Do you dare to touch this substance?
Case-based Health and Safety Education

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Outline

1. The Case, an introduction to the teaching sequence
2. Some background information about white crystals, substance analysis and new mobile gadgets
3. How to solve the case and making a risk assessment
4. Hands-On activities
Outline

1. The Case, an introduction to the teaching sequence
2. Some background information about white crystals, substance analysis and new mobile gadgets
3. How to solve the case and doing a risk assessment
4. Hands-On activities
Why case-based?

«...an active, student-centered approach to learning, it encourages the development of critical thinking and lifelong learning skills.”

Carder et al. (2003)
What characterizes case based learning?

Some points from Herreid (1998):
1. A good case tells a story.
2. A good case is relevant to the audience.
3. A good case is conflict provoking and decision forcing.
4. A good case is short!
5. A good case must have pedagogic utility.

«For the case to be a real thing [...] there must be drama, there must be suspense.»
1. The Case

Hedinn Gunhildrud
The challenge:

Help me, chemical detectives!

1. I did something wrong. Conduct a risk assessment with your group, using Student Data Sheets.
2. Which substance caused my illness? Discuss your risk assessment with me, before entering the lab.
3. Prepare a short presentation to discuss and defend your findings with your classmates.
Outline

1. The Case, an introduction to the teaching sequence
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3. How to solve the case and doing a risk assessment
4. Hands-On activities
Would your students dare to touch this substance?
### Risk Assessment Guidance

**Other polybasic organic acids & their salts (2)**

<table>
<thead>
<tr>
<th>Malic acid</th>
<th>2-hydroxysuccinic acid, 2-hydroxybutanedioic acid</th>
<th>HOOCCH(OH)CH$_2$COOH (134.09)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tartaric acid</td>
<td>2,3-dihydroxybutanedioic acid</td>
<td>HOOCCH(OH)CH(OH)COOH (150.087)</td>
</tr>
<tr>
<td>Citric acid</td>
<td>2-hydroxypropane-1,2,3-tricarboxylic acid</td>
<td>HOOCCH$_2$C(OH)(COOH)CH$_2$COOH (192.12)</td>
</tr>
<tr>
<td>Citric acid-1-water</td>
<td>citric acid monohydrate</td>
<td>HOOCCH$_2$C(OH)(COOH)CH$_2$COOH.H$_2$O (210.14)</td>
</tr>
</tbody>
</table>

**WARNING**

Causes serious eye irritation [H319]. Causes skin irritation [H315]. May cause respiratory irritation [H335]. Note: Classification/labelling vary. Some suppliers indicate: May cause serious eye damage [H318] along with the GHS 05 pictogram, DANGER.

**Storage**

Storage code: **GOrg**

[White crystalline solids]

---

**Potassium sodium tartrate**  
*Rochelle salt, potassium sodium 2,3-dihydroxybutanedioate-4-water*  
KNaC$_4$H$_4$O$_6$.4H$_2$O (282.1)

**Sodium citrate-2-water**  
C$_6$H$_5$O$_7$Na$_3$.2H$_2$O (294.10)

Currently not classified as hazardous.

**Storage**

Storage code: **GIn**

[White crystalline solids]

_Source: CLEAPSS (2018)_
The problem:

Most solid chemicals are «white» crystals
- colourless
- odourless

⇒Students and teachers cannot see if a substance is hazardous or not!
Professional substance analysis


«ultra-violet (UV), infra-red (IR) and nuclear magnetic resonance spectroscopy (NMR) or mass spectrometry (MS) to be conducted alongside either high performance liquid chromatography (HPLC) or gas chromatography (GC). [...] These techniques require specialist knowledge to perform and interpret their outputs.»
BeyonSense™
To be introduced in 2019

Stratio will introduce the world's first mobile-compatible Short Wave Infrared (SWIR) camera in 2019. This groundbreaking camera will incorporate a germanium sensor to see the SWIR (800-1600 nm) range. For the first time, everyone with a smartphone will be able to enjoy the benefit of SWIR technology. The applications abound from cooking to driving to health monitoring to night vision.

VISIT WEBSITE

Follow Your Curiosity

Explore and discover a world the eye can't see with a revolutionary material sensor

SCiO for Consumers

Alternatives:
http://tellspec.com/en/ etc.
Starting with some physics
electromagnetic radiation

Penetrates Earth’s Atmosphere?

