

Chemistry Assignment

by Luke Reidy

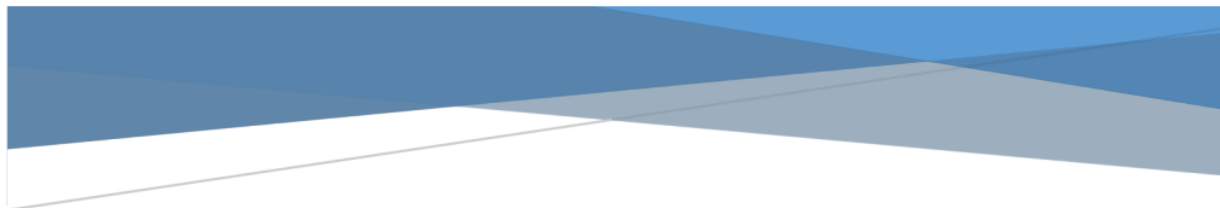
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THE EFFECT OF WATER ON SOME ARTICLES AND SUBSTANCES

Abstract

A ~2000 word report aiming to explore the various chemical effects that water has on explosive articles and substances.

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Introduction

This report seeks to explore the ever-present threats and effects that water, in all its forms, poses to the safe operation and successful use of explosive materials and articles. This report will explore the various interactions that water can have with explosives and munitions, the effects this has on the functioning of the articles, and the potential solutions that can be implemented to reduce or prevent this effect.

What is water?

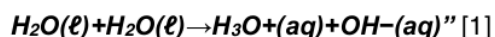
First, we will establish what water is, and the common forms of water that we, and our materials, will interact with. Water is characterised by the bonding of two Hydrogen atoms, and one Oxygen atom, making H_2O . It exists on Earth mostly in liquid form, either as sea water (containing salt), fresh water, ground water, and rain water. It also exists as a solid, in the form of ice, which is more common at high/low latitudes and high altitudes. Finally, it exists as a gas, water vapour, which is measured as humidity according to its density in the air around us. Water in all of these forms can present different issues towards munitions and explosives, whether it be the direct reaction of water with energetic compounds, the freezing of water molecules within a mixture or on the container, or the oxidising reactions with water molecules in vapour form. 

 3  An important chemical aspect of water is its polarity. The two hydrogen atoms in water are positively charged, and the oxygen atom is negatively charged, as such:



This has the effect of attracting other water molecules, as the slight positive charges of the hydrogen attract the slight negative charges of the oxygen, even in other molecules.

Another property of water is that it is generally pH neutral – it is neither an acid nor a base, sitting at ~7 on the pH scale. It is known as an ‘amphiprotic’ compound, as it can both accept and donate a proton, allowing it to act as an acid in some reactions, or a base in others. “About 6 in every 100 million (6 in 108) water molecules undergo the following reaction: 



Understanding this about water allows us to better understand some of the ways it may interact with the materials in question – as a result of this ‘auto ionization’, water becomes an impure and mixed substance, which provides more potential for additional reactive compounds or corrosive properties to emerge.

What Makes Up an Explosive?

The essential items for an explosive are a fuel, such as carbon or sulphur, and an oxidiser, such as potassium nitrate. Together, the mentioned chemicals make up gunpowder, which deflagrates according to the following simplified equation:



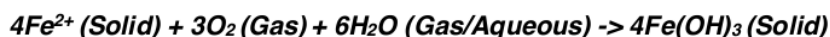
Potassium Nitrate (Solid) + Sulphur (Solid) + Carbon (Solid) → Potassium Carbonate (Solid) + Potassium Sulphate (Solid) + Carbon Dioxide (Gas) + Nitrogen (Gas)

It is specifically the fast expansion of the gas parts of the equation which causes the 'explosive' effect. The effects of gunpowder is fairly low compared to many modern explosives. It does not detonate (meaning expansion faster than the speed of sound).

