Greening Chemistry at the University of Bradford

Greening the Chemistry Curriculum

As part of the University of Bradford's Ecoversity project to embed the principles and practice of sustainable development within all courses, in 2009-10 the Chemistry Department:

1. Reviewed international best practise in incorporating sustainability into taught chemistry programmes.
2. Surveyed employers, staff and students. This found that 75% of graduate, and 78% of first year, students were interested in knowing more about green chemistry, and that 92% and 86% respectively would change their current lab practice to comply with its principles (see overleaf).
3. Piloted the modification of undergraduate practical scripts to include questions on the hazards of the chemicals used, and the scope for making them greener through alternative reagents and methods, such as catalysis.
4. Undertook a pilot audit of laboratory environmental impacts, with assistance for the US LabRATS initiative.
5. Developed green chemistry metrics such as yield efficiency as a tool to compare experimental alternatives, and to increase student awareness.

The work involved Ecoversity STEM champion Dr. Beverley Lucas; Dr. Ian Scowen and Dr. Tasnim Munshi from the Department of Chemistry; and a former student, Amy Ridley, who was employed part-time. Green chemistry metrics and new or modified practical scripts and methods are now being introduced into most Chemistry undergraduate courses, components of an MSc on Analytical Sciences and relevant modules of related degrees such as Chemical Engineering.

Modified First Year Solvent Extraction Experiment

You have carried out the experiment; solvent extraction from a liquid: extraction and purification of caffeine from tea. Now consider the following:

1. Re-read your practical script. This practical uses a number of solvents during extraction and recrystallisation.
2. Identify the solvents used in the experiment.
3. Place these solvents in the order of which you think is the least harmful to most harmful giving reasons for each choice.
4. Look at the twelve principles of green chemistry, which principle do you think this relates to?

Dr. Beverley Lucas

Key Points

- As part of the University's Ecoversity programme, taught chemistry modules reviewed and modified to incorporate sustainability issues and green chemistry principles
- High level of student interest in green chemistry and willingness to change lab practices in response
- Modification of existing courses and practical scripts preferred to separate 'bolt on' modules
- Use of common experiments to broaden awareness of environmental and toxicity issues related to solvents
- Employers value knowledge of sustainability issues in graduate chemists so actions improve employability
- Laboratory operations assessed as well as curriculum issues
- Green chemistry seen as competitive advantage in student recruitment

S-Lab Case 11 – Greening Chemistry at the University of Bradford

Key Benefits

Employability – responses from employers of chemistry undergraduates (the majority of whom are outside the chemical sector) showed that they place high value on students who understand sustainability and green chemistry, and the regulatory and other factors that are increasing their importance.

Environmental Improvement – the audit identified many opportunities to minimise energy and water usage, and waste, within chemistry laboratories. Guidance materials are being planned to translate the increased awareness arising from the curriculum changes into practical action, e.g. closing fume cupboard sashes when not in use.

Recruitment – the Department anticipates that a green chemistry focus will differentiate its courses from most others, and therefore attract more students.

Principles of Green Chemistry

1. *Prevention* (i.e. avoiding the need to deal with waste).
2. *Atom Economy* (maximising the incorporation of all materials used in the process into the final product).
3. *Less Hazardous Chemical Syntheses* - use and generate substances with little/no human or environmental toxicity.
4. *Designing Safer Chemicals* (same functionality, less toxic).
5. *Safer Solvents and Auxiliaries* (e.g. separation agents).
6. *Design for Energy Efficiency* (synthetic methods conducted at ambient temperature and pressure wherever possible).
7. *Use of Renewable Feedstocks* (e.g. biological rather than fossil fuel).
8. *Reduce Derivatives* (derivatization often requires additional reagents and can generate waste).
9. *Catalysis* - catalytic are superior to stoichiometric reagents.
10. *Design for Degradation* – into innocuous products.
11. *Real-time Analysis for Pollution Prevention* – avoiding unwanted hazardous substances in chemical processing.
12. *Inherently Safer Chemistry for Accident Prevention* – minimising the potential for releases, explosions, and fires.

Source: Anastas P. & Warner J., *Green Chemistry*, 1998.

Dr. Tasnim Munshi

Views

"Using routine experiments to introduce the concepts of green chemistry has been very effective. Students can stay in their comfort zones, but still think much more deeply about the environmental and safety features of everyday lab chemicals, what happens to the waste they wash down the sink, and whether there needs to be so much of it."
Dr. Tasnim Munshi

"Our approach to Greening STEM has been to integrate the existing curriculum rather than bolt on a module or a few lectures on sustainability, which may be disconnected from the rest of the course."
Dr. Beverley Lucas

"I took no care, didn't think about what [chemical] I was using, how much I used or the disposal. The green chemistry lecture made me think."
Graduate student

Further Information – www.goodcampus.org and www.bradford.ac.uk/admin/ecoversity.
Bradford contact: Dr. Tasnim Munshi at t.munshi@bradford.ac.uk.