Ultra low cost, explosiveness test

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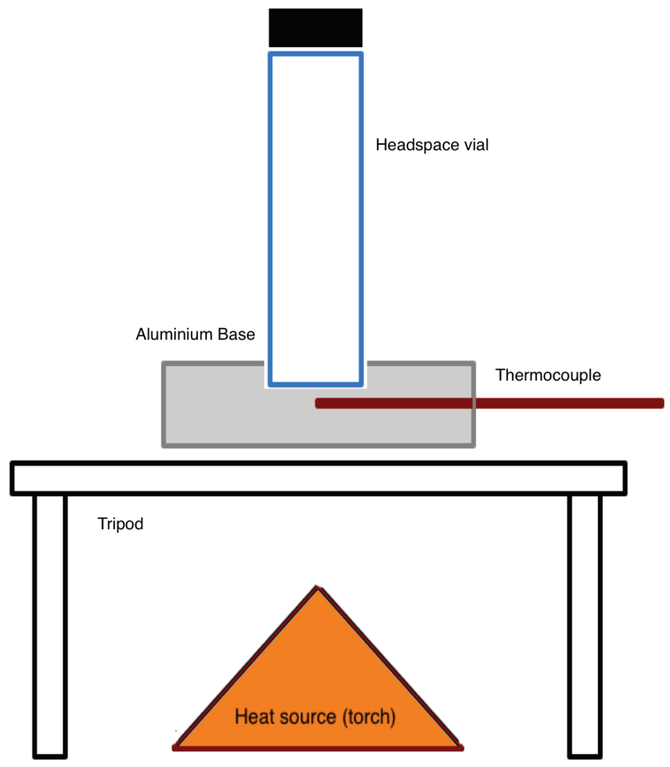
Abstract

A burn to violent reaction or cook-off, is one of the primary hazards when assessing the safety of munitions and explosives. We have investigated an ultra low cost method to study the explosiveness of explosives such as 1,3,5-trinitroperhydro-1,3,5-triazine (RDX). A small quantity of explosives was sealed into glass vials. The vials were placed into a heated aluminium block, until combustion was achieved. On average the heating cycle took 3-4 min before ignition of the explosive was observed.

Interestingly, the combustion of RDX was very different to that observed for 3-Nitro-1,2,4-triazol-5-one (NTO) and 2,4-dinitroanisole (DNAN). RDX did not burn when heated as observed with NTO and DNAN. We observed that the RDX partly sublimed and then partly thermally decomposed in the gaseous phase. Then the partially decomposed RDX vapour underwent a violent burning reaction. This burn to violent reaction occurred in the gaseous phase at temperatures as low as 270 ºC. Ultimately, we understand that a similar setup could be used for assessing explosiveness and safety aspects of new explosives formulations.

Methodology

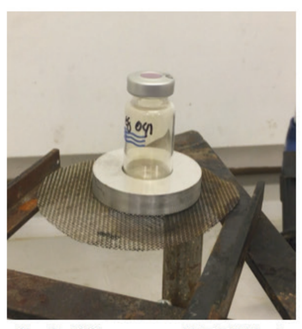
The experimental setup constituted of a sealed 10 mL vial (Chromacol 10-CV-P715 GCMS headspace vial) with small samples (10–20 mg) of 1,3,5-trinitroperhydro-1,3,5-triazine (RDX). The vial was then placed on a custom made aluminium disk (5 cm diameter, 1 cm thick, a 2 mm thermocouple slot drill from the edge to the centre and a 0.5 cm central groove to accommodate the headspace vial). A thermocouple was attached and the whole set can be placed on a tripod. The heat source was a handheld butane torch (PT-200 butane blow torch) that can be moved beneath the aluminium base using a separated set of stand and clamps. The temperature data were collected using a Pico data logger USB TC-08 attached to IEC-KX-2 thermocouple and the data were recorded using a PicoLog Recorder software (version 5.25.3) at a rate of a measurement recorded per second.



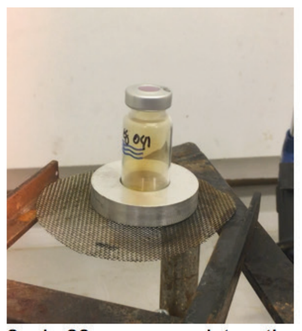
Aircraft burning on USS Enterprise, 1969

Results

0 min 07 sec. – experiment commencing



3 min 26 secs – all RDX is in vapour phase and starting to indicate NOx presence. Heat source removed



3 min 30 secs - pre-detonation - ignition

After detonation, headspace vial remains intact

We have observed that RDX melts and begins to evaporate (230ºC, 3min after the heating started). While in vapor-liquid equilibrium, the vapor phase undergoes a decomposition reaction, indicated by the presence of brown vapor within the headspace vial. The evaporation is completed after 3min 28sec (268ºC). The heat source was removed, but the temperature kept raising and at temperatures beyond 270 ºC the vapor phase to ignite and burn to a violent reaction (BVR).

Conclusion

we observed that when RDX is slowly heated it first melts, than vaporises. When in the vapour phases it ignites and transitions to a violent burning reaction. This behaviour was not observed for reduced vulnerability explosives such as NTO and DNAN. This experiment could be a useful tool to better our understanding of the vulnerability of explosives

Image from https://commons.wikimedia.org/wiki/File:Aircraft_burning_on_USS_Enterprise_(CVN-65).jpg

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