<table>
<thead>
<tr>
<th>Radiation Type</th>
<th>Wavelength / m</th>
<th>Approximate Scale of Wavelength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gamma ray</td>
<td>$10^{12}$</td>
<td>Atomic Nuclei</td>
</tr>
<tr>
<td>X-ray</td>
<td>$10^{10}$</td>
<td>Atoms</td>
</tr>
<tr>
<td>Ultraviolet</td>
<td>$10^{8}$</td>
<td>Molecules</td>
</tr>
<tr>
<td>Visible</td>
<td>$0.5 \times 10^{-6}$</td>
<td>Protozoans</td>
</tr>
<tr>
<td>Infrared</td>
<td>$10^5$</td>
<td>Needle Point</td>
</tr>
<tr>
<td>Microwave</td>
<td>$10^2$</td>
<td>Butterflies</td>
</tr>
<tr>
<td>Radio</td>
<td>$10^3$</td>
<td>Humans</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Buildings</td>
</tr>
</tbody>
</table>

Frequency / Hz:
- $10^20$
- $10^{18}$
- $10^{16}$
- $10^{15}$
- $10^{12}$
- $10^8$
- $10^4$
Infrared

By Cody.pope, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=3484188
What happens at the molecular level?
IR - spectroscopy

https://www.chemguide.co.uk/analysis/ir/interpret.html
NIRS = Near InfraRed Spectroscopy

So how does the SCiO or similar products work?
Ill.: https://www.researchgate.net/publication/222568388_Chapter_Five_-_Visible_and_Near_Infrared_Spectroscopy_in_Soil_Science
SPECTRO SCAN RESULTS

Spectral Fingerprint

intensity vs. wavelength

Scanned with SCIO
Follow Your Curiosity

Explore and discover a world the eye can't see with a revolutionary material sensor.
Outline

1. The Case, an introduction to the teaching sequence
2. Some background information about white crystals, substance analysis and new mobile gadgets
3. How to solve the case and doing a risk assessment (the teaching sequence)
4. Hands-On activities
Learning objectives:

1. Health and safety education: Risk assessment
   ASE (2018):
   The health & safety principles which students should learn include the following.
   • How to recognise and identify hazards
   • How to identify the possible risks from those hazards
   • What actions are needed to reduce those risks to an acceptable level”

2. Near infrared spectroscopy as an example method to identify materials and chemicals

3. Argueing and communicating findings
The science curriculum context

Some examples from

Key stage 3

• use appropriate techniques, apparatus, and materials during fieldwork and laboratory work, paying attention to health and safety

• Chemistry: the identification of pure substances

• Physics: the transmission of light through materials: absorption, diffuse scattering and specular reflection at a surface
The Case
A) The accident
The challenge:

Help me, chemical detectives!

1. I did something wrong. Conduct a risk assessment with your group, using Student Data Sheets.

2. Which substance caused my illness? Discuss your risk assessment with me, before entering the lab.

3. Prepare a short presentation to discuss and defend your findings with your classmates.
B) Introducing and learning to handle the spectrometer
Download the app and create a user.
Trouble connecting your SCiO?
Try resetting your Bluetooth® connection.

My SCiO is not listed here.
A cheese item is being scanned by a device to determine its nutritional content. The device shows that the cheese contains:

- **24% Fat**
- **280Kcal** (14% of Daily Value)
- **24g Fat** (37% of Daily Value)
- **55g Water**
- **16g Proteins** (31% of Daily Value)
→ Trustworthy, quantitative information about real life materials, instead of hazardous chemical tests!
Sodium hydroxide

also applies to Soda lime and Potassium hydroxide

<table>
<thead>
<tr>
<th>Substance</th>
<th>Hazard</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium or potassium hydroxide</td>
<td>CORROSIVE</td>
<td>DANGER: causes severe skin burns and eye damage. It gives out heat when added to water which can cause boiling or create a choking mist.</td>
</tr>
<tr>
<td>Solid</td>
<td>HARMFUL</td>
<td>Potassium hydroxide is also harmful if swallowed. It is used in the home for clearing drains.</td>
</tr>
<tr>
<td>Also known as caustic soda and caustic potash. Soda lime contains about 5% sodium hydroxide, 1% potassium hydroxide, 0.2% silicon dioxide, 14 – 19% water and the remainder calcium hydroxide (it is used to absorb carbon dioxide).</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
C) Performing a risk assessment