The effects of Rust on OME Articles

Water will almost always need to be considered as a potential issue when it comes to using OME materials, due to the presence of water molecules in the air, in the form of vapour. Water vapour induces/catalyses the oxidation of iron and iron-related metal compounds, causing iron oxide build-up also known as rust. Rust can have a wide range of negative effects on our explosive articles, mostly affecting the structural integrity and environmental sealing of the article, which leads to further negative effects and can enlarge the exposed surface area, promoting further and deeper rust, and causing direct contact between the explosive substance and water, and potentially other compounds.

The formula for the oxidation of iron can help us understand how iron degrades into rust through exposure to regular and common elements:



Rust can be a serious problem for the safe storage of explosives. Over time, containers affected by rust will lose their environmental seal, allowing for dust and foreign materials to enter the containers. Additionally, a structurally compromised container will be far less likely to prevent sympathetic detonation, increasing the severity of a potential accidental detonation due to the lack of proper containment.

The results of this rusting, even on insensitive munitions, can range from corroded bullets becoming stuck within firearms, causing blowbacks or misfires, to the spilling of toxic explosive chemicals into the environment, or even resulting in an explosive incident due to the exposure.

We can reduce the effects of rusting through ensuring we galvanise the iron, usually in the form of painting with a primer. This protects the surface iron from reacting with the oxygen in the air. We can also ensure we have humidity controls in place in our storage facilities, and that the interior climate is measured appropriately.

Water with Hygroscopic Chemicals

A 'Hygroscopic' chemical is a substance which absorbs water, "forming a saturated solution." [2] The result of this is the formation of crystals if enough water is absorbed, which can result in a change in the sensitivity and reactivity of explosive compounds.

One such compound is Acetic Acid, a precursor to TATP and HMTD.

Another hygroscopic compound is Barium Nitrate, a precursor compound which can cause an explosion if mixed with "ammonium nitrate, charcoal, thermite, sulphur, combustible substances or acids."

Once a compound has been saturated with water, this water will absorb some of the heat generated by the explosion, and "[act] as a solvent medium that can cause undesired chemical reactions."

[3]

So, on top of the issue of rusting, water also saturates some of our compounds, rendering them less stable, less effective, and decomposing them, whilst also rusting the containers that hold them. We must ensure, as mentioned earlier, that properly galvanised and managed storage solutions are used.

Another aspect we would like to talk about is Polymerisation. These reactions occur when two monomers combine to form polymers, and water or Hydrochloric acid molecules. Within the context of an explosive, it can be very dangerous and cause condensation or build-up of compounds in other parts of the container, such as underneath the lid, making the container a hazard.

The Effects of Water on Black Powder

According to HSE's ER2014, "Water and moisture can be incompatible with some of the ingredients of explosives and can affect the sensitivity of explosives." and so it should, in most cases, be a managed aspect of your storage environment. This was something that powder-mills had to take care of, ensuring that their gunpowder was only damped just enough to make it safer to work with, but not too much that it reduces the effect.

If Black Powder comes into contact with water, it can become permanently ruined and no longer function as an explosive, due to the presence of Potassium Nitrate, also known as Saltpetre. Potassium Nitrate is the oxidiser for black powder, and is also soluble in water, meaning when gunpowder comes into contact with water, the oxidiser is removed from good contact with the fuel, and cannot deliver its oxygen for the reaction as effectively. However, a small amount of water can have almost the opposite effect:

"The mix was dampened with alcohol or water during grinding to prevent accidental ignition. This also helps the extremely soluble saltpeter to mix into the microscopic pores of the very high surface-area charcoal." [4]

The Effects of Water on ANFO

ANFO becomes far less effective, and even completely non-explosive, if it comes into contact with water. This is due to the opposite interactions with water between the oxidiser and the fuel components of the explosive - the oxidiser becomes wet, but the fuel is hydrophobic, causing the fuel to repel the oxidiser. In this state, the explosive is far less effective, and requires far greater initiation, and will produce far less of an explosive effect. It is also likely to produce toxic compounds.

