Liquid Nitrogen Experiment Tips

Dipping Fingers In
- Use a clear plastic cup to make it easier to see
- Place in only for maximum of 1 second
- Hold in air with at least 50cm space underneath. If someone leaves fingers in for too long you have plenty of room to rapidly move the cup away
- In case of splashes keep away from eye level of pupils nearby

Tipping it Over Yourself
- Don't tip too much
- Look out for anywhere it could collect ... e.g. shirt pockets, bras etc

Watching and Listening to it Boiling
- Place on different surfaces and listen/watch
- Consider thermal conductivity on surface

Flowers
- Place flowers in and wait
- Smash either directly onto desk or with hammer
- Use a black bin liner - makes it dead easy to clear up
- You can loosely pick up pieces - they sound like glass

Fruit / Lettuce
- Same as flowers
- BBQ tongs are useful for removing fruit.
- Do not tightly grip fruit or allow pupils to do so
- Black bin liner is useful to make clearing up easy

Balloons
- Blow up balloons (long modeling ones are good)
- Place into nitrogen with a gloved hand watch it shrink
- When removed from nitrogen hold with gloves hand as this reduces chance of bursting (unless you want it to!)

Rubber Hose
- Cool rubber hose by placing into liquid nitrogen
- Watch where the end is pointing as liquid will spray out
- Goggles needed
- Smash with hammer

Soapy Water
- Hot water works best
- Consider pyrex beaker in sink or doing it outside
- Plenty of Fairy Liquid

Plastic Bell
- Ring bell at room temperature
- Place into liquid nitrogen
- Remove and ring again

Pouring on Floor

- Watch out for sandals or open toe shoes
- Watch out for anything on floor (bags, blazers etc)
- Can get pupils to sit on desks / stools with feet up
- Best to line them up down wall of corridor (or similar arrangement in classroom)
- Watch out for it going under doors into adjacent rooms

Levitation

- Cool superconductor with magnet in place
- Use a microscope slide to position magnet
- Wait until superconductor is cold, then remove microscope slide
- Superconductor can be spun, pushed and pulled
- Small plastic tweezers are useful for manipulating superconductor
- Magnets can be purchased from
  www.first4magnets.com eg product code F646
- Superconductor disks can be purchased from
  http://www.can-superconductors.com/products/levitation-disks/

Ice Cream

- Various recipes ... experiment yourself
- Large plastic mixing bowl from Tesco
- Wooden spoon
- Pyrex jug
- 1 x 397g tin of condensed milk
- 1 pint single cream
- Flavouring eg tablespoon of Cadbury Bournville drinking chocolate (red tub), raspberries, strawberries, apple sauce, Pimms, Whiskey....
- Make sure you mix well right to the edges

Making Liquid Oxygen

- You need an oxygen gas cylinder and an oxygen regulator (it should have a symbol of an oil can crossed through)
- You need a copper coil or still (these can be bent from a thin piece of copper pipe around a scaffold bar former)
- Ensure that all items you use pyrex or borosilicate glass as these will handle the low temperatures
- Ensure that all glassware / copper coil etc are thoroughly clean (the danger with liquid oxygen is that is causes organic materials to burn very well)

General Safety

Wear goggles
Only wear gloves with handling objects cooled by liquid nitrogen, never for pouring or handling liquid nitrogen
Suede or leather gardening gloves are perfect
Always wear proper shoes
Never transport it in a car - use a trailer, tow bar mounted rack, convertible car, van with a sealed bulk head or pickup truck
Never transport in a lift with passengers or where there is a possibility passengers may enter.
Never store in an enclosed space. Calculations are provided below showing the minimum room size for storing of one 10 litre dewar or one 25 litre dewar.

10 Litre Dewar
From a normal oxygen level of 21%

"A room shall be sufficiently ventilated for the two, normal conditions not to cause a reduction in oxygen concentration below 19.5%:

(i) the normal evaporation of all dewars and liquid nitrogen containers within the room
(ii) the filling losses from filling the largest dewar from a warm condition.

Additionally, the complete spillage of the contents of the largest dewar shall not cause the oxygen concentration to fall below 18%"

Section 8.2.5 of BCGA Code of Practice CP30 'The Safe Use of Liquid Nitrogen Dewars up to 50 litres'

So following Annex 3 of the same code, accounting for the normal evaporation rate of the 10 litre dewar the concentration of oxygen in the room after a long period will be

$$C_{\infty}=\frac{V_r\times 0.21\times n}{L+(V_r\times n)}$$

where V_r is the room volume, L is the gas release in m^3/h and n is the number of air changes in the room per hour.

