LEAF

(Laboratory Efficiency Assessment Framework)

Mills group briefing notes

About these briefing notes

The following notes address many of the LEAF objectives. All members of the Mills research group have received training from Prof. Mills based on these notes and are encouraged to consult them regularly and suggest changes and additional material to Prof Mills. Prof. Mills is responsible for up-dating these notes and all LEAF-related material on the Mills group website, https://www.profandrewmills.com/leaf-documents/.

The Mills group laboratories

laboratory	Laboratory Officer (LO)	key number	Extension	fume cupboards	wet or dry lab	names
DKB.01.003	CR	2NZ83	4455	2	wet	Chris's lab
DKB.01.112	LM	2NZ54	4437	0	wet	Bio lab
DKB.01.139	LM	2NDZ12	4453	4	wet	large lab
DKB.01.409	SM	2NBZ27	4468	1	dry	NOx lab
DKB.03.419	CR	2NBZ30	4193	0	dry	laser lab
CR: Christopher O'Rourke; SM: Stephanie Mills; LM: Lauren McDonnell						

The person in charge of the laboratory is the **L**aboratory **O**fficer, LO. Contact them if you have any queries regarding any work you are doing in that laboratory. If they aren't about, contact CR or the **P**rinciple **I**nvestigator, PI, Prof. Mills (AM). If you have any concerns regarding your or another's work, contact the LO or CR. If the concern is safety-related, contact the PI (AM) immediately.

LEAF documents on the Mills website

Up to date versions of all the documents referred to in this briefing document – including a copy of these briefing notes – can be found on the Mills group web site, https://www.profandrewmills.com/leaf-documents/.

They can also be routinely accessed using the QR code on this page. Labels with this QR code are on most instruments in all laboratories, so that they can be accessed readily *in situ*.

Mills Research Group

LEAF documents

Downloads

Health Safety and Environment Slides

Mills Group Chemical Inventory

Mills Group Gas Cylinder Inventory

Folders

Completed LER Forms

Completed COSHH and Risk Assessment Forms

COSHH Forms

Risk Assessment Forms

Downloadable Forms

SOP's

Professor Andrew Mills

Andrew Mills is Professor of Materials Chemistry at the School of Chemistry and Chemical Engineering, Queen's University Belfast. Previously, he has held Chairs in Chemistry at Swansea and Strathclyde University.

Research Areas

The research interests of the Mills group are wide and varied including: dye and semiconductor photochemistry, redox catalysis (in particular, oxygen catalysis), solar energy conversion (in particular artificial photosynthesis) and colour and fluorescence based indicators and smart inks and plastic films.

Archive

February 2023

October 2022

LEAF documents on the Mills website

Key LEAF documents on the Mills website include: (1) a complete chemical inventory, (2) the School's health, safety and environment slides used to train all new staff/students, (3) SoPs for the most-used pieces of equipment, (4) all the group's COSHH and risk assessment forms (including the School's guidelines to completing a COSHH form), (5) the current 'laboratory environment responsibilities' (LER) form for each of the laboratories, a copy of which is on the inside of the entry door of the respective laboratory, (6) overnight reaction form and (7) electrical and chemical waste disposal forms.

Downloadable versions of all of the above forms can be found in the 'Downloadable Forms' folder on the Mills group, LEAF documents, web page, https://www.profandrewmills.com/leaf-documents/.

Waste and bins

Waste bins

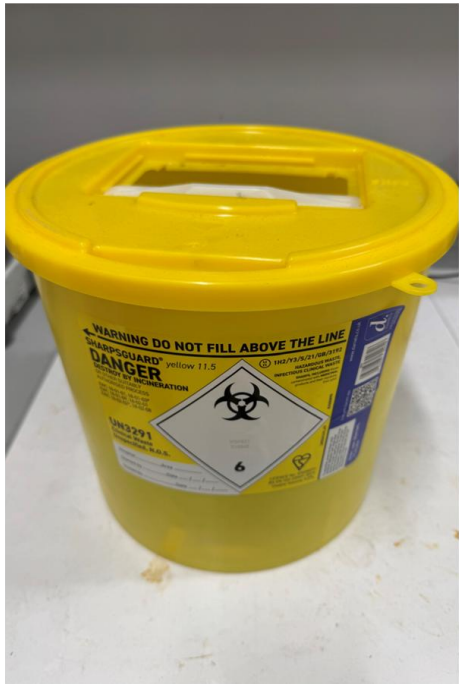
All laboratories have the appropriate bins for the work conducted therein. A list of these are given in the table below. When a glass or sharps bin is full – notify the person who is in charge of the laboratory (the LO – see slide 4 for list). The other bins (Household waste, recycle bins) are emptied every morning by the cleaners.

