

Chemistry assignment - water

by Jesamy Kellow

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Chemistry assignment - Report on the detrimental effect of water on Explosive materials and OME articles and processes.

By Jesamy Kellow 2030428 (OME L4 apprenticeship)

Abstract -

This report discusses the unusual but useful physical and chemical properties of water and its effect on OME articles and processes.

The role of water in various chemical processes, naturally in the atmosphere, as water vapour and humidity, and in the body's cells, as well as in a laboratory in redox reactions and acid/base chemistry. It discusses the adverse effects of moisture getting into OME articles and possible methods, such as storage conditions, changing solubility and waterproofing to prevent the adverse effects from the water ingress.

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1. Introduction 2

This report discusses the properties of water and why it is such an unusual but useful compound. When it comes to OME, water is used in a lot of chemical processes but it can cause a lot of adverse effects which are also going to be discussed in this report. Finally possible solutions to these adverse effects are going to be discussed to try and reduce the effects or completely remove them..

2. Properties of water

Water is a chemical compound, with the chemical formula H_2O , made up of one oxygen atom and two hydrogen atoms. The oxygen is covalently bonded to the hydrogen, sharing an electron with each other, and also has 2 pairs of outer electrons. As both of these atoms have isotopes, it is also true that water has isotopes too [2].

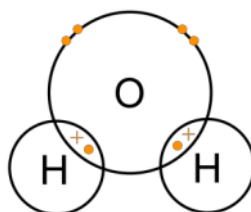


Figure 1: Water molecule diagram [1]

Water is a polar molecule meaning the density of electrons is unevenly distributed - there is a partial negative charge due to its unshared pairs of electrons, and a partial positive charge near the hydrogen atoms. The ability to dissolve things in water is due to its polarity [3].

2.1. Physical properties of water

Hydrogen bonds between the water molecules create unique properties in water. Hydrogen bonds hold water molecules further apart in a solid than in a liquid which is why ice floats. Because of hydrogen bonds it also has other unusual properties. Below is a table showing some physical properties of water.  3

Selected physical properties of water	
molar mass	18.0151 grams per mole
melting point	0.00 °C
boiling point	100.00 °C
maximum density (at 3.98 °C)	1.0000 grams per cubic centimetre
density (25 °C)	0.99701 grams per cubic centimetre
vapour pressure (25 °C)	23.75 torr
heat of fusion (0 °C)	6.010 kilojoules per mole
heat of vaporisation (100 °C)	40.65 kilojoules per mole
heat of formation (25 °C)	-285.85 kilojoules per mole
entropy of vaporisation	118.8 joules per °C mole

Figure 2: Table of water properties [4]

2.2. Chemical properties of water

2.2.1. States of water

The chemical compound of water consists of two hydrogen atoms and one oxygen atom. Water is the name of the compound in liquid state. When solid the compound is known as ice, at melting point 0 degrees celsius and when in gaseous form the compound is known as steam, at boiling point 100 degrees celsius.

2.2.2. Amphoteric nature

An amphoteric substance has the ability to act as both a base and an acid. Water being amphoteric is one of its most important properties of water. In a natural state, water has the pH of 7 meaning it is neutral, so neither acidic or basic. Because of this reason, water is able to donate and accept protons, making it really useful in a lot of processes. [5]

2.2.3. solvency

Due to water's physical attributes and chemical contribution, water is described as the universal solvent. Water has both negative and positive charges in the hydrogen and oxygen. Meaning it has dipoles of partially charged area These charges allow the water to attract to other molecules and allow them to dissolve. [9]

3. Water in the atmosphere

Water is found in the atmosphere as a gas (vapour) in varying amounts from 0% to 4%, mostly in the lowest layer of the atmosphere, the troposphere. The amount in the atmosphere makes up only a very small percentage of the total water on earth.

3.1. Relative humidity

Relative Humidity (RH) is the concentration of water vapour present in the air. It is expressed as a percentage of the amount of moisture that can be retained by the atmosphere [6].