Assuming a value of n=0.4 and L is twice the manufacturers quoted value of 0.2 liquid litres per day and the gas volume factor is 683 so that L=0.0114 then the minimum room volume to not fall below 19.5% oxygen is 0.38 m^3 .

No filling of dewars will take place at schools.

Following Annex 4 of the same code, accounting for the complete spillage of the 10 litre dewar the minimum room volume for storage/use will be given by

$$C=\frac{0.21(V_r-(\frac{V_d\times f_g}{1000}))}{V_r}$$

where C is the oxygen concentration, V_d is the dewar capacity in litres and f_g is the gas volume factor (683). Solving this leads to a minimum room volume of 48 m^3 so that the oxygen concentration will not fall below 18%.

25 Litre Dewar
From a normal oxygen level of 21%

"A room shall be sufficiently ventilated for the two, normal conditions not to cause a reduction in oxygen concentration below 19.5%:

(i) the normal evaporation of all dewars and liquid nitrogen containers within the room
(ii) the filling losses from filling the largest dewar from a warm condition.

Additionally, the complete spillage of the contents of the largest dewar shall not cause the oxygen concentration to fall below 18%"

Section 8.2.5 of BCGA Code of Practice CP30 'The Safe Use of Liquid Nitrogen Dewars up to 50 litres'

So following Annex 3 of the same code, accounting for the normal evaporation rate of the 25 litre dewar the concentration of oxygen in the room after a long period will be

$$C_{\infty}=\frac{V_r\times 0.21\times n}{L+(V_r\times n)}$$

where V_r is the room volume, L is the gas release in m^3/h and n is the number of air changes in the room per hour.

Assuming a value of n=0.4 and L is twice the manufacturers quoted value of 0.2 liquid litres per day and the gas volume factor is 683 so that L=0.0114 then the minimum room volume to not fall below 19.5% oxygen is 0.38 m^3 .

No filling of dewars will take place at schools.

Following Annex 4 of the same code, accounting for the complete spillage of the 25 litre dewar the minimum room volume for storage/use will be given by

$$C=\frac{0.21(V_r-(\frac{V_d\times f_g}{1000}))}{V_r}$$

where C is the oxygen concentration, V_d is the dewar capacity in litres and f_g is the gas volume factor (683). Solving this leads to a minimum room volume of 120 m^3 so that the oxygen concentration will not fall below 18%.

Sample Risk Assessments

Activity

Transporting 25 Litre Liquid Nitrogen Dewars (LN2)

Persons at Risk

People handling dewars

People driving or passengers of vehicle

People in close vicinity

Hazards Identified

Cold gas/liquid (cold burns)

Spillages from overfilled dewars

Oxygen depletion in confined space/small rooms

Lifting dewars

Transporting dewars

Required Control Measures

(1) Wearing of appropriate PPE: goggles or safety glasses and gloves. Ensure they are carried in vehicle.

(2) No 'open toed' footwear

(3) Ensure no loose ends on sleeves, do not wear rings or watches, do not wear shorts or short skirts

(4) Get assistance to lift heavy dewars if necessary

(5) Ensure warning sign is displayed on vehicle indicating presence of liquid nitrogen

(6) Never transport nitrogen in a car; always use a van with a specially sealed cargo area or a car with a trailer/rack

(7) Ensure dewar is securely held in place in vehicle to prevent movement during transport

(8) Do not use lifts to transport filled dewars without first making certain no other passengers are able to access lift. Do not travel in a lift with a filled dewar – always send it to the correct floor to a waiting colleague.

Training Required

Persons handling liquid nitrogen should be trained in its use

Waste Disposal

N/A

Access Restrictions

Trained personnel only

Emergency Procedures

Spillage of liquid nitrogen - vacate room

Cold Burns - immerse affected part in warm water, seek medical advice

Vehicle accident - any split liquid nitrogen will quickly evaporate harmlessly. Move bystanders away from accident site. Note that there may be white 'smoke' visible briefly from any liquid nitrogen spill – this is just water vapour.