LAB	CLEAR Biohazard	YELLOW sharps	RED glass	BLACK Household	BLACK plastic	BLACK metal
1.003		X	X	X	X	X
1.112	X	X		X		
1.139		X	X	X		
1.409		X		X		
3.419		X		X		

Bin types

General Waste

Sharps



Glass

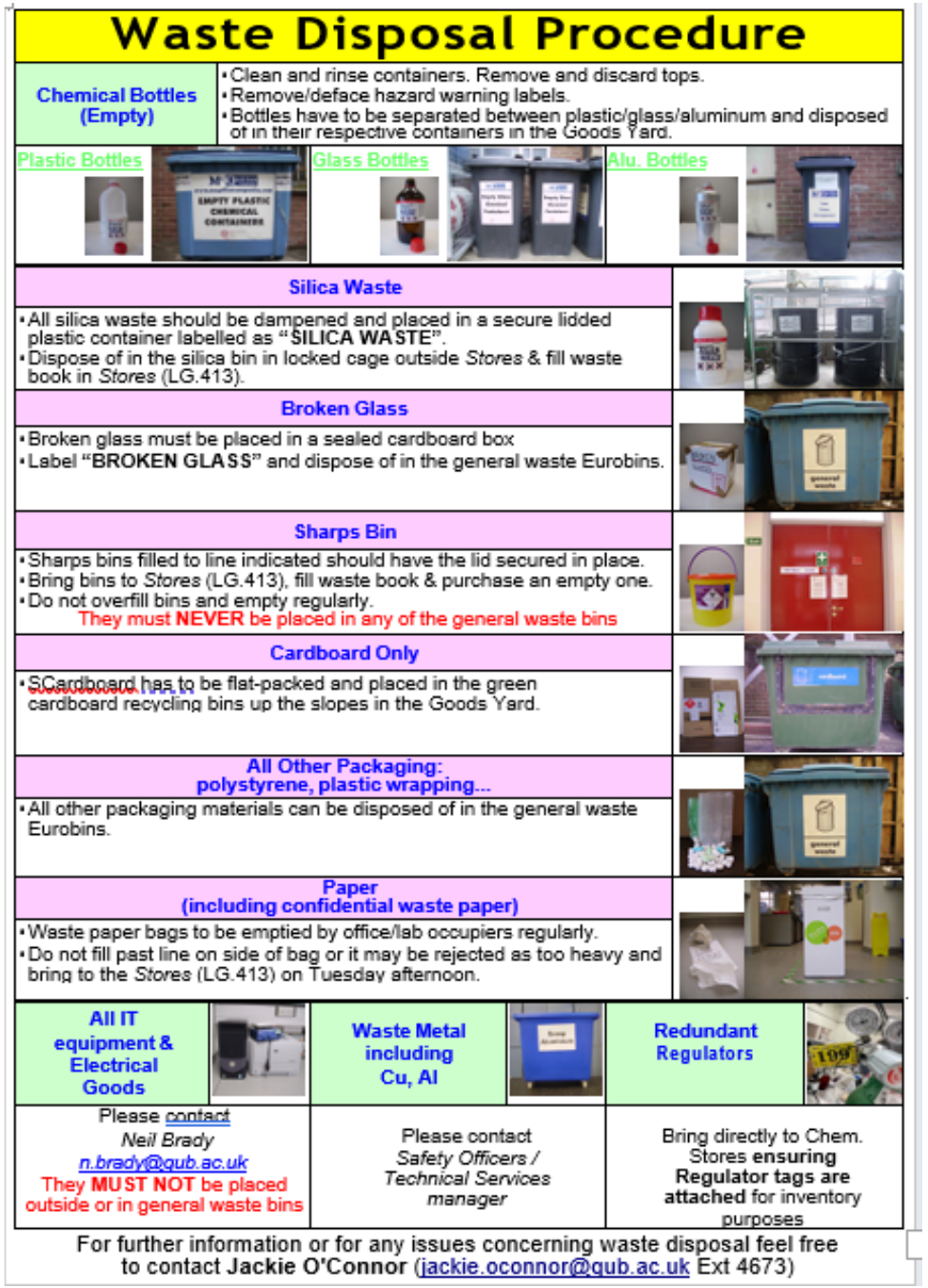
Biohazard

Cleaner's responsibilities

- Sweeping and mopping floors in labs and offices
- Emptying General waste bins
- Emptying Waste bins in Offices
- Cleaning high touch point areas, such as door handles
- Dealing with large water spills - e.g. leaking sink/tap or burst pipe (specialist equipment)
- Cleaning hand wash sinks
- Cardboard – WILL ONLY BE REMOVED BY CLEANING STAFF IF FLAT PACKED AND PLACED BESIDE BINS IN LAB

Waste disposal

Waste disposal training is provided by the School Health&Safety team, details of which are given in the Safety Talk slides on the LEAF documents page https://www.profandrewmills.com/leaf-documents/. The poster opposite – from the Safety Talk, slide 94, outlines the common waste disposal procedures. All new group members also receive hands-on training in these methods from the experienced group members, such as the LO.



Waste Disposal Procedure

Chemical Bottles (Empty)

- Clean and rinse containers. Remove and discard tops.
- Remove/deface hazard warning labels.
- Bottles have to be separated between plastic/glass/aluminum and disposed of in their respective containers in the Goods Yard.

Plastic Bottles | Glass Bottles | Alu. Bottles

Silica Waste

- All silica waste should be dampened and placed in a secure lidded plastic container labelled as "**SILICA WASTE**".
- Dispose of in the silica bin in locked cage outside *Stores* & fill waste book in *Stores* (LG.413).

Broken Glass

- Broken glass must be placed in a sealed cardboard box
- Label "**BROKEN GLASS**" and dispose of in the general waste Eurobins.

Sharps Bin

- Sharps bins filled to line indicated should have the lid secured in place.
- Bring bins to *Stores* (LG.413), fill waste book & purchase an empty one.
- Do not overfill bins and empty regularly.

They must **NEVER** be placed in any of the general waste bins

Cardboard Only

- SCardboard has to be flat-packed and placed in the green cardboard recycling bins up the slopes in the Goods Yard.

All Other Packaging: polystyrene, plastic wrapping...

