INFUSING TOXICOLOGY THROUGHOUT THE CHEMISTRY CURRICULUM AT SOUTH DAKOTA STATE UNIVERSITY

Green Chemistry | SDSU

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South Dakota State University
CHEM 484 “Chemical Toxicology”

Offered since 2012-2013

Course Description: Understanding of the principles of toxicity, including the molecular basis for toxicity and the fate and transport of chemicals in the environment.
COURSE OUTLINE

Fundamentals of Toxicology
• Terminology
• Toxicodynamics/Dose-Response Relationships
• Classes of Toxicants
• Legal and Regulatory Issues

Toxicity Mechanisms and Actions
• Absorption, Distribution, Metabolism, and Excretion
• Acute Toxicity
• Carcinogenesis, Mutagenesis, Teratogenesis

Environmental Toxicology
• Risk Assessment
• Bioaccumulation and Degradation
• Transport and Fate of Toxicants in the Environment
Our New Initiative

Honors/Majors Curriculum
Modified 1-2-1 curriculum. Second semester (freshmen) is first organic course.

Academic Affairs Scholarly Excellence Grant
Introduce toxicology into first honors/majors organic course via three lectures on toxicology fundamentals, EPI Suite exercise, and bioassay laboratory.
Sample of toxicological principles described and discussed:

• Stereochemistry and Thalidomide
  ✓ exposure, dose, dose/response

• Development of Teflon and Halogenated Compounds
  ✓ environmental exposure, remediation, chemical disposal hazards

• Grilling Food and Polycyclic Aromatic