Name of Assessor

Dr Matthew French

Activity

Storing liquid nitrogen at schools

Persons at Risk

People handling liquid nitrogen

Other people in the same room – teachers and pupils

Hazards Identified

Cold gas/liquid (cold burns)

Spillages from overfilled dewars

Oxygen depletion in confined space/small rooms

Lifting small 'onion' dewars

Transporting dewars

Required Control Measures

(1) Wearing of appropriate PPE: goggles or safety glasses and gloves

(2) No 'open toed' footwear for those handling liquid nitrogen

(3) Get assistance to lift heavy dewars if necessary

(4) Do not use lifts to transport filled dewars without first making certain no other passengers are able to access lift. Do not travel in a lift with a filled dewar – always send it to the correct floor to a waiting colleague

(5) Do not leave dewars unattended in unlocked classrooms/corridors

(6) If pupils are present, ensure that liquid nitrogen and any objects which have been cooled with it are attended at all times in the classroom by trained personnel

(7) Dewars should be stored where they are not likely to be knocked over.

(8) To avoid oxygen depletion, full 25 litre dewars should be stored in a room with a volume of at least 120m^3, or a cupboard which opens into a sufficiently large room/corridor. In this case the door must be prevented from closing when any person enters the cupboard.

Training Required

Persons handling liquid nitrogen should be trained in its use

Waste Disposal

N/A

Access Restrictions

Trained personnel only

Emergency Procedures

Spillage of liquid nitrogen - vacate room

Cold Burns - immerse affected part in warm water, seek medical advice

Name of Assessor

Dr Matthew French

Activity

Using liquid nitrogen for demonstrations in school classrooms

Persons at Risk

People handling liquid nitrogen

Other people in the same room – teachers and pupils

Hazards Identified

Cold gas/liquid (cold burns)

Spillages from overfilled dewars

Oxygen depletion in confined space/small rooms

Lifting small 'onion' dewars

Transporting dewars

Contact between skin and cold objects

Required Control Measures

(1) Wearing of appropriate PPE: goggles or safety glasses and gloves

(2) No 'open toed' footwear for those handling liquid nitrogen

(3) Ensure no loose ends on sleeves, do not wear rings or watches, do not wear shorts or short skirts for those handling liquid nitrogen

(4) Get assistance to lift heavy dewars if necessary

(5) Do not use lifts to transport filled dewars without first making certain no other passengers are able to access lift. Do not travel in a lift with a filled dewar – always send it to the correct floor to a waiting colleague

(6) Do not leave dewars unattended in unlocked classrooms/corridors

(7) Ensure pupils and teachers are warned of and understand the dangers of cold burns before any experiment takes place

(8) If pupils are present, ensure that liquid nitrogen and any objects which have been cooled with it are attended at all times in the classroom by trained personnel

Training Required

Persons handling liquid nitrogen should be trained in its use

Waste Disposal

N/A

Access Restrictions

Trained personnel only

Emergency Procedures

Spillage of liquid nitrogen - vacate room

Cold Burns - immerse affected part in warm water, seek medical advice

Name of Assessor

Dr Matthew French

Getting Liquid Nitrogen

Try to get in touch with your local University (Physics, Chemistry or Engineering Departments). They will probably charge for regular use anywhere between 20p and £1.50 per litre.

You may possibly be able to borrow a dewar from the University, but otherwise you will need your own one. You will probably want either a 10 litre or 25 litre. They cost around £500 and can be purchased from

BOC
http://www.boconline.co.uk/products/products_by_type/cryogenic_equipment/dewars_and_accessories.asp

Satebourne

http://www.statebourne.com/

It can be stored / transported in a simple thermos flask (DO NOT SCREW ON THE LID as it could eventually explode)

BOC will deliver liquid nitrogen and lend you a dewar although this is typically quite expensive around £40 for a delivery plus £2.50 per litre, plus VAT on the whole lot.

http://www.boconline.co.uk/how_to_buy/delivery_options/liquid_gas_delivery.asp

Prices or information from calling them on 0800 111 333

Remember you can't transport it in a ordinary car. You can get some couriers to deliver it e.g. City Sprint http://www.citysprint.co.uk/

Further Information

Links to some further information, videos, risk assessments and my Physics Education publications

http://www.matthewfrench.net/liquidnitrogenfun.html

http://www.matthewfrench.net/scienceteach/levitation/riskassessments.pdf

http://www.matthewfrench.net/levitation.html

http://www.matthewfrench.net/liquidoxygen.html

http://www.matthewfrench.net/icecream.html

Making Liquid Oxygen, M. M. J. French and Michael Hibbert, Phys. Ed. 45 221 (2010)

http://www.matthewfrench.net/pubs/ped45221.pdf

The Wonders of Levitation, M. M. J. French, Phys. Ed. 45 37 (2010)

http://www.matthewfrench.net/pubs/ped4537.pdf

Email me: mail@matthewfrench.net