


MSIAC
Munitions Safety Information Analysis Center
Supporting Member Nations in the Enhancement of their Munitions Life Cycle Safety


Bulletin



IN THIS ISSUE



Energetic Materials Round Up 1

AC/326 SG/A 3

Explosives Hazard Data Sheets 4

Publications 4

Industry & Techn. Press Review 5

Farewell ... from Manfred Becker 5

And Welcome to Wade Babcock 5

Also welcome to our trainees 6

August 2015

CONTACT INFORMATION

☎ 32-2-707.54.16

☎ 32-2-707.53.63

☆ <http://www.msiac.nato.int>
✉ info@msiac.nato.int

ENERGETIC MATERIALS ROUND UP

This quarter we briefly review the presentations and proceedings relating to energetic materials from two energetics conferences; 46th International Annual Conference of the Fraunhofer ICT held in Karlsruhe and the Insensitive Munitions and Energetic Materials Technology Symposium held in Rome. We also cover other activities occurring around the nations and some forthcoming meetings of interest for 2016.

IMEMTS

A summary of IMEMTS was presented in the last newsletter but with a focus on the IM awards and winners. This quarter's IMEMTS review focuses more on the energetic materials research being carried out across the nations and the globe. IMEMTS was very well attended with 200+ attendees including representation from all MSIAC member nations.

Processing

Mahoney (NAWC) reported on the re-establishment of a TATB plant at BAe Holston facility but returning to the Benzinger process in order to obtain material with the same specification as legacy material. Eck/Stenmark (Eurenco) highlighted some more work to improve the crystal morphology of RDX, now producing VI-RDX with fewer intra-granular voids, smoother crystals and slight reduction in shock sensitivity (PBXN-109).

A number of papers discussed work on LLM-105, with Ervin (BAe) presenting work on scale up from the lab to pilot plant. Zucherman (LLNL) presented their LLM-105 synthesis using microflow reactor to nitrate the pre-cursor diaminopyrazine-1-oxide (DAPO). David Am Ende (Nalas) also investigated crystal growth and morphology of LLM-105 by determining the effect of different quenching solvents and the use of an in-situ probe to observe growth rates.

Wilmet (Roxel) gave a thorough presentation on the use of Resonant Acoustic Mixing (RAM) across 5 families including epoxy inhibitors and composite propellant. They were able to drastically reduce the processing times for their inhibitors and use 'one pot' mixing methodologies. The RAM mixed products also were shown to have lower batch to batch variance when testing mechanical properties. Work on 1.3 HTPB minimum smoke propellants is still in progress.

Synthesis & Ingredients

A number of programs are screening new explosive molecules for different applications. Sledd (NAVSEA) in conjunction with SERDP are investigating replacements for RDX in their minimum smoke propellants. The down selected compound was bis(4-nitro-3-furazanylamino)methane (MBANF) which has a positive enthalpy of formation (115kcal/mol), good density (1.782g cm⁻³), an oxygen balance less than RDX (-35.3%), good eco/toxicological assessment and good predicted performance (I_{sp}) in a model propellant formulation.

(Continued on page 2)



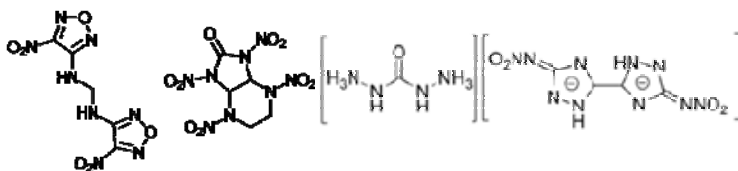


Figure 1 (a) MBANF, (b) HK-56, (c) CBNT

Price (BAe) reported on the GrIMeX program investigating replacements for Comp B. A number of compounds were reported covering aspects such as ease of synthesis, particle morphology, scalability and toxicology. Of interest was the work on 3(5),4-dinitropyrazole (DNP), 1-methyl-3,5-dinitro-1H-1,2,4-triazole (DNMT), and 2,5,7,9-tetranitro-2,5,7,9-tetraazabicyclo[4.3.0]nonan-8-one (HK-56). Morris (RDECOM) reported on the FREEDM program with its goals of finding IM compliant Octol and PBXN-9 replacements. Compounds of interest were similar to the GrIMeX program included HK-56, 2,4,6-trinitro-2,4,6,8-tetraazabicyclo[3.3.0]octan-3-one (HK-55) and carbonic dihydrazidinium bis[3-(5-nitroimino-1,2,4-triazolate)] (CBNT) showing potential as a HMX replacement. CBNT synthesis has been reduced to 3 steps with the removal of a potential hazardous intermediate. DeHope (LLNL) reported on the work at LLNL to discover and develop energetics that exceeds existing materials. The work highlighted three materials 4-amino-3,5-dinitropyrazole (ADNP; LLM-116), and two compounds based on poly oxadiazols - LLM-175 and LLM-201.