3.1.1. Humidity and explosives

When working with a lot of explosives, depending on their sensitivity, it is important to monitor the relative humidity. Depending on the materials being worked with too high or too low humidity can affect the process. If the humidity is too high it can affect the explosives speed to degradation. And can therefore cause harm to the material. However if humidity is too low, this can increase the risk of there being an electrostatic discharge event and can cause harm to the operators. [7]

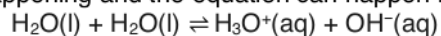
4. The role of water in various chemical processes

4.1. acid/base chemistry 4

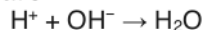
Water plays a huge role in acid base chemistry and it is required to define what an acid and what a base is. It is also used to test whether something is an acid or a base.

The definitions of an acid and a base are *"an acid is any substance that increases the concentration of the H^+ ion when it dissolves in water. A base is any substance that increases the concentration of the OH^- ion when it dissolves in water."* [8]

Water is not only used in defining an acid and base but also in testing for them. Water is naturally amphoteric. This means it can act as both an acid (can donate a proton) and a base (can accept a proton). The below equation most clearly shows this happening and the equation can happen in both directions.



Water is made up of two ions in the below equation.



When an acid is mixed with water there is a contribution of H^+ ions. To determine acidity, the pH is used. pH means the probability of H^+ ions in comparison to OH^- ions in a substance in a substance. How this probability relates can be seen below.



neutral solution $[\text{H}^+] = [\text{OH}^-]$ $\text{pH} = 7$

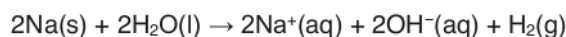
acidic solution $[\text{H}^+] > [\text{OH}^-]$ $\text{pH} < 7$

basic solution $[\text{OH}^-] > [\text{H}^+]$ $\text{pH} > 7$

The number of H ions can be measured in a solution and pH determined. [4]

4.2. Redox reactions

When an active metal is put in contact with water, an exothermic reaction occurs and releases hydrogen gas. An example of this is with sodium and water. The equation for this reaction is below.



This reaction is an example of a redox reaction as the definition is transferring electrons from one atom to another. In this case electrons transfer to water molecules from sodium atoms producing hydrogen gas and two ions which form sodium hydroxide. The other alkali metals have similar reactions with water but less viciously as they get less active.

4.3. Other processes

4.3.1. Living cells

Water is directly involved in a lot of chemical reactions in living cells. They build and break down parts of the cell. The formation and breaking down of DNA and proteins occurs by a reaction producing water and using water respectively.

In plants, the process of photosynthesis is used to keep the plants alive by creating sugars and this process of forming sugars requires water. The water is oxidised to form glucose.

Cytoplasm is made up of around 90% water for a number of reasons:

1. Transportation of materials into and out of the cell through osmosis.
2. Chemical reactions within the cell - e.g synthesis of glucose and in mitochondria
3. Maintains cell structure [10,11]

4.3.2. Rusting in metals

Water is vital in the process of rusting metals as the water helps the oxygen molecules break. Not all metals rust. For example aluminium doesn't because it has a layer of aluminium oxide on its surface which stops the metal coming into contact with water (or moisture in the air) and oxygen.

Iron does rust because it forms ferrous hydroxide, ferric hydroxide and hydrogen when it comes in contact with water and oxygen. The hydroxides lose their water to make more iron compounds. All of these chemical reactions happening at once makes the rust flake and fall off, exposing more iron and repeating the process on the new layer. [12]

5. The adverse effects of water on various OME related materials, articles and processes.

5.1. Flash cartridges and flares 9

All flares are considered water resistant, however if water does penetrate into the inner material, through humidity, rain or submerging, it can break down the material and cause it to fail. There is a possibility that once damaged by water, the flare is rendered ineffective and will not fire.

Some flares are rated waterproof and can even be ignited under water. These use o-ring seals and are designed for divers.