- All other packaging materials can be disposed of in the general waste Eurobins.

Paper (including confidential waste paper)

- Waste paper bags to be emptied by office/lab occupiers regularly.
- Do not fill past line on side of bag or it may be rejected as too heavy and bring to the *Stores* (LG.413) on Tuesday afternoon.

All IT equipment & Electrical Goods	Waste Metal including Cu, Al	Redundant Regulators
Please contact *Neil Brady* n.brady@qub.ac.uk They **MUST NOT** be placed outside or in general waste bins	Please contact *Safety Officers / Technical Services manager*	Bring directly to Chem. Stores **ensuring Regulator tags are attached** for inventory purposes

For further information or for any issues concerning waste disposal feel free to contact **Jackie O'Connor** (jackie.oconnor@qub.ac.uk Ext 4673)

Reducing consumable use

It is very important that we reduce our use of consumables and every year we need to know who much we have consumed and examine our procedures to see how this can be reduced. In particular, in our laboratories the use of single-use plastics is not great (pipettes, petri dishes, pipette tips (for Gilson pipettes) and cuvettes). Reusable glassware is used for all other purposes (e.g. for beakers, bottles, measuring cylinders). To reduce the group's use of single-use plastic goods, all spectrophotometry and fluorimetry must be conducted using glass/quartz cuvettes and all non-biological work must use glassware, including pipettes. Wherever possible reusable glassware must be used in place of single use plasticware. This group policy is recorded in the Energy and environmental impacts under normal, abnormal and emergency conditions SOP – which must be read and acted on by everyone using any current or new SOP. Dr. O'Rourke will monitor all orders and generate a list of the orders for single use plastics made, so that at the beginning of each year we can see how much we are using and explore ways to reduce it.

Recycling

There are recycle bins for plastic bottles and metal cans in the large laboratory DKB 01.003. All group members MUST use these, or other similar, near-by recycle bins (such as in lecture theatre 01.403).

All cardboard waste is placed beside the Household waste bin and taken by the cleaners to the School's recycling bin at the back of the stores.

Note: the correct bin MUST be used for the appropriate waste, as cross contamination has a significant negative impact of recycling efficiency and adds to the cost of recycling and disposal.

Recycling

The School operates a rigorous recycling programme, which includes: (1) Winchesters collected by McQuillan Environmental for recycling and collected either as Glass, Plastic or Aluminium, (2) Gas regulators which cannot be reused / recycled and are disposed via QUB Estates as metal waste, (3) dedicated, carboard, paper, aluminium and steel food cans, (4) Electrical waste and It equipment, which is itemised and collected by an external contractor for disposal, (6) Spent battery recycle bins, which are serviced by QUB Estates, (7) QUB operates the WARP-IT scheme, where staff can place items they no longer require and can be claimed for re-use purposes. These items include chairs, desks, office equipment, and laboratory equipment, (8) When clearing a Lab or room, the school circulates a school wide email to see if any other users can use anything therein, including glassware / chemicals / equipment. (9) QUB also list most of their reuse and recycling activities, which includes the above and printer cartridges and books on the following website:
https://www.qub.ac.uk/directorates/EstatesDirectorate/SustainabilityatQueens/WasteandRecycling/#books-915947-5.

Why it is important to sort out waste

- It is important to sort out waste because it, (i) can negatively impact public health and safety, (ii) can reduce waste, (iii) has numerous environmental benefits, (iv) reduces pollution, (v) helps conserve valuable resources and (vi) saves money.
- Sorting waste before disposal is essential to maximize recycling, conserve natural resources, and protect the environment by reducing landfill volume,
- Proper sorting enables hazardous materials to be handled safely, reduces harmful greenhouse gas emissions from landfills, and reduces energy consumption
- Separating hazardous substances (like batteries or chemicals) from general waste prevents pollution of soil and water,
- Efficient sorting can reduce disposal costs and creates jobs in the recycling and waste management sector

Biological waste

All biological work, mainly confined to using BSL 1 bacteria, must only be conducted in DKB 01.112, which houses the autoclave and fridge with the biological samples. The disposal of biological waste is covered by the SOP on 'Processing biowaste' which is available for reading and/or downloading on the Mills group website (https://www.profandrewmills.com/leaf-documents/). Any group member conducting biological work MUST read this SOP - and have received training by the LO (Dr. McDonnell) on how to dispose of biological waste as described in this SOP, as well as how to handle biological material, before starting any work. New researchers will always conduct their biological work under the supervision of the LO. This training will include how to operate and clean the autoclave, which is serviced twice a year. In all biological work, the autoclave should only be run when full to minimise the unnecessary expenditure of energy.

Electrical and computer waste

- For information on disposal of electrical equipment, contact Susanne Evans (s.evans@qub.ac.uk).
- For information on disposal of computers and IT equipment, contact Neil Brady (n.brady@qub.ac.uk).
- Copies of the relevant disposal forms are available in the ‘Downloadable Forms’ folder on the Mills group, LEAF documents, web page, https://www.profandrewmills.com/leaf-documents/.

Induction: School Heath, Safety and Environment Training

Before starting, all new researchers (staff, PDRAS, RAs and Visiting Scholars) are given Health, Safety and Environment (HSE) training by the School safety team. Details of this training are given in the Health, Safety and Environment slides.pdf document on the LEAF documents page on the Mills group web site, https://www.profandrewmills.com/leaf-documents/. Please use this to revise and refresh your memory regularly regarding current Health, Safety and Environment practice and policy. This training includes sections on: (i) University Health&Safety arrangements (including mandatory H&S annual courses, such as on COSHH forms), (ii) emergency arrangements, (iii) general School safety information regarding working hours, waste disposal and responsibilities. The University also runs the following annual, mandatory safety e-based training courses for members of staff: Annual fire safety, Health and Safety Essentials, and Health and Safety for Computer users.