Formulations

Eck/Stenmark (Eurencor) described a new, 'simple' technique for reducing the sensitiveness of energetic materials using only low percentages of a plastic coating. The example given for HMX/Wax (98.3/1.7) and HMX/PE (98.7/1.3) showed an increase in drop hammer from 39 cm to 74 cm respectively. The formulation technique was not described but is covered by several patents which are due for release later this year.

Di Stasio (ARDECOM) discussed development of a pressable version of IMX-104 as a booster/transfer charge to reduce costs for 155mm round. The granular IMX-104 was formulated with Indramic wax (percentage not released in the presentation) and went through qualification trials. The addition of the wax improved the response to friction (128N to >360N), reduced the critical temperature (164°C to 138°C) and increased the sensitivity to shock (49.6kbar to 36.1kbar) when compared against flake IMX-104. Overall the formulation exceeded the set requirements and testing/qualification continues.

Past and present IMEMTS presentations and papers can be found on the MSIAC secure website site for your reference. Remember to visit Weblink:

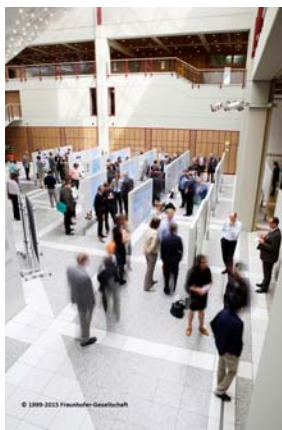
<https://weblink.msiac.nato.int/weblink>

ICT

The theme of the conference was "Energetic Materials: Performance, Safety and System Applications". The conference was well attended with 240 registrants from 22 countries; this was down on last year's conference plus a large number of overseas registrants did not travel. MSIAC nations were well represented with 10 out of 13 present; Canada, Italy and Spain were the nations not represented. Germany was very well represented with almost 50% of the attendees.

The conference was opened by the chairman, Thomas

Fisher, who gave a brief welcome address and was followed by Dr Stephan Wilker from German BAAINBw (Bundesamt für Ausrüstung, Informationstechnik und Nutzung der Bundeswehr). He mentioned that the ICT conference is an important place for research, development and connection between research, industry and procurement. He again highlighted that meetings like ICT are very important when reduced resources are affecting all nations.



One of the highlights from this year's conference was the paper delivered by de Klerk (TNO) on "In-situ tensile testing of propellant samples within SEM". The tensile testing of 1/4 JANNAF dog bones of HTPB/AP/Al propellants were performed within a Scanning Electron Microscope that allowed the researchers to observe the failure of the propellant which started via the debonding of the polymer from the large particles of AP. It was noted that only low strain rates have been tested and that the small sample size introduces error through inhomogeneity of the sample. This technique has the potential to provide a better understanding of the failure modes for propellants and PBX.

There was an in-depth study by Lamos (Brazilian Navy) on "the effect of energetic plasticizers on a glass-to-rubber behaviour of Desmophen 2200 based elastomer". The research highlighted the changes to the physical properties of the binder with change in plasticizer and the techniques (DSC, TGA, DMA and tensile measurements) used to observe the changes.

GAP and Ammonium dinitramide (ADN) featured a number of times in the conference with a couple of presentations on ADN particle morphology, which highlighted some European collaboration on energetics research. The first from Mansell (Roxel) focused on the membrane emulsification technique used to produce spherodised ADN particles. The produced particles had a mean particle diameter $D_{50} = 25 - 32\mu\text{m}$ (condition dependent) which were a factor of 4-5 smaller than a Eurencor comparison batch. Of the hazard data reported the Figure of Insensitiveness (Fol) for the emulsion processed ADN was less sensitive than the raw needle-like ADN. The second paper was from Liljedahl (FOI) covered a number of techniques for processing ADN including emulsion prilling, spray prilling using a prilling tower and pressurised spray prilling. The merits of the latter technique were justified in reduced processing hazards, better control over particle size and morphology and anti-solvent recovery. Work was still on-going into producing ADN particles with 100% TMD.