Underwater flares use both a combustible substance, could be hydrogen or acetylene depending application, and oxidiser, oxygen gas, supplied through hoses since there is no oxygen under water. To keep the flame burning, there must be a bubble around the flame typically made out of water vapour and carbon dioxide. The gas supplied is higher than the water exerted by the water. [13]

5.2. Outgassing

When filling ammunition, there is a possibility of air gaps and moisture getting in between the materials and the explosive inner material. The moisture causes cracks in the bullet and causes a reaction with carbon forming carbon dioxide which is called outgassing. These gaps and moisture causes there to be an uneven fill and therefore undesired effect when in use and even premature explosion.

5.3. Polymerisation reactions (binder, e.g. HTPB and HTPB)

Polymerisation is a process accompanied by the formation of water. Polymer bonded explosives (PBXs) are bound together using a polymeric binder. The two most commonly used polymers and polyurethane binders are based on hydroxy-terminated polybutadiene prepolymer (HTPB) and Hydroxy-terminated polyethers (HTPE). When excess water gets into the binders, they can further react to make other molecules with differing properties. [14,15]

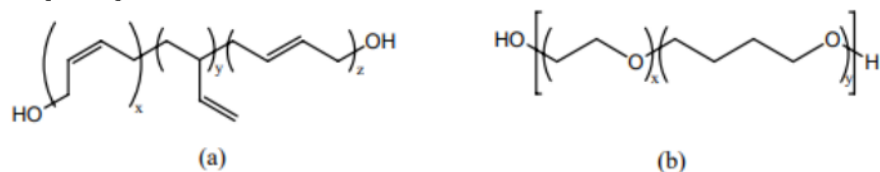


Figure 3: Diagrams of molecules of binders (a) hydroxy-terminated polybutadiene (HTPB), (b) hydroxy-terminated polyether (HTPE) [14]

5.4. Other examples

5.4.1. Dynamite

Dynamite was invented by Alfred Nobel. It is made out of primarily nitroglycerin (about three quarters) but also diatomaceous earth (the other quarter). Nitroglycerin is very sensitive and explodes easily when moved.

Nitroglycerin isn't stable in damp or humid environments as it is water soluble, this is due to water causing the nitroglycerin to leak out of the mixture and build up and explode unexpectedly

Although dynamite isn't used much nowadays the formulation has changed to make it insoluble in water. Instead of diatomaceous earth, gelignite is used to hold the nitroglycerin.[16]

6. Possible solutions that prevent performance issues associated with moisture ingress

6.1. Storage and working conditions

Water can cause a lot of adverse effects in OME articles and processes. Storage and working conditions are the main solution to prevent performance issues with moisture ingress.

6.1.1. Temperature and humidity

In desert environments, the high and low temperatures can have detrimental effects due to slow change in the materials, for example, nitroglycerin starts to decompose at around 50 degrees centigrade. After consistent poor temperatures, small cracks are created which change the performance of the charges. These cracks also allow for water to access the material in high humidity environments from moisture in the air and condensation and cause further damage. [17]

In an experiment completed at Cranfield university, the effect of moisture on nitrocellulose was investigated. It was discovered that 'The rate of decomposition at lower temperatures increased significantly when moisture was present... there is also a change in the reaction mechanism as the humidity increases'. [18]

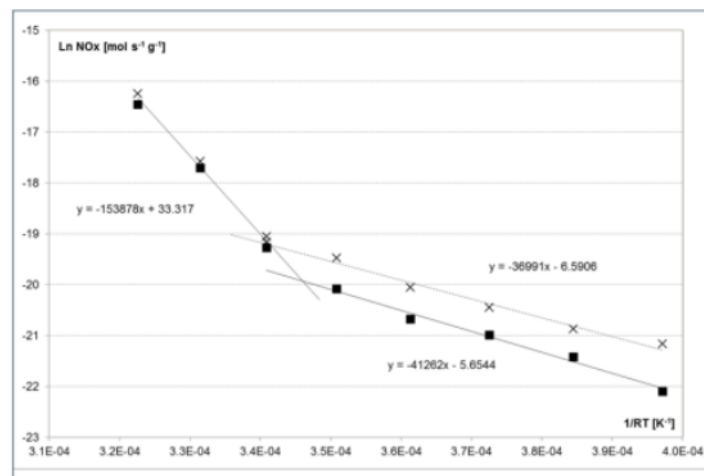


Figure 4: Data from the Cranfield university investigation of the rate of decomposition when moisture is present. [18]