**What is risk assessment?**

A risk assessment is a judgment of how likely it is that someone (anyone) might come to harm if a planned action is carried out. The law requires the likelihood or harm to be reduced to as low as is reasonably practicable. Risk assessments, although an excellent idea for all of us, are only legally required for actions which take place at work. The significant findings of risk assessment must be recorded. (You must show the answer, you don't have to show your workings).

A **hazard** is anything which could cause harm. For example, some chemicals, electricity at high enough currents, glass (if it breaks) and even you running in the corridor are all hazards because they can all cause harm. Although sometimes you can use your common sense to identify a hazard, often you will need specialist information, eg as provided on CLEAPSS Student Safety Sheets or on chemical suppliers' Safety Data Sheets.

The **risk** is the likelihood that a hazard would cause significant harm. It is a matter of judgment and depends on:

- how likely it is that something would go wrong with this hazard;
- how serious any resulting injuries would be; and
- how many people would be affected.
Student safety sheets

Student form for assessing risks

Proposed practical activity: .................................................................

Name(s) of pupil(s) completing form: ..............................................

Class / set: ......................................................... Date: ........................

A hazard is anything which could cause harm, eg, a hot tripod, a cluttered floor.

A risk is the likelihood of harm actually being caused.

Use the CLEAPSS Student Safety Sheets, the practical instructions and the labels on the bottles to fill in this form.

<table>
<thead>
<tr>
<th>Hazardous chemical or procedure</th>
<th>Type of hazard</th>
<th>Control measures to reduce the risk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Why do we want the pupils to read the real stuff?

- ASE (2018):
  - “For more advanced, often post-16 or BTEC students, they should be taught how to read and understand manufacturers’ safety data sheets and other sources of hazard and risk information.”

- [https://www.ase.org.uk/resources/topics-in-safety](https://www.ase.org.uk/resources/topics-in-safety)
5L of Pro-Kleen Sink & Drain Blitz - Plughole/Drain Unblocker - Dissolves Hair & Grease - Super Strength Formula: up to 20 Treatments
by Pro-Kleen

20 customer reviews | 32 answered questions

Price: £18.95

In stock.

No sellers are currently delivering this item to Norway. Learn more

Dispatched from and sold by Sales Direct Online.

1 new from £18.95

- This SUPER STRENGTH Sink & Drain Unblocker is 20x stronger than other brands
- The unique, best-selling formula that completely dissolves grease and hair clearing blocked sinks and drains
- Up to 20 treatments per bottle when using 250ml per treatment! (Use 500ml for more severe blockages)
- Easily clean all types of drains and sinks and restore complete efficiency - safe for ALL pipework
- Pro-Kleen's 5L Sink & Drain Blitz provides excellent value for money - less than £1 per treatment

ZEISS
Smudge free, streak free, smart cleaning

> Shop now

ZEISS Smartphone Wipes, Pack of 60
Smartphone Wipes

£5.99 Prime
SODIUM HYDROXIDE

500g
So what is the active ingredient in the first one?


- **Frequently asked questions**

  - What is the active ingredient in this, is it sulphuric acid?

  The active ingredient is sodium hydroxide.
D) Advising the teacher

1. Eye-protection!
2. Lab-coat!
3. Gloves!
E) Investigating the substances with SCiO
Three possibilities

1. Take spectroscans and compare manually
2. Build an applet based on the known substances and let the SCiO compare.
3. Build an applet based on the unknown substances and let the SCiO compare.

→ Whatever solution: Coordinating and documenting is crucial!
Three possible «accidents»

A. The easy one: One distinct substance
B. Household substances: Sugar + citric acid
C. The chemistry-show: Sucrose + Potassium chlorate
F) Argueing and communicating the findings

A: The easy one: «Sugar» aka Sucrose
- Nice and distinct absorbance
- Very good comparability
- “This product has no classification under CLP.”
Sucrose

Typical control measures to reduce risk

- Wear eye protection when handling hazardous solids and solutions, e.g., when food testing.
- Do not consume sugars or indeed any food or drink in laboratories; taste-testing investigations must be done outside laboratories unless scrupulous hygiene and no contamination can be ensured.