ANFO is also Hygroscopic, so it will absorb moisture from the air over time - "the Nitrogen is in two very water soluble forms, ammonium (NH_4^+) and nitrate (NO_3^-)

ions. ANFO has no water resistance, therefore its Nitrogen is readily soluble if exposed to water." [5]

The effects of water on Dynamite

Dynamite, invented by Alfred Nobel in 1867, is a conventional explosive "made of Nitro-glycerine, sorbents (such as powdered shells or clay) and stabilisers." Dynamite is still used today mainly in commercial explosives industries. Originally, the Nitro-glycerine was absorbed into Diatomaceous earth, which is a "soft, sedimentary rock" [6]. Finally, some sodium carbonate is added as a stabiliser.

A big difference between the original dynamite formula and the dynamite used today is the sorbent - damp and wet environments caused the dynamite to become unstable, and this was found to be due to the effect water has on the sorbent material. The presence of water around the dynamite would cause the Nitro-glycerine to leak away, which could cause an explosion if it builds up.

"For this reason, the formulation was changed. Instead of Diatomaceous earth, Gelignite was used to hold the Nitro-glycerine." [6]

Additionally, water can have a large effect on the actual explosion itself. In a study, "For sympathetic detonation, the author discovered that the hole separation distance nearly doubled when the boreholes were filled with water versus when the boreholes were dry." [7] This implies an increase in the sympathetic effectiveness of the explosion, and is useful as it can help us determine the necessary quantities of explosives required within differently saturated mediums.

Moisture Outgassing of TATP

The outgassing of gas compounds, specifically water vapour and moisture, is of great interest to OME engineers, due to the issues it can pose to stored explosives. "Because water can attack and accelerate decomposition, aging, or rusting of various parts, the assembly of an apparatus with 'wet' materials can shorten the lifetime of the apparatus." [8] Additionally, outgassing can take place over years, even if it was seemingly dry initially. Sealed containers can sometimes be observed to be 'expanded', which is typically a sign that the compound has deteriorated.

There are potential solutions to this – ensuring the absolute dryness of the products before storage can help reduce the outgassing of water vapour over time from the compounds. Additionally, hydrophilic desiccants can help keep the humidity of the container low. Finally, regular checks and cleans of the containers should allow for these things to be noticed and tackled before reaching a hazardous level of pressure.

Conclusion

In conclusion, water can have a large range of effects on explosive compounds, mostly reducing the effectiveness and stability of the compounds, thus making them unsafe to work with and unpredictable to use. For this reason, we must ensure we

are taking appropriate measures to counteract the effects of water and humidity on explosives and the containers we use.

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Chemistry Assignment

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

50/100

PAGE 1

PAGE 2

PAGE 3



Comment 1 |  **Criteria 5**

3rd person writing and passive voice should be used



Comment 2 |  **Criteria 3**

nicely mentioned here the effect of various water states f matter on OME



Comment 3

is this a reference?



Comment 4

it is not 6 in 100 million

PAGE 4

PAGE 5

PAGE 6

PAGE 7

LUKE REIDY

50

CRITERIA 1

(20%) Engagement with Literature Skills



only websites referenced; IEEE format applied

8

CRITERIA 2

(25%) Knowledge and Understanding Skills



knowledge of basic chemistry concepts related to the water in OME (corrosion, hygroscopicity, outgassing, etc) good understanding of described issues but lack of depth

13

CRITERIA 3

(25%) Cognitive and Intellectual Skill



good analysis and explanation of various issues related to the presence of water within OME

14

CRITERIA 4

(20%) Practical Application Skills



very short abstract (should be around 200 words)
introduction resembles abstract; concise ability to
apply a correct format of the report

10

CRITERIA 5

(10%) Transferable Skills for Life and Professional Practice



abstract not included in TOC sections are not
numbered 1st person writing occasionally

5