The posters were equally of interest with topics ranging from synthesis, particle morphology to testing and ageing. The winners of the posters are highlighted in Table 1. There were several well informed posters on display. The poster by Jin Kim (ADD) showed results from the synthesis of a new energetic gem-dinitro alkyl ester with good plasticizer properties, miscibility with HTPB and low solubility for RDX. The presence of the nitro groups should provide a degree of interaction (bonding agent) with the energetic fill and increase wettability. Work is still on-going to test the performance



of the binder and a RDX/binder formulation.

The poster presented by Dejeaive (PB Clermont) on their continued work towards replacing anti-oxidants and plasticisers in SB and DB propellants. The work shows promise with good results for the HFC for both SB and DB propellants. Of the commercially available compounds declared including 1,2,3-trimethoxybenzene, 2,3,5-trimethylphenol, curcumin and α -tocopherol all showed effective stabilising ability for DB propellants containing up to 40% nitroglycerine. This work compliments that of Goede (FOI) and their work on Stab-5, 1,1'-[1,2-ethanediylbis(oxy-2,1-ethanediyl oxy)]bis(2,6-dimethoxybenzene, containing stearyl hindered benzene rings available for nitration. The work presented included burn characteristics for a propellant using the stabiliser, a new scale up procedure for the material, and some theoretical toxicity determination of the by-products using TEST.

It was noted that more presentations, at both ICT and IMEMTS, now include toxicological considerations, be it theoretical or experimentally, as part of the development process rather than an after thought.

Author	Title	
Peng-Yuan Chen et al (Nanjing University of Science and Technology)	Theoretical Study of BTF/TNA Cocrystal: Effect of Hydrostatic Pressure and Temperature	
C. Schragen et al (Dynamit Nobel Defence GmbH)	Cast-cured Explosive Applied in a Subsonic Penetrator for Shoulder-launched Weapons	
Joern van Keuk et al (Fraunhofer Ernst Mach Institute)	SIMIB: A New Lumped Parameter Code for Interior Ballistics Simulations	
Veronica Kuchenreuther-Hummel et al (ICT)	Kinetics of Aluminum and Magnesium in Nitrogen	
Jutta Boehnlein-Maus et al (ICT)	Influence of Different Plasticizers on the Glass Transition Temperature of Mixtures with Energetic Thermoplastic Elastomers	

Webinar Series

SERDP and ESTCP have launched a series of webinars to "promote the transfer of innovative, cost-effective and sustainable solutions developed through funded projects". The funded programs cover five areas including Munitions Response and Weapons Systems & Platforms. The most recent webinar, held on 16th July 2015, was entitled "Sustainable Pyrotechnics: Flares and Projectiles" with presentations from Dr Eric Miklaszewski (NSWC, Crane) and Dr Jared Moretti (ARDEC, Picatinny). The topics covered by both presenters showed the research efforts to replace perchlorates (both potassium and ammonium salts) from flares and incendiary compositions.

The flare program focused on increasing the weight percentage of barium and strontium nitrate in the formulations to generate the green and red light respectively. In order to achieve the required wavelength and colour intensity a source of chlorine, PVC, was still required and a change was made to the binder material using an epoxy cure (Epon/Versamid) system. Some of the reported compositions have been qualified for Navy and Army use (Mk124, M126A1) and meet the current performance requirements. Other research is being carried out into high nitrogen organic compounds and ceramic fuels but further details were not reported in the presentation.

The incendiary work focused on sodium periodate, as the oxidiser, with magnalium to replace the current formulation of barium nitrate, potassium perchlorate and magnalium. The performance of the incendiary composition was affected by the bulk properties of the formulation, the density of the formulation when pressed into the round and the presence of any processing aids (Cab-O-Sil® or calcium stearate). The work showed that the replacement oxidiser was able to achieve the required criteria for the M8/Mk257 round.