Departing staff: what to do when leaving the group

All students and staff, when departing the group must,

(i) Clear all computers (office and instrument) of all their files and make copies for the PI where appropriate

(ii) Clear their office and laboratory workspaces (tops, cupboards and fume cupboards). In particular, in the laboratory, they must dispose of all samples, except those explicitly retained for further work by the PI.

(iii) Return the laboratory keys to the PI

(iv) Complete and sign the 'Exit tracking form' on https://www.profandrewmills.com/leaf-documents/, in the 'Downloadable Forms' folder, which must be checked, countersigned by the LO or PI and filed with the PI.

Laboratory environmental responsibilities (LER) form and Laboratory Officer (LO) duties

Details of who is responsible for what, in terms of energy and waste, in each laboratory are given on its respective Laboratory environment responsibilities (LER) form, an example of which is illustrated on the righthand side. For each laboratory, a copy of this form is on the inside of the laboratory door entrance and also available on the Mills group, LEAF documents web page, https://www.profandrewmills.com/leaf-documents/, under 'Completed LER forms' folder. Each LO has a copy of their LER form(s) and must be aware of the duties laid out therein.

All researchers are responsible for their conduct, experiment design and practice and maintaining a tidy workspace. All researchers have a duty to take reasonable care of their own health and safety and that of others who may be affected by their acts or omissions. If anyone sees any unsafe practice(s)/actions they MUST call it out by immediately cautioning the person concerned and reporting it to the LO and PI.

Any laboratory member who is regularly not fulfilling their responsibilities (such as cleaning up after themselves and switching off instruments, ovens, hotplates and stirrers) will be reported to the PI who will take immediate action.

Laboratory Environment Responsibilities (LER) form

Laboratory Number: DKB 01.003; **Laboratory Officer (LO):** Christopher O'Rourke; **Building Liaison Officer (BLO):** David Parker; **Principal Investigator (PI):** Professor Andrew Mills

PC Monitors
Minimising PC monitor energy use (minimising screen brightness and setting the time to sleep function for the screen to 15 min is the responsibility of the user of their PC and all computerised instrumentation they use in the laboratory and will be checked randomly by the Principal Investigator (PI), Professor Andrew Mills

Fume cupboards
Checking the functions of each fume cupboard (sash, light and status) is the responsibility of the LO. Switching it off is the responsibility of the user and will be checked by the LO.

Water
The use and switching off water from condensers or cooling systems is the responsibility of the user and overseen by the LO. Water should NEVER be left flowing overnight. All leaks should be reported to the LO who will then report it to the Building Liaison officer, BLO, and PI.

Waste
Quantity of bins, their status, contents and regular emptying is the responsibility of the LO.

Fridges/Freezers
Setting the appropriate temperature and defrosting are the responsibility of the LO. Packing and appropriate sample labelling (date, and contents) are the responsibility of the user, checked by the LO.

Ovens, furnaces, hotplates and incubators
The person using any of the above is responsible for setting the correct temperature and time and switching it off. Unless necessary, and approved by the LO/PI, all these items should be switched off at the end of the day.
Any energy or environmental issues should be reported to the LO and then BLO.

Any laboratory member who is regularly not fulfilling their responsibilities will be reported to the PI who will take immediate action.

Acronyms: LO: Laboratory Officer; PI: Principal Investigator; BLO: Building Liaison officer.

A copy of this document and other LEAF documents can be found on the following Mills group web page: https://www.profandrewmills.com/leaf-documents/

Team activities and talking to each other

At the beginning of each calendar year, all members of the group must participate in in the annual laboratory spring-clean and associated training course. This typically lasts ca. two days and involves a thorough clean-up of all the laboratories, the updating of all LEAF-related documents and forms (including the LER forms) by the PI, and a LEAF training session, given by the PI, based on the updated version of the LEAF training notes.ppt, see (1). On each of these two spring-cleaning days, there is an informal lunch, in which ways to improve our LEAF-related activities are discussed. In addition, the group has a bi-monthly group lunch to discuss, amongst other things, ways to improve energy and waste minimisation in the laboratory. The Mills group has a WhatApp group allows the rapid communication of news, advice and suggestions for improving LEAF practice. The group or members of the group have regular (weekly if not daily) on-line meetings with the PI on MS Teams (http://go.qub.ac.uk/MillsGroup). Although the latter is used mainly for meetings with the PI, it is also available for use for online meetings between group members and between group members and industrial collaborators. All members are encouraged to use the above methods of communication, and email, to share their results, even negative results, and experiences, with an aim to find solutions and improve performance, which includes LEAF-related activities.

Equipment Life cycle assessments (LCAs)

For all equipment purchases the University requires an LCA from the vendor. The energy consumption (in Watts) in a typical cycle of operation of every instrument must be specified in the quote or in the technical brochure.

For all equipment tenders, as part of the evaluation process, the University requires written details of the steps taken by the organisation to reduce the environmental impact of the product/service/supply, making reference to the supplier's audited systems and processes that are in place to ensure environmental impact is minimised, managed and recorded. The given response to this requirement must include the impact in relation to energy and resource use, waste management and travel.

