

ACDA2060 written summary

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Figure 1 Corroded 9mm ammunition [12]

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Advanced Chemistry ACDA2060

TECHNICAL SUMMARY

ACDA 2060

1. Introduction

Presentation title: Chemical Compatibility and Decomposition Pathways in Energetic Materials

Technical summary section to be reviewed: Stabiliser Chemistry.

This technical summary will be reviewing the key concepts covered, any supporting technical explanations, as well as reviewing the relevance to OME lifecycle chemistry in the stabiliser chemistry section of the named presentation.

2. An introduction to stabilisers

Slide 1 of this section describes explosive stability succinctly expressing 'Explosive stability could be described as: An explosive material that can be transported, handled and stored under normal conditions without undergoing unintended initiation' [1]. While slide 2 covers what stabilisers are and how they work, as chemical additives that impede the natural decomposition of energetic materials. As seen in figure 2 with the addition of the following information:

What are Stabilisers

- The stabilisers used in explosives are chemical additives that impede the natural, spontaneous decomposition of energetic materials.
- The stabilisers achieve this by actively participating in chemical reactions
- These stabilisers work primarily by foraging decomposition products such as acids and nitrogen oxides regarding explosives within the nitrate ester group.
- Without these stabilisers the decomposition products would cause an autocatalytic effect. This effect can be either one or a combination of the mechanisms Jess has explained.
- This differs from plastic explosives and PBXs where plasticisers and binders are used to desensitise the explosives*

[1] [2] [3]

Figure 2 Slide 2 of Stabiliser Chemistry Section [1] [2] [3]

The presenter explained some of the explosives found in the nitrate ester group consisting of: NG, NC, NQ, PETN, EDGN and ETN. An example of SEMTEX was used describing the use of PETN within SEMTEX. PETN is within the nitrate ester group of so is susceptible to the same degradation mechanisms, however PETN is much more chemically stable than the propellants in the same group due to the specific structure of PETN, this process is slower under normal conditions.

It was highlighted that desensitising and stabilisation are chemically different mechanisms, where stabilisation is where chemicals are actively participating in chemical reactions, PBXs differ often though additives that 'fill the gaps' surrounding the explosive particles and then plasticisers that then make this new material malleable. Although it is still important to remember that some polymers found within PBX's are susceptible to hydrolysis, a degradation mechanism stated earlier within the presentation [1] [2] [3].

3. Common stabiliser types

Slide 3, figure 3, It was explained that the most used stabilisers for the nitrate ester group belong to the aromatics functional group. More specifically aromatic amines and aromatic urea derivatives. The amount used is typically 1-5% of the propellants mass. [4] [3]

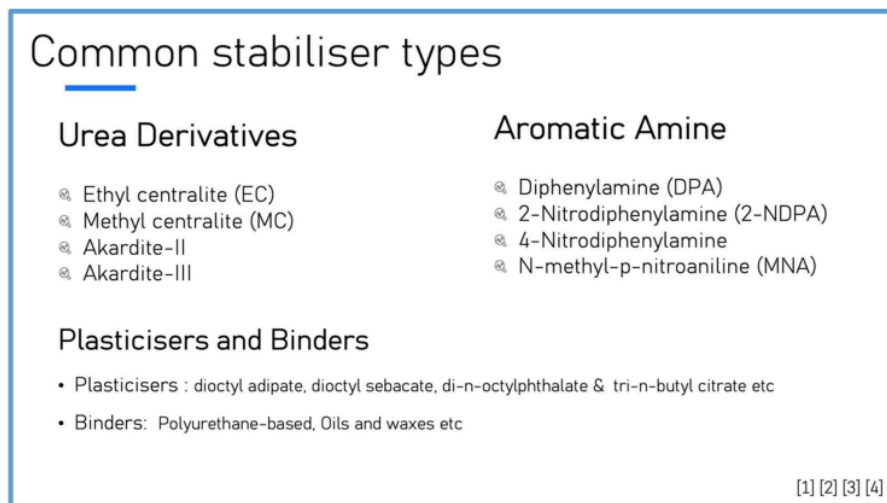


Figure 3 Common stabiliser types [3] [4]

Again, plasticisers and binders were mentioned with a reiteration that the explosive compositions that utilize them are typically more chemically stable so don't require the same mechanism of stabilization. Plasticisers can be explosive and both plasticisers and binders can go through their own separate age/storage related breakdown.