The presentation and other past presentations, including audio, from the presenters are available on the SERDP site: <https://www.serdp-estcp.org/Tools-and-Training/Webinar-Series/07-16-2015>

Future presentations of interest to the community include **Munitions Response: Water Geophysical Sensors** (17th September 2015), **Assessment and Treatment of Contaminated Sediments** (29th October 2015) and **Munitions Response: Land Based Program Closeout** (12th November 2015). Registration is required prior to the event in order to listen live and interact with the webinar.

Forthcoming Meetings

There are a number of energetics related meetings planned for the remainder of this year and 2016. Follow the links to the respective event for further details.

Date	Event	Location	Website
8-10.09.15	9 th International Heat Flow Calorimetry Symposium on Energetic Materials	Tampere, Finland	www.hfcs2015.com
21-25.09.15	15 th International Symposium on Fireworks	Bordeaux, France	www.isfireworks.com
09-11.11.15	Parari 2015	Sydney, Australia	www.parari.com.au
End of April '16	MSIAC Workshop: Science of Cook Off	East Coast, USA	www.msiac.nato.int
17-18.05.16	New Energetics Workshop 2016	Stockholm, Sweden	POC: Patrick.goede@foi.se
31.05-01.06.16	7 th International Nitrocellulose Symposium	Montreal, Canada	http://www.ncsymposium2016.ca/
05-10.06.16	Cordon Research Conference on Energetic Materials	Stowe, USA	http://www.grc.org/programs.aspx?id=11248
28.06-01.07.16	47 th ICT	Karlsruhe, Germany	http://www.ict.fraunhofer.de/en/conferences/conferences/annconf.html
10-15.07.16	42 nd International Pyrotechnics Society Seminar	Grand Junction, USA	

Dr Matthew Andrews
MSIAC Energetic Material Specialist



AC/326 SG/A: TEST METHODS APPLIED TO CHEMICAL COMPATIBILITY

The NATO sub-group for energetic materials (AC/326 SG/A) has requested MSIAC support with hosting discussions surrounding chemical compatibility. We are looking to the NATO community, academia, industry and government, with expertise in carrying out compatibility



testing associated with energetic materials, to join in discussions on the following topics:

- ⊕ Understanding of the chemistry and physical phenomena related to chemical compatibility
- ⊕ Understanding of the interaction between the energetic material and contact material
- ⊕ What are the limits of the test methods
- ⊕ Are the current tests still applicable?
- ⊕ Are additional techniques available?
- ⊕ Do the techniques achieve the required accuracy and precision?

Benefits

- ⊕ Provide awareness to member nations and AC/326 members of current techniques used in compatibility
- ⊕ Input could be used by custodian nation of STANAG 4147

MSIAC has set up a file sharing site, ShareFile, whereby participants can upload and download literature relating to test methods, chemical interaction and energetic materials compatibility and incompatibility. ShareFile is hosted on the MSIAC servers and will require access credentials.

A discussion board will be opened in September to those who have shown interest in participating. Should you be interested in participating please contact:

Dr Matthew Andrews
MSIAC Energetic Material Specialist
m.andrews@msiac.nato.int



MSIAC
Shaped Charge Jet Workshop Final Reports
are now available

The final reports from the 2014 SCJ workshop are now available in the MSIAC database. The comprehensive report is **L-186 "MSIAC FINAL REPORT ON THE 2014 SHAPED CHARGE JET WORKSHOP"**. It documents the entire workshop and contains appendices for all the presentations, break out sessions, and results from the workshop. The entire report is over 700 pages, think twice before printing it all! The reports from each of the break out sessions are also available as a stand alone documents, as well as being linked into the main report. The comprehensive & individual reports are :

- L-186 MSIAC Final Report on the 2014 Shaped Charge Jet Workshop**
- L-188 Detonics & Response Mechanisms**
- L-189 Small Scale Testing**
- L-190 Modeling**
- L-191 Test Set-up**



EXPLOSIVE HAZARD DATA SHEETS (EHDS)

In a recent survey on the Energetic Materials Compendium (EMC) we received feedback asking whether Material Safety Data Sheets (MSDS) or Explosive Hazard Data Sheets could be incorporated into the product. We have started this process for non-energetic materials by creating a link within the references for each material. This link points directly to our WebLink repository therefore when logged into EMC (and the Portal) you will be one click away from the data.