Turning off lights and equipment at end of the day

At, or by, the door of each laboratory there is a sign instructing all students and staff to turn off the lights when they are the last to leave the laboratory. All laboratory members have a responsibility to turn off all equipment they are using after use. The last laboratory member has the responsibility to turn off all equipment that might have been left on accidentally, unless the signage states otherwise. All such (exceptional) signage requires the approval of the PI and LO. Any laboratory member who is regularly not fulfilling their responsibilities must be reported to the PI who will take immediate action. It is very important that we do not leave lights or instruments on when not necessary. This is an important part of our LEAF efforts.

Fridges, freezers and ovens/furnaces

In each laboratory, it is the duty of the LO to inspect and service (clean, defrosted, remove unwanted samples, check ventilation and seals and for leaks, etc.) the fridges and/or freezers in their laboratories monthly. This duty is listed on the LER form posted on the laboratory door and on the group's web site, https://www.profandrewmills.com/leaf-documents/. All samples placed in a fridge/freezer must be labelled. No fridge/freezer should be overloaded, but, where possible, the fridges and freezers should be operated as full as possible. However, do not put strong oxidants (such as H_2O_2) or corrosive chemicals (such as Br_2) without consulting the LO and ensuring it is properly packaged, so that it presents no risk of contamination or reaction with the other chemicals/samples present. There is a fridge in 01.003, labelled 'cold reactor' that MUST not be used for storing chemical, as it is a cold reactor - used to provide (when on) chilled conditions for a reaction (usually indicator colour change); always talk to the LO before use.

No new fridge/freezer will be purchased unless an existing one is no longer fit for purpose, or near to overflowing. If a new fridge/freezer needs to be purchased – email the PI, who will review the case.

All ovens and furnaces are switched off after use, with signage on each unit instructing the user to do this.

Fume cupboards and LEVs

Fume cupboards and local exhaust ventilation cabinets should never be used to the extended storing of goods. Wherever possible they should be clear or have items that are in active use over the coming days.

As a general rule, fume cupboards should be switched off when not in use to save energy. Consult the LO if you think a fume cupboard needs to be left on – especially overnight. The LO will provide training for first time users on when and how to use a fume cupboard responsibly, including when and how to lower the cupboard sashes and, when finished with, how and when to turn them off. Most of the groups fume hoods can be switched off after use, with the sash lowered. Before doing so, however, always consult with the LO.

All workers using the fume cupboards must follow the guidelines given by the signage on the fume hoods, use them appropriately and minimise their use of energy. The LO will monitor fume hood use and ensure they are used properly and left in a suitable condition for the next user.

Water

All aqueous reaction solutions MUST be made up using the doubly-distilled, deionised (DDDI) water that is in the main laboratory (DKB 01.139). This water is high purity, with a conductivity < 1.0 μS/cm

The DDDI water still in DKB 01.139 is maintained by the LO – any problems must be reported immediately to the LO AND PI, as it is **essential** that this is fixed asap.

Tap water (conductivity: 50-500 μS/cm) can be used initially to rinse out glassware, but the final rinse solutions must be DDDI water. NEVER use any other water that DDDI water to make up solutions.

The School does have a reverse osmosis water supply (conductivity: 20-200 μS/cm) which the group doesn't use as it is not pure enough for the research being carried out.

When using tap water – say to initially clean glassware - the taps must never be left running. Cold water circulators, and NOT tap water, must be used on any distillation rig.

Other sustainability actions

Turning off equipment etc.

- The School's Health&Safety training session you received covers the usual sustainability practices operated within the School and University, such as recycling and minimising waste and optimising energy usage, e.g., by turning off equipment when not in use or not re-ordering chemicals, when there is still some available. A copy of the notes associated with this training session, entitled 'Health, Safety and Environment slides.pdf' is on the Mills group website, https://www.profandrewmills.com/leaf-documents/.
- When designing any new experiment, energy and waste minimisation must be a paramount consideration. Thus, minimise the need for single use plastics and always switch off any associated instruments and water taps when the experiment is at an end.
- For each laboratory, an outline of the general laboratory/office sustainability actions and responsibilities are outlined on its Laboratory Environment Responsibilities (LER) form, see slide 16.

Equipment breakdown: what to do?

In the event an equipment breakdown/failure, the user MUST always notify immediately the LO and PI, who – between them - will, (i) arrange for the equipment to be fixed, either by the PI and Dr. O'Rourke, or the School's electronics engineer, or by an appropriate a service engineer asap, (ii) identify, wherever possible, an alternative instrument/equipment to be used in the meantime or identify alternative experimental work that needs to be carried out in the meantime, and (iii) notify the rest of the group of the breakdown and the actions taken. LO's and the PI will also conduct regular checks on laboratory equipment to check it is working and clear of samples and old data. The PI and Dr. O'Rourke have enough experience to carry out medium level of maintenance and repair on most instruments, such as reinstalling software, changing lamps, fuses, columns, lasers and detector units.

12 principles of Green Chemistry

- Is a framework for reducing environmental impact of chemical processes.
- Although a number of these principles are more relevant to synthetic (and physical) chemists, it is important that all group members are aware and try, to their best abilities, to adhere to the 12 principles, including suggesting ways to each other and the PI in which the group can improve their adherence to the principles and the use of less harmful chemicals. All ideas welcome.

The 12 Principles of GREEN CHEMISTRY

Green chemistry is an approach to chemistry that aims to maximize efficiency and minimize hazardous effects on human health and the environment. While no reaction can be perfectly 'green', the overall negative impact of chemistry research and the chemical industry can be reduced by implementing the 12 Principles of Green Chemistry wherever possible.