4. Simplified Mechanism of Action

A simplified diagram of the mechanism of action displayed on the slide seen in figure 4, although not an indicative representation the diagram displayed is an easy-to-understand, broad explanation of

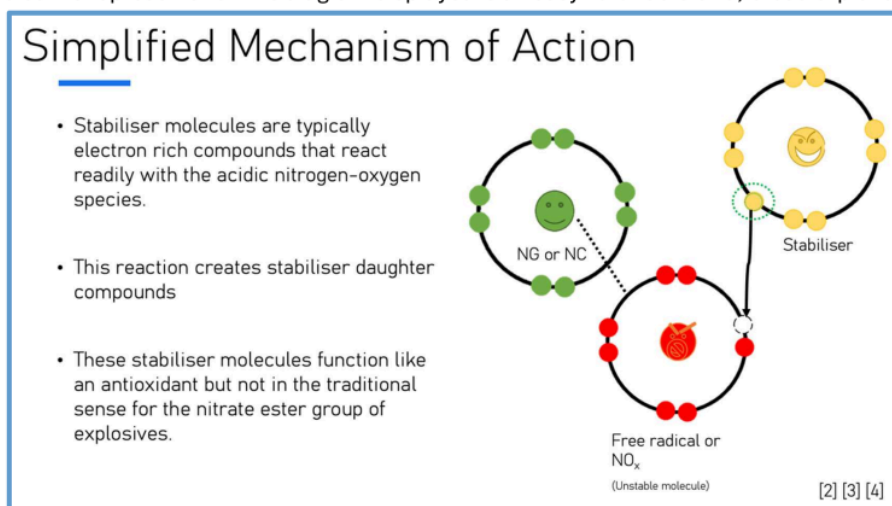


Figure 4 Slide 4 a simplified mechanism of action [2] [3] [4]

how the aromatic amines and aromatic urea derivatives previously mentioned interact with the nitrogen oxide radical breakdown products, this reaction forms what is known as stable daughter compounds. The molecules function like an antioxidant but not in the traditional sense for the nitrate ester group of explosives, however antioxidants are added to PBX's and plastic explosives [2] [3] [4].

5. Case study

The case study covered looked at nitrocellulose and stabilisers ethyl centralite (EC) and diphenylamine (DPA). To understand the reactions of EC and DPA there must firstly be an understanding of the breakdown process of nitrocellulose. Seen on slide 5, figure 5.

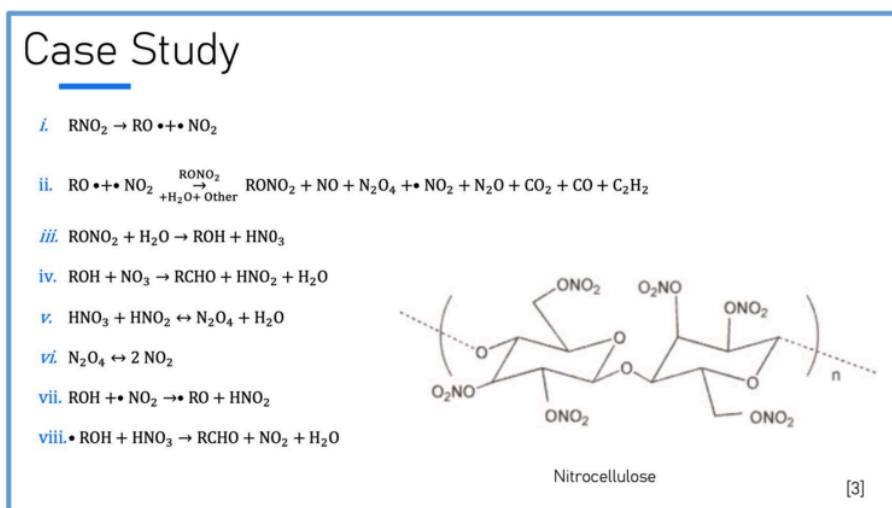


Figure 5 Slide 5 NC decomposition process [3]

The NC decomposition process involves a series of complex reactions that produce nitrogen oxide, nitrogen dioxide and free radicals consisting of alkoxy radical and methylene. The nitrogen oxides produced then react with the remaining moisture in the NC forming nitrous (HNO_2) and nitric acids (HNO_3). This is primarily thermolysis and hydrolysis, initiating in reaction 3&4 with propagation from reaction 5 onwards seen in figure 5.

Slide 6, figure 6 explains in depth the absorption interaction between NC and DPA, with DPA bonded to the NC matrix.