We do, however, not have a full record of MSDS or EHDS for a number of energetic materials, both ingredients and compositions. If you are a manufacture of energetic materials and are able to share this information with us then please get in touch. Any documents received will be held on our secure server and access will be available only to all registered and approved MSIAC members.

Please email the Energetic Materials TSO with any submissions or further questions/clarification:
m.andrews@msiac.nato.int

Dr Matthew Andrews
MSIAC Energetic Material Specialist



All PUBLICATIONS on can be found in the **Technical Reports** section on our **Secure Web-environment** via this **hyperlink**.

More Publications

(Available on the MSIAC secure webenvironment
<https://sw.msiac.nato.int/SecureWeb/> or on request at info@msiac.nato.int)

OPEN PUBLICATIONS

- O-159 Review of the Fragment Impact Test**
- O-160 Shaped Charge Jet Workshop**
- O-161 Case Study: Transport & Storage of IM**
- O-162 EUROPYRO 2015: Intergrated MHM**
- O-163 Environmental Impact of Munitions Life Cycle: A Case Study using Composition B**
- O-164 MSIAC Supporting Munitions Safety Community**
- O-165 MTM**



SCIENCE, TECHNOLOGY AND PROCUREMENTS

If you have information that you consider of relevance to this section, contact MSIAC at info@msiac.nato.int.

The Procurement and Munitions Business Activities section begins with report on Lockheed Martins purchase of Sikorsky Aircraft, Germanys decision to proceed with MEADS in their Tactical Air Defense System, while Turkey now further contemplates negotiations with China for their missile defense system. Significant munitions procurements from the last three months, spanning re-procurements for traditional systems to the latest equipment, are then also mentioned.

The Science and Technology section includes recent accomplishments and system redesigns, including two interesting laser weapon systems demonstrations by MBDA and Lockheed Martin. This issues concludes with an excellent article on 3D printing and adaptive manufacturing: "Machines Building Machines". The article estimates that researchers have already printed 80 percent of the components that go into a modern missile system, including printed energetics, warhead and seeker components, rocket motors and electronic circuits.

 [Click here to read more.](#)

Manfred Becker
MSIAC Warhead Technology Specialist

FAREWELL ... FROM MANFRED BECKER

I cannot believe three years at MSIAC has come and gone so quickly. Coming to Europe, learning so many new things, and certainly experiencing such a varied kaleidoscope of work and personal adventures was beyond my expectations. Of course, doing the SCJ workshop with many of you in Brest France was a highlight. As was Parari, and the following week of briefings and eating Thai food with Matt, Emmanuel and our host Chris McGregor. Participating with the fantastic team working to incorporate an entirely new process into the Fast Cook Off standard was interesting, challenging and let me see parts of Sweden beyond the "happy swamplands". There were parts of this job that really were fun – and most of that was due to the people I got to know. Keeping up with Science and Technology has made the years fly by. Who would have believed 3 years ago the price of oil would drop in half, Russia/Ukraine/ Crimea would evoke (pre?) cold war memories, or that 3D printing, RAM (Resonant Acoustic Mixing), laser weapons and little UAVs would develop to their current state. Even just working at NATO HQ has opened my eyes to a whole new world... but really, I can do without the Nth review in Sub Group meetings to approve NATO terminology terms. Seriously. That's worse than walking around Canada in February when it's -25°C. Been there, done that too.

I know that MSIAC has interviewed an exceptional panel of applicants for my replacement, and whomever takes over, you will be extremely pleased with their knowledge

and abilities! The best for this office is just around the corner.

Beyond work, having the chances to travel throughout Europe, including up into Scandinavia, over to Eastern Europe, skiing in Italy with the NATO ski club, and even a few incursions into Africa, was amazing. And biking in Belgium, combined with its selection of beers, is certainly different than back in California!

As of this September, I'm trading in my suits and wingtips for a dive suit and bike clips (most of the ties I got rid of already...) From the bottom of my heart, I want to say how much I've enjoyed working with so many of you. I wish you all the best and look forward to hearing about the many great things you'll all accomplish in the coming years. Feel free to contact me at manfred.fred.becker@gmail.com and let me know when you come to California... or Fiji, or just want to share a drink, go for a dive or a bike ride, tell stories or ...

