.de/PHYSIK/VORLESUNG/OPTIK/node153.html#SECTION00623000000000000000000000

Acknowledgements

The authors are indebted to and like to thank Dr. G. Holl and Dr. M. Kaiser from the WIWEB, a division of the German Department of Defense Technology and Procurement (BWB) for the long and excellent collaboration.

We like to thank Mr. D. Adam, M. Sc. for the preparation of TNTA, DNTA and TNMA; Dr. U. Wiesner for the development of the measurement and interpretation program from the basic HP VEE software; the mechanical workshop of the chemistry department for the excellent construction of the drophammer and Mrs. C. Nowak for her help with the diagrams and drawings. We also would like to thank the Ludwig-Maximilians-University Munich and the Fond der Chemischen Industrie for financial support. We would also like to thank one referee for many valuable suggestions and corrections.

(Received September 10, 2000; Ms 2000/041)