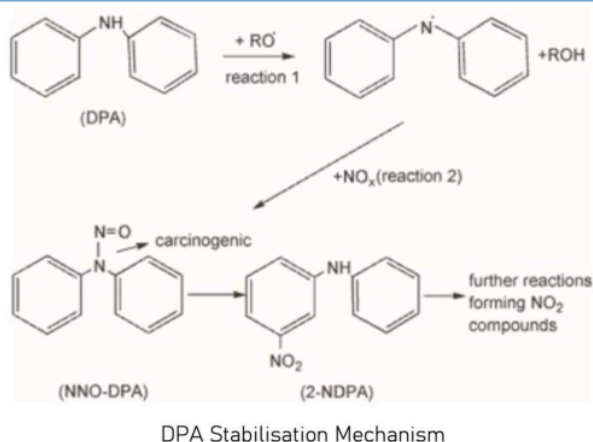
A free radical alkoxy group originating from the NC, reaction 1 in figure 6, abstracts hydrogen from the amine group of DPA resulting in the formation of a stable ROH compound. An ROH compound is a compound containing a carbon-hydrogen chain within the hydroxyl functional group. Another reaction forming stable N-nitroso diphenylamine (NNO-DPA) occurs through the reaction between the radical formed on the amine and nitrogen oxide, reaction 2 on figure 6. Additionally, the interaction between NO_2 in NC and DPA forms nitramine, which is unstable and further degrades into derivative 2-nitro diphenylamine (2-NDPA). These daughter products can also act as stabilisers [3].

Case Study

Diphenylamine (DPA)
absorbs NO_2

Transitioning into
derivatives of:

- C-nitro
- N-nitroso



[3]

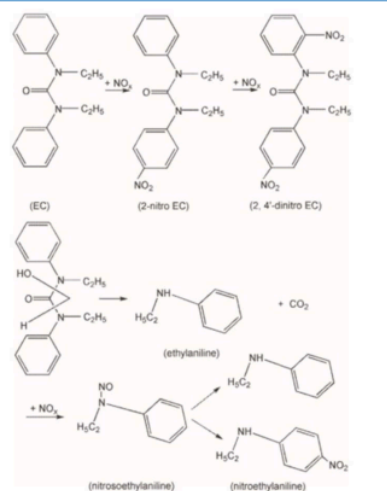
Figure 6 Slide 6 DPA Stabiliser [3]

Ethyl centralite reacts with the nitrogen oxide species of breakdown products of NC by nitrosation with the nitro reactions like DPA, but the nitro substitution occurs with a preference for the ortho and para of the phenyl group, so where it is situated on the benzene ring, while a phenol group is a hydroxyl (-OH) group directly attached to a carbon atom in an aromatic ring. The depletion of EC will break an aromatic ring, and its molecules will be hydrolysed by water in an acidic medium simultaneously. Once this urea bond is split, monoaromatic derivatives will be formed, resulting in the formation of ethylaniline and the release of carbon dioxide (CO_2) [3] this can be seen in figure 7, slide 7.

Case Study

Ethyl Centralite Stabilisation
Mechanism

Nitro substitution similar to DPA
but with a preference for the
ortho- and para of the phenyl
group



[3]

Figure 7 slide 7 Ethyl Centralite stabiliser [3]

To conclude this section a comparison between the two stabilisers was performed and displayed on slide 8, figure 8. DPA is shown to be carcinogenic and ethyl centralite is less toxic during production and handling, there have been studies showing daughter products of EC are more toxic than DPA and vice versa. It was explained how EC increases thermal stability by increasing the activation energy while DPA works well without affecting performance, however due to the bonds formed between NC & DPA that can't seem to be separated makes detection and future lifecycle monitoring difficult. A key point to note is that DPA can only be used with single based propellants due to its

incompatibility with nitroglycerin. It was also highlighted that both stabilisers will be consumed over time, once it has all be consumed the normal degradation process will occur as explained by the colleague in 'degradation mechanisms', section one of the presentation. [5] [6] [7]

DPA Vs EC		
Stabiliser	Positives	Negatives
DPA	Stabilises NC well Doesn't affect NC performance	Daughter products carcinogenic, mutagenic, and toxic to both humans and animals
	Daughter products also act as stabilisers so increase shelf life	Difficult to monitor so Difficult to predict shelf life
		ONLY compatible with SB propellants
Ethyl Centralite	Improves thermal stability	The formation of CO ₂ cause cracking contributing to further degradation
	Reduced Toxicity when compared to DPA*	
	Acts as stabiliser and plasticiser	
	suitable for single, double & triple based propellants.	

[6] [7] [8]

Figure 8 slide 8 stabiliser comparison [5] [6] [7]

6. Lifecycle and Environment

Figure 9, slide 9 demonstrates the the need and current push for 'green stabilisers' some studies have found mass bio accumulation in soild of both EC and DPA in the surroundings of military bases, this relivant to waterways due to the toxicity of both stabilisers to aquatic environments while DPA is an EU priority pollutant, EC still had longterm adverse affects [5] [6] [7] [8] [9] [10].