Temperature and humidity can have a detrimental effect on explosive degradation, sensitivity and therefore safety, so when being stored, transported or in use, they must be consistently monitored to stay within pitmum levels. [19]

6.1.2. Packaging

A secure environment with correct packaging is vital in preventing moisture ingress in OME. If packaging isn't up to a good standard, and is broken or out of approved spec it can allow moisture to access the materials and cause degradation. If the explosives being stored or transported are water soluble or in liquid form, the packaging must be water resistant, as if it isn't and water gets in, this will affect the concentration of the material, which is against the transport laws, also shows the importance of packaging and water tightness. [20]

6.2. Waterproofing

Waterproofing of articles can be permanent or temporary normally depending on whether it's included in the initial design or whether it is being carried out after designing and in the field. For quick and temporary applications, it is possible to put articles in waterproof bagging to prevent moisture getting to them. In the video, this can be seen to protect pyrotechnics (fireworks) from a storm. [21]

For more permanent waterproofing, it can be put into the article's design. For example, a waterproof crimped ring cap being put on a fuse if required, and a detonator cord having a waterproof outer covering to prevent moisture getting in. [22,23]

6.3. Solubility

As seen with dynamite, it is possible in some cases to change the mixture in explosives to to make them insoluble to water. Changing a material's makeup to prevent water ingress by making it insoluble but provide the same performance is worth the prevention of water ingress. [16]

7. Conclusion

In conclusion, water is a very useful molecule which has a lot of unusual properties. However it can have a detrimental effect on OME articles and processes. Because of these possible effects, it is important to have a high standard and consistency of storage and transport conditions and waterproofing where possible and necessary.

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Chemistry assignment - water

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

53 / 100

PAGE 1

PAGE 2



Comment 1 |  **Criteria 5**

abstract is missing in the TOC; it is not numbered but should be included;
sections should be numbered for easier navigation

PAGE 3



Comment 2

adverse effects should be the only focus of this report



Comment 3 |  **Criteria 3**

should be discussed in more detail;
implication to OME not discussed

PAGE 4



Comment 4 |  **Criteria 3**

what is the impact on OME materials?

PAGE 5



Comment 5

it is concentration, not probability



Comment 6 |  **Criteria 3**

relation to OME



Comment 7 |  **Criteria 2**

irrelevant



Comment 8 |  **Criteria 3**

relation to OME

PAGE 6



Comment 9 |  **Criteria 2**

what damage specifically water can cause?

PAGE 7

PAGE 8

PAGE 9

PAGE 10

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JESAMY KELLOW

53

CRITERIA 1

(20%) Engagement with Literature Skills



various sources accessed literature independently
found with majority of websites major errors in
following IEEE model Ref 7: authors' names Ref 12,

8

13, 14 capital letters missed are Refs 17-22 books, chapters or articles?

CRITERIA 2

(25%) Knowledge and Understanding Skills



knowledge of the basic chemistry concepts demonstrated limited understanding of these concepts with a lack of depth in explanation; some irrelevant information (living cells)

14

CRITERIA 3

(25%) Cognitive and Intellectual Skill



rather descriptive approach graph in Fig 4 not discussed in depth; work in controlled humidity not discussed;

13

CRITERIA 4

(20%) Practical Application Skills



ability to construct a professional report is demonstrated the problem of water presence in various OME materials and processes identified and general solutions to mitigate it provided

11

CRITERIA 5

(10%) Transferable Skills for Life and Professional Practice



in professional reports abbreviations such as it's
can't should be avoided and full words should be
used (it is; can not) good word count all figures,
graphs and tables should be mentioned within the
text and discussed