Cheers,

Manfred Becker
MSIAC Warhead Technology Specialist



AND WELCOME TO WADE G. BABCOCK

Wade Babcock will join MSIAC this month as our new *Technical Specialist Officer for Munitions Materials Technology*.

Prior to that he was at the US Naval Surface Warfare Center in Indian Head, Maryland. In the more than 15 years there, he most recently led the Weapon Effects and Analysis Branch, in addition to other technical project stewardship and engineering work. Wade has worked in the areas of munition materials, sensor integration, weapon/target effects, and modeling & simulation.

One of the highlights of the past ten years was his participation in a NATO Applied Vehicular Technology Panel technical exchange group on the topic of munitions health monitoring. The AVT panel is part of the NATO Science and Technology Organization, and from 2007-2011 Wade was the co-chair of the munition health monitoring task group and helped prepare a report on the state of the art in the technology.

Wade completed a bachelor of science degree (1993) and a master of science (1995) at North Carolina State University in Materials Science and Engineering with a minor in Industrial Design, and holds a green belt in Lean Six Sigma.

Current areas of specific interest are understanding and modeling the long term material degradation in munition systems, application of novel sensor technologies to capturing environmental exposure and explosion effects, and health management of "perishable" munitions inventory items whose safety, service life, or performance is affected by exposure to heat, cold, humidity, chemicals, etc.



MSIAC ALSO WELCOMES 2 TRAINEES FROM ENSTA

MSIAC was also happy to welcome 2 French students from post-graduate state engineering school ENSTA Bretagne, based in Brest (France), which belongs to the DGA (Direction Générale de l'Armement). They started here on 8 June and will work here until 14 August 2015.

The school gathers military and civilian students from all parts of France, upon results of a national entrance examination. Military students are intended to become IETA (national engineers for armament).

Thibaut and Grégoire are in the 2nd year of engineering classes and at the end of the 3rd year, they will graduate with a Master degree of Engineering diploma in Mechanics, with specialty in Energetic Materials. They are attending a 10-week internship within the MSIAC division, of which the main field of expertise perfectly matches their specialty.

Thibaut Balay will work on the effect of ageing upon insensitive munitions



Currently, the IM and HC tests are performed on brand new munitions. But with age, the characteristics of the energetic material will change with a potential effect on the response to the HC/IM threats. Work has been reported from studies conducted independently or as part of the EDA or TTCP efforts.

Thibaut will create a review document which covers these studies and summarizes the findings. His second objective is to exploit this work for the wider safety ageing issues. Evolutions of the properties of the energetic material with ageing has been studied (especially the sensitivity of EM) and it will be beneficial to link these evolutions with the potential changes of the response of the munitions to the HC/IM tests. This work will provide MSIAC nations with a state of the art on the effect of ageing upon insensitive munitions. The benefits will be to gain an understanding of EM reaction after ageing and to identify the gaps in this knowledge.

Grégoire Jacquemin will work on small scale tests related to cook-off



Each munitions needs to comply with the NATO Insensitive Munitions specifications.

Specifications mean favourable responses of the munition to many threats (mechanical, thermal, operational...). In this purpose, many tests are performed to identify the response of munitions to the thermal

threat. These tests consist in heating a sample at different heating rates (from 10's °C/hr. to 10's °C/s).

However testing the munition with a full scale experiment is expensive and can be a very long process. That is why some tests have been developed to test small samples of energetic materials used in munition. Grégoire will create a review document which will present all these tests thanks to a in-depth review of literature and models

regarding cook-off of munitions. This could include: fundamental reaction mechanisms, test methods and collation of data from the MSIAC database. This task would involve helping prepare background information and technical reports on cook-off for the MSIAC community.

If you are interested in these 2 topics and/or would like to contribute, please feel free to contact MSIAC: e.schultz@msiac.nato.int or m.andrews@msiac.nato.int.

Our trainees do not only take their assignment at MSIAC very seriously, but also found it their duty to help the IS (International Staff) win the 19th MILREP Annual Football Tournament. About 20 teams participated: different national delegations, the IS and the NATO Staff Center and this time, the IS team took home the cup!

As you see, its not all work and no play.



Do not forget...

IM Response Descriptors meeting
NATO HQ, Building Z
meeting room W142
on
21-22 September 2015!

MSIAC WISHES YOU ALL ...