Lifecycle & Environment			
Stabiliser	Human	Animal	Environment
DPA	Acute toxicity	Acute hazard to aquatic environment	Long lasting cumulative affects
	Target organ toxicity		EU Priority pollutant
	Carcinogenic derivatives		
Ethyl Centralite	Harmful if swallowed	Harmful to aquatic organisms	Long term adverse affects
	Low toxicity		
	Derivatives found to be more toxic* than DPA		

[8] [9] [10] [11]

Figure 9 Slide 9, environmental impacts of stabilisers [5] [6] [7] [8] [9] [10]

7. Closing slide and overview.

Figure 10, slide 10 shows a simple overview of what stabiliser to use when while highlighting the key point that these pairings may not always work, like DPA can only be used with single based propellants, not all stabilisers are compatible. This section was then handed to a colleague to continue the 'compatibility testing methods' section of the presentation [3] [4] [5] [11].

What Stabiliser Where?		
Degradation mechanism	Example stabilisers*	Mechanism of action
Autocatalysis / Oxidation / Hydrolysis	Diphenylamine Centralites & Akardites	Aromatic amine and aromatic urea derivatives halt the autocatalysis cycle by essentially removing the catalytic species of NO _x
Mechanical	* Hydroxyl-terminated polybutadiene (HTPB) Fluoropolymers	Used to bind explosives together, with the addition of the plasticiser to dramatically reduce brittleness

[7][8]

Figure 10 Slide 10, Overview [3] [4] [5] [6] [11]

This group did well to cover and explain the process from degradation to stabilisation and then to testing and monitoring, the simple explanations with a deep dive into nitrate esters was key to the easy to follow and understand the theories of the chemical reactions within the real-world environment of energetics. The whole presentation was clear and flowed well from one presenter to the next following the same pattern, so it was easy to understand.

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FINAL GRADE

59/100

GENERAL COMMENTS

Engagement with Literature 11.5/15

You used a range of relevant sources, including peer-reviewed journal articles and technical references, and IEEE referencing was generally applied correctly. This demonstrates awareness of the research base surrounding stabiliser chemistry. However:

.
Some statements in the presentation are not clearly supported by references.

.
In the reflection, literature is often reported rather than critically engaged with.

.
The inclusion of non-academic sources (e.g. anecdotal web content) weakens academic judgement.

To improve: Focus on using literature to justify choices, compare alternatives, or challenge assumptions, rather than simply citing it to support factual statements.

Knowledge and Understanding 12/20

You demonstrate recognition of relevant chemistry (e.g. DPA and ethyl centralite mechanisms, NO_x scavenging, degradation pathways), and the material is clearly related to OME systems rather than generic chemistry. However:

.
Explanations are often unclear or imprecise, particularly when delivered verbally.

Terminology is sometimes used inconsistently, and key ideas are read directly from slides without confident explanation.

Reactions are shown, but understanding of what they imply chemically is limited.

In the reflection, mechanisms are explained but not developed beyond description (e.g. no discussion of kinetics, activation energy, or temperature dependence).

To improve: Aim to explain why reactions occur and why they matter, not just what happens. At L6, chemical mechanisms should be interpreted, not just presented.

Cognitive and Intellectual Skills 12/25

You attempted to compare stabilisers (e.g. DPA vs ethyl centralite), which is appropriate, but the comparison remains largely descriptive. Analytical depth is limited, and explanations of trade-offs (toxicity, compatibility, monitoring difficulty) are not always clear.

The reflection shows awareness that stabiliser selection involves trade-offs, but:

There is little evaluation of which factors dominate decision-making and why.

Limitations, uncertainties, or conflicting literature are not explored.

The reflection does not

critically assess the chemistry or your understanding of it.

To improve: Move beyond “what each stabiliser does” to why one may be preferred under specific OME conditions, and what compromises this involves.

Practical Application Skills 14.5/25

Your work is clearly grounded in real OME contexts, including storage, degradation, safety, and environmental impact. The use of case studies is appropriate, and the chemistry selected is relevant. However:

Application remains general rather than operational.

There is little discussion of how stabiliser chemistry informs real decisions (e.g. monitoring thresholds, shelf-life prediction, compatibility testing).

The reflection does not clearly show how this knowledge would be applied in professional OME practice.

To improve: Explicitly link chemistry to real-world actions, such as inspection criteria, stabiliser depletion limits, or disposal decisions.

Transferable and Reflective Skills 9/15

Your presentation delivery was confident and engaging, with good structure and time management. However:

.

There was heavy reliance on reading from slides and notes.

.

Mispronunciation and

hesitation reduced clarity when explaining technical content.

The reflective account does not fully meet the expectations of a reflection as it largely restates technical content from the presentation.

The writing answers “what was covered” rather than “what was learned and why it specifically matters in OME”.

PAGE 1

PAGE 2

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PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8

PAGE 9
