

Real Options for Lab Stewardship Okanagan Campus



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Presenting on behalf of the
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Overview

Introduction / Re-introduction to the Okanagan Campus

Experimental Changes – Greening Undergraduate Labs

Pilot - Small Scale Solvent Distillation

Questions



The View from the Okanagan



5 years...
and still growing...

Our Growing Community



5 Years growth...

100% increase in service...



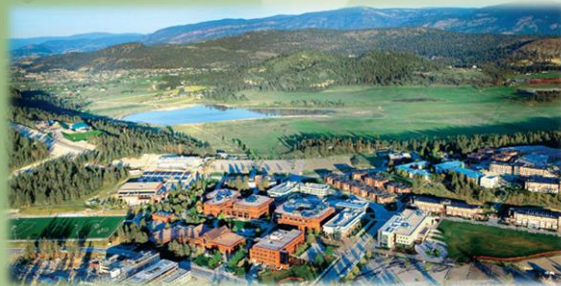
From 3479 to 7079 students

More than 400% increase in housing...



From 336 to 1400 beds

100% increase in land...



2010 UBC purchased an additional 103.6 ha of land adjacent to the Okanagan campus

Our Growing Space

New Buildings

2008 – Fipke Centre for Innovation and Research

2009 – University Centre

September 2010 – Arts & Sciences II

Coming Soon...

Health Sciences Centre
Engineering Management Education



Okanagan Campus Green Highlights....

Did you know...

Geothermal energy provides a portion of the heat to the campus.

Our Earth tub can compost 150 lbs of pre-consumer organics daily...organics are taken from the campus kitchens.

Styrofoam on campus is collected free of charge and re-used by a local company to make insulating liners.



Okanagan Campus Green Highlights....

Did you know...

The Fisher/Corning Life Sciences Plastic Recycling Program was piloted at the Okanagan campus...diverting plastic from landfills.

Liquid chemical wastes are collected and transported in their original bottles and boxes...
...reducing containers needed to hold and transport waste.

The Biological Sciences Department is improving source separation by colour coding
...getting the waste into the right waste stream



Experimental Changes Greening Undergraduate Labs



Caffeine Extraction From an Energy Drink – first year Chemistry

Sulphonamide Synthesis – second year Organic Chemistry

Solvent-Free Alkylation of Carbanions

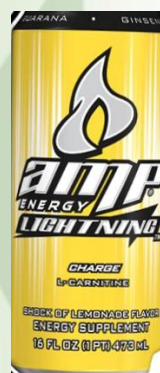
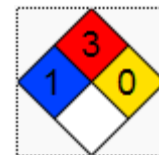
Solvent-Free Wittig Reaction – third year Organic Chemistry

K_{sp} of $PbCl_2$ - first year Chemistry

Caffeine Extraction from Energy Drink¹



	Original:	Replacement:
Name:	Reactions of Functional Groups	Caffeine Extraction from Energy Drink
Waste composition:	heavy metals, halogenated organics, ketones, aldehydes, hexane, cyclohexene	2-propanol, sodium chloride, energy drink



1. (Murray and Hansen 1995)

Caffeine Extraction from Energy Drink – Waste Reduction¹

- Original Experiment
 - 12 mL hazardous waste/group
 - 120 mL hazardous waste/lab section
 - 4.1L/term
 - More hazardous reactants
- Greener Experiment
 - 2 mL hazardous waste/group
 - 20 mL hazardous waste/lab section
 - 0.68L/term
 - Less hazardous reactants

83% waste reduction



Sulphonamide Synthesis¹



New experiment added to curriculum
Water as solvent in organic chemistry

Waste composition

Acidified water (62 ml/group)

Sulphonamide (0.7 g) – lab product

Shows “real-life” experimentation

Pharmaceutical production

Demonstrates green labs



Solvent-Free Alkylation of a Carbanion



Production of C-C bond using Mortar and Pestle

23 different combinations of bases, ketones and electrophilic alkanes in 2 steps:

1. Ketone + Base = Deprotonation
2. Add Electrophilic Alkane = Alkylation

Products:

unable to isolate a satisfactory amount

Conclusion:

Not suitable for a teaching lab



Solvent-Free Wittig Reaction¹



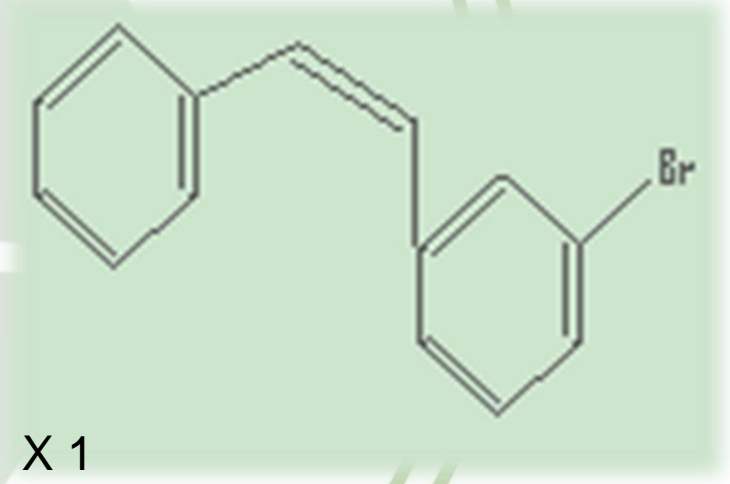
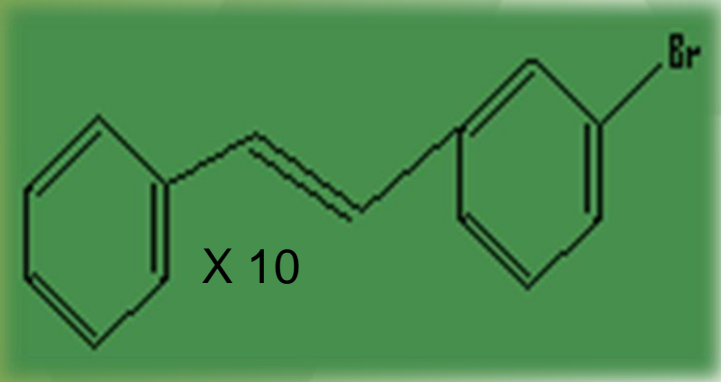
	Original:	Replacement:
Name:	Classic Wittig	Solvent-Free Wittig
Reagents:	trimethylphosphonoacetate, benzaldehyde, sodium hydride, ammonium chloride	benzyltriphenyl phosphonium chloride, potassium phosphate tribasic, 4-bromobenzaldehyde
Method Basis:	chemical reactants	physical mixing with a mortar and pestle
Extraction:	Tetrahydrofuran, ether, methanol, dichloromethane	Water



Products of the Solvent-Free Wittig Reaction



HNMR showed a 10:1 ratio of trans : cis isomers in product...as expected.



Solvent-Free Wittig Reaction¹ – Waste Reduction



Original:
1500 ml/term

Greener:
180 ml/term

88% waste reduction

K_{sp} of Lead Chloride ($PbCl_2$) A Modified Experiment



	Original:	Replacement:
Name:	Solubility Product of Lead Chloride	
Starting Volumes:	PbNO ₃ : 110 mL =2.4L/lab NH ₄ Cl: 130 mL section	PbNO ₃ : 55 mL =1.2 L/lab NH ₄ Cl: 65 mL section
Waste Composition:	160 mL PbNO ₃ + NH ₄ Cl/group 1.6 L/lab section	40 mL PbNO ₃ + NH ₄ Cl/group 0.4L/lab section
Total Waste Volume:	54.4L/term	13.6 L/term

**75% waste
reduction**



Green Labs Summary



Experiment	Improvements
Caffeine Extraction	83% decrease in waste Less toxic starting materials
Sulphonamide Synthesis	Adds a green component to existing experiments Demonstrates water as solvent
Solvent Free Wittig	88% decrease in waste
Solubility Product Constant of Lead Chloride	75% decrease in waste

Small Scale Solvent Distillation Project



2 Waste sources used:

- Homogeneous waste – high concentration acetone
- Heterogeneous waste – alcohols, acetone, diethyl ether, ethyl acetate and water

2 Set-ups:

- Simple Distillation Apparatus
- Fractional Distillation Apparatus

2 Purity Analysis:

- Purity of acetone (HNMR & GCMS)
- Residue left after evaporation (HNMR & GCMS)

Small Scale Solvent Distillation Project



Success!!

Simple distillation procedure using homogeneous waste:

- Very few contaminants in acetone
- No residue left after evaporation

Fractional distillation procedure using homogeneous waste:

- Not necessary

Small Scale Solvent Distillation Project - More Opportunities:



Simple distillation procedure using heterogeneous waste:

- A few contaminants in acetone shown on the GCMS spectrum
- No residue left after evaporation

Fractional distillation procedure using heterogeneous waste:

- Very few contaminants in acetone
- No residue left after evaporation



Small Scale Solvent Distillation Summary



Small scale works – with relatively pure wastes...creates acetone for cleaning...

**Recycling potential = 412 L
of acetone waste¹/year**

1. Acetone composition of 50% or greater

Next Steps for the Okanagan Campus



1. Provide lab Environmental Impact Statements (EIS) to PIs and lab managers
2. Educate waste generators about final fate of wastes
3. Increase recycling potential by better waste segregation
4. Create targets for waste reduction

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References

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Questions





a place of mind

THE UNIVERSITY OF BRITISH COLUMBIA