1. WASTE PREVENTION

Prioritize the prevention of waste, rather than cleaning up and treating waste after it has been created. Plan ahead to minimize waste at every step.

2. ATOM ECONOMY

Reduce waste at the molecular level by maximizing the number of atoms from all reagents that are incorporated into the final product. Use atom economy to evaluate reaction efficiency.

3. LESS HAZARDOUS CHEMICAL SYNTHESIS

Design chemical reactions and synthetic routes to be as safe as possible. Consider the hazards of all substances handled during the reaction, including waste.

4. DESIGNING SAFER CHEMICALS

Minimize toxicity directly by molecular design. Predict and evaluate aspects such as physical properties, toxicity, and environmental fate throughout the design process.

5. SAFER SOLVENTS & AUXILIARIES

Choose the safest solvent available for any given step. Minimize the total amount of solvents and auxiliary substances used, as these make up a large percentage of the total waste created.

6. DESIGN FOR ENERGY EFFICIENCY

Choose the least energy-intensive chemical route. Avoid heating and cooling, as well as pressurized and vacuum conditions (i.e. ambient temperature & pressure are optimal).

7. USE OF RENEWABLE FEEDSTOCKS

Use chemicals which are made from renewable (i.e. plant-based) sources, rather than other, equivalent chemicals originating from petrochemical sources.

8. REDUCE DERIVATIVES

Minimize the use of temporary derivatives such as protecting groups. Avoid derivatives to reduce reaction steps, resources required, and waste created.

9. CATALYSIS

Use catalytic instead of stoichiometric reagents in reactions. Choose catalysts to help increase selectivity, minimize waste, and reduce reaction times and energy demands.

10. DESIGN FOR DEGRADATION

Design chemicals that degrade and can be discarded easily. Ensure that both chemicals and their degradation products are not toxic, bioaccumulative, or environmentally persistent.

11. REAL-TIME POLLUTION PREVENTION

Monitor chemical reactions in real-time as they occur to prevent the formation and release of any potentially hazardous and polluting substances.

12. SAFER CHEMISTRY FOR ACCIDENT PREVENTION

Choose and develop chemical procedures that are safer and inherently minimize the risk of accidents. Know the possible risks and assess them beforehand.

12 principles of Green Chemistry ones particular relevant to group

1. Waste prevention. Prevent waste rather than cleaning it up.
2. Safer solvents and auxiliaries: Choose safest solvent and minimise the amount used.
3. Design for Energy Efficiency: Where possible, conduct chemical reactions at room temperature and pressure whenever possible to minimize energy usage.
4. Use of Renewable Feedstocks: Utilize raw materials and feedstocks that are renewable rather than depletable.
5. Real-time Pollution Prevention: Develop analytical methodologies for in-process monitoring to prevent the formation of hazardous substances.
6. Safer Chemistry for Accident Prevention: Choose substances and the form of substances used in a chemical process to minimize potential accidents, including fires, explosions, and releases.

School analytical facilities

There are a number of School analytical facilities. A list of these are given on the next slide. Discuss with the PI before using any of these so he can decide if they are appropriate and provide you with a charge code. Below is a list of the analytical facilities available and how to access/book these facilities – but, if in doubt talk to Dr. Chris O'Rourke who will help you submit your samples.

School analytical facilities

CCE analytical facility charges September 2025		
Analytical Technique	**Cost**	**Unit**
Elemental Analysis (CHN)	£5 0	sample
ICP-OES (microwave sample digestion)	£10 0	sample
ICP-OES (no sample digestion)	£5 0	sample
ICP- OES (peroxide fusion)	£10 0	sample
Mass spectrometry	£20 0	sample
TGA	£10 0	sample
DSC	£10 0	sample
A.A. Anaysis (microwave sample digestion)	£10 0	sample
A.A. Anaysis (no sample digestion)	£5 0	sample
TOC	£5 0	sample
Surface area analysis (BET)	£20 0	sample
SEM	£40 0	hour
Powder XRD	£10 0	hour
Single Crystal XRD	£10 0	hour
FT-IR/UV-Vis/Karl Fisher	No charge	
Standard ^{1}H NMR	£5 0	sample
Standard ^{13}C NMR	£10 0	sample
Standard 1D NMR (other nuclei)	£10 0	sample
2D NMR experiments	£50 0	sample
Solid state NMR (standard HR-MAS)	£50 0	hour

School analytical facilities

The system used for booking communal equipment is Calira (formerly Clustermarket) and can be accessed via the following link (https://app.clustermarket.com/login). Details of the equipment/analysis available through the system can be found at (https://www.qub.ac.uk/schools/SchoolofChemistryandChemicalEngineering/Discover/Facilities/).

In order to gain access to the booking system, each student/PDRA has to email Angela Brownlie (a.brownlie@qub.ac.uk) who is the lead analytical technician for ASEP. She will then sort out appropriate training for using the desired instruments prior to use.