Assessing the risks

- What are the details of the activity to be undertaken? What are the hazards?
- What is the chance of something going wrong?
- How serious would it be if something did go wrong? e.g., small amounts of contaminants entering the mouth during taste-testing activities.
- How can the risk(s) be controlled for this activity? e.g., can it be done safely? Does the procedure need to be altered? Should goggles or safety spectacles be worn?

Emergency action

- In the eye: Flood the eye with gently-running tap water for 10 minutes. Consult a medic if pain persists.
- Swallowed: In small amounts, unlikely to be hazardous unless contaminated.
- Spilt on the skin or clothing: Brush solid off contaminated clothing. Rinse clothing or the skin as necessary.
- Spilt on the floor, bench, etc: Brush up solid spills, trying to avoid raising dust, then wipe with a damp cloth.
B Citric acid

Student safety sheets

Citric, Oxalic & Tartaric acids
2-hydroxypropane-1,2,3-tricarboxylic acid, ethanedioic acid and 2,3-dihydroxybutanedioic acid

Substance | Hazard | Comment
--- | --- | ---
2-hydroxypropane-1,2,3-tricarboxylic acid (citric acid), solid and most solutions (if 0.5 M or more) | IRRITANT | WARNING: causes serious eye and skin irritation and may cause respiratory irritation.

It is an approved food additive, E330. Concentrated lemon juice may contain 2-hydroxypropane-1,2,3-tricarboxylic acid (citric acid) up to 1.7 M.

Typical control measures to reduce risk
- Use the lowest concentration possible.
- Wear eye protection for all but the most-dilute solutions; goggles for concentrated acids.
- Avoid the possibility of swallowing oxalic acid or its salts, eg, by using a safety pipette filler.

Assessing the risks
C Chemistry show

From a student presentation:

- Spectral Fingerprint
- Dextrose
Potassium chlorate

SECTION 2: Hazards identification

2.1 Classification of the substance or mixture

Classification according to Regulation (EC) No 1272/2008

- GHS03 flame over circle
- Ox. Sol. 1 H271 May cause fire or explosion; strong oxidiser.
- GHS09 environment
- Aquatic Chronic 2 H411 Toxic to aquatic life with long lasting effects.
- GHS07

- Acute Tox. 4 H302 Harmful if swallowed.
- Acute Tox. 4 H332 Harmful if inhaled.

Other hazards that do not result in classification No information known.

2.2 Label elements

Labelling according to Regulation (EC) No 1272/2008 The substance is classified and labelled according to the CLP regulation.
Sodium chloride

People have been killed through consuming very large amounts of salt. At ‘normal’ levels, can cause high blood pressure, hence heart disease. Adults should not eat more than 6 g/day, children less. Potassium chloride is approved food additive, E508, used as a ‘low-salt’ substitute.

<table>
<thead>
<tr>
<th>Sodium and potassium chloride, bromide and iodide</th>
<th>LOW HAZARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid &amp; solution</td>
<td></td>
</tr>
</tbody>
</table>
G. Testing the chemicals

Potassiumchlorate vs. Sugar
The Case at a glance:

A. The accident & assignment
B. Introducing the spectrometer
C. Developing a risk assessment
D. Advising the teacher
E. Investigating the substances with SCiO
F. Argueing and communicating the findings
G. Testing the chemicals
Outline

1. The Case, an introduction to the teaching sequence
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4. Hands-On activities
4. Hands-on:
1. Download the app and create a user.
2. Close and reopen the app to activate.
3. Connect with your device and start investigating your surroundings.
Pedagogical summary of the used device:

- [https://learn.sparkfun.com/tutorials/scio-pocket-molecular-scanner-teardown-/all](https://learn.sparkfun.com/tutorials/scio-pocket-molecular-scanner-teardown-/all)
Some critical points:
And some positive aspects
I want to thank:

- The Department for teacher education (ILP) in Tromsø
- Hedinn Gunnhildrud at NordNorsk Vitensenter for being model teacher in this presentation and having many practical ideas

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