Computer monitors, fridges/freezers/ovens, lights

It is important that each member of a laboratory is proactive in minimising energy consumption when using all equipment, such as PC monitors, fume cupboards, fridges/freezers and ovens/furnaces/hotplates/incubators. Also, it is important to minimise the use of water as a coolant. Although each researcher is responsible for addressing the above, mainly by turning equipment off, once it is no longer, required, the LO is responsible for checking that these energy saving processes are carried out by those working in the laboratory and the PI will be informed and take the necessary action to ensure it doesn't happen again. The LO must ensure all ovens/furnaces/hotplates/incubators/fume hoods are switched off after use. The LO must ensure all fridges/freezers are at an appropriate (not too low) temperature. The responsibilities of the laboratory members and LO with respect to each laboratory environment is described on the LER form (see slide 17) for that laboratory. The LER form is posted on the inside door of each laboratory and downloadable from the group's web site, https://www.profandrewmills.com/leaf-documents/. Note: PC monitors must operate with minimal brightness and switch off after 15 min unuse. The PI will carry out regular, random checks to ensure this policy is adhered to.

Data management

It is essential you regularly back up your data on portable hard drives – which the group will provide upon request (contact PI). Note that all instrument PCs are regularly cleared of data – so researchers must NOT routinely use instrument PCs to store their data. Instead, it must be transferred to the Researcher's PC, their portable hard-drive AND stored on Microsoft 365 OneDrive. The latter is available to all QUB employees and a cloud service that connects you to all your files. On OneDrive, your files are stored and protected and you can share them with others.

Data management

Google Drive can be used to back up and share important documents/data between group members for current projects. In GoogleDrive, all members of the group have the option to access the files on the shared account (andrewmillsgroup@gmail.com) either via the downloaded app (https://ipv4.google.com/intl/en_zm/drive/download/) or simply by logging in through their web browser (https://drive.google.com). The password is shared between all current members of the group. Once projects are complete, the data is then reviewed and any unnecessary files are deleted.

All members of the group are encouraged to save their data immediately to an external storage device, like a USB drive. USB drives are readily available from Stores in the department and are funded by the group. Dedicated USB drives for transferring data from instrument computers to office computers reduce the risk of viruses, which also reduces the risk of losing important data. Group members should use the QUB Dropbox service to transfer large data files (https://dropoff.qub.ac.uk/). By logging in with a QUB username and password, files up to 20.0 GB can easily be sent.

Sharing results – especially negative results and how to improve a procedure

It is vital that all group members talk to each other about their research – especially about negative results, new lessons learnt and suggestions as to how to improve procedures. It is important to learn from previous errors and avoid repeating the same work. Although we do this routinely – usually through small group discussion with the PI, use the Mills group WhatsApp or other means (face to face or MS teams) to discuss your experiences. Do NOT wait to do this at the regular lab meetings; please be pro-active. This activity is very much encouraged in the group, as it helps each other save time and effort by learning through our mistakes. Always include the PI and LO in these discussions so they area ware of any issues and suggested improvements that they can then effect.

Laboratory sample labels

All laboratory samples, in or out of fridges/freezers, must have a label with name, date and details of the sample on it.

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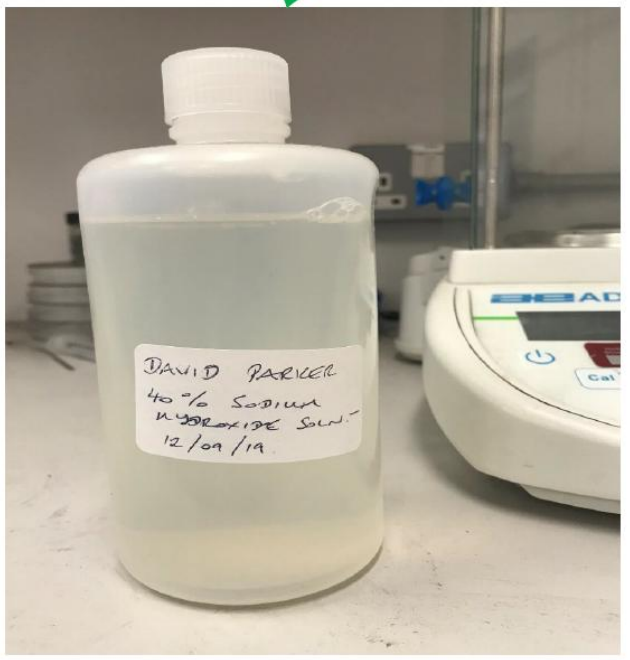
Sample labelling and Storage



Sharing chemicals: Mills group chemical and cylinder Inventory

- A downloadable copy of the Mills group chemical and cylinder inventory, Mills group chemical inventory.xls, and Mills group gas cylinder inventory, Mills group gas cylinder inventory.xls, is given on the Mills group web site, https://www.profandrewmills.com/leaf-documents/.

- The inventory is maintained by Dr. Christopher O'Rouke, CR and the LOs. It is the responsibility of each laboratory group member to notify the LO when a chemical/cylinder on the inventory has been used up/disposed and when a new chemical/cylinder has been purchased.

- Chemical/cylinder sharing is standard procedure within the group to minimise unnecessary orders for the same chemical/cylinder.

SOPs, COSHH and Risk Assessment forms

The 12 standard operating procedures, SOP's, and 9 risk assessments, which cover the major instruments in the laboratories and common lab practices, can be seen or downloaded from the Mills group web site, https://www.profandrewmills.com/leaf-documents/. In addition, the web site contains the completed COSHH forms which cover the current groups research activities and the slides of the School's COSHH safety talk, 'COSHH Safety Talk.pdf' to help in the filing out of any new COSHH form. Whenever a new experiment has to be carried out, an appropriate new COSHH form needs to be completed before work can begin. Details as to how to do this are given in the School's 'COSHH Safety Talk.pdf', which is on the same website. Blank COSHH and RA forms are on the group's web site, under 'Downloadable Forms'.

Equipment calibration

The School's Health and safety team organise an annual calibration of all balances. In addition, the LO of each laboratory is responsible for checking the calibration of each balance in their laboratories using two check weights (2 and 20 mg).

All pipettes mut be calibrated by the user each year using the 'pipette and weigh' technique using water. Anyone unfamiliar with this process will be trained up by the LO.

Laboratory building (leaks, heating, lighting etc.) issues

If there are any building issues with a laboratory, the Estates department must be contacted asap, through the building liaison officer, BLO. Typical issues are, ventilation, room pressure, water leaks, heating & cooling. If there is a building problem, contact asap the lab's BLO, and LO. For each laboratory, the respective BLO is named on the laboratory's LER form. The BLO is David Parker for both 1st and 3rd floor laboratories.

Disposing of hazardous waste

Hazardous waste

Details of how to dispose of chemical waste, including hazardous waste are given in the School's Health, Safety and Environment (HSE) training program, the slides for which 'Health, Safety and Environment slides.pdf' are on the LEAF documents page on the Mills group web site, https://www.profandrewmills.com/leaf-documents/. If this information is not sufficient to deal with the waste issue, consult the LO and PI immediately. Also look at a copy of the 'Hazardous Waste Chemicals Disposal Guide' by Margaret-Ann Armour, copies of which are on the shelves of the two the big laboratories, 01.003 and 01.139. Always refer to a copy of this book whenever you have a new project that has possible hazardous waste implications. In addition, refer to this book when preparing any COSHH form involving hazardous materials. Do NOT remove the laboratory's copy of this book. When dealing with a new hazardous material, also always consult with the LO and PI as to how it is best disposed of, who will then consult the School's Health and Safety team if they need further advice.

What to do if a hazardous chemical waste has been disposed of incorrectly?

- If possible, retrieve the waste sample bottle so it can be disposed of correctly. For example, this action will be possible if the error was in the boxing up of the hazardous sample for disposal along with non-hazardous powder samples.
- If the problem cannot be readily resolved, then make the LO, PI and School's safety officer aware of what has happened, so that they can devise and effect an appropriate action plan. For example, most solid, or very dense, hazardous samples disposed down the sink (such as Hg) can be extracted from the sink's trap and then disposed of correctly. Also, the risk posed by most poisonous, or corrosive, chemicals that may have been accidentally put down the sink can be minimised by diluting them with copious amounts of water. When dealing with the disposal of hazardous materials, always seek the advice of the LO and/or PI before taking any action.

Energy and environment impact minimisation (under normal, abnormal and emergency conditions)

When carrying out any procedure, it is important to consider energy and environmental impacts under normal, abnormal and emergency conditions. There is an SOP which identifies the many general ways this can be achieved in our research. This, SOP - Energy and environmental impacts under normal, abnormal and emergency conditions, can be found on the Mills group web site, https://www.profandrewmills.com/leaf-documents/. All members of the group are encouraged to identify ways to improve any SOP in all aspects, including energy use and environmental impacts; if you have an idea how to improve things please contact the PI or LO. Because of its importance, details regarding what to do in case of an emergency, such as a large chemical spill, power cut, flood, or major accident are given on the next slide.

Energy and environment impact minimisation (under emergency conditions)

Most of the above slides cover how we address energy and environment impact minimisation under normal conditions and who is responsible for ensuring action is taken. However, it is important that all laboratory users also consider these two subjects under *emergency* conditions, such as the advent of a large chemical spill, power cut, flood, or major accident. Obviously, initially, the focus will be on resolving the immediate problem. For example, in the case of a major chemical spill, the LO, PI and School's safety officers must be consulted and an action plan devised and effected. In the case of a major accident, the University's emergency response team must be contacted (x2222) immediately. However, when the emergency situation is under control, then energy and environment impacts need to be considered and addressed – usually by the LO. Thus, in all cases which render the laboratory temporarily unusable – all electrical equipment must be switched off when and where possible. If a fume hood is being used to vent off volatiles due to a major spill, the LO is responsible for ensuring it is switched off after this has been completed.

Learning sustainability tips from other laboratories

It is important that we learn about the sustainability practices of other laboratories and *vice versa*. Thus, when visiting any laboratory, such as that of Prof. Gilmore/Dr. Kelly in Pharmacy, or industry (Oculer ltd.) please ask about their sustainability practices. Let the group know your findings, through the groups WhatsApp, especially if the practices are in any way an improvement on ours. It is important we learn and improve our work in this area from other groups. Also, share our practices with any visiting researchers, so they can do likewise.

Conclusions

This LEAF training session, these notes and all the supporting documentation, such as RAs, SOPs, especially the SOP Energy and environmental impacts under normal, abnormal and emergency conditions, which are on the Mills group website, highlights the constant needs for you to consider the environmental impact of your work and, oftentimes, the need for necessary pro-active actions and revised procedures. When working in the laboratory it is important to minimise energy and waste and the above slides outline show how we usually do this and who is responsible for what. Hopefully, you'll also see we welcome suggestions for improving our procedures.

Any queries regarding LEAF and the above slides, do not hesitate to talk to the LO and/or PI. Refresh your memory of our LEAF activities regularly over the year by consulting these slides and the other documents on the Mills group website, https://www.profandrewmills.com/leaf-documents/. And if you recognise anything that could lead to the more efficient sue of energy and resources, let everyone, including me, the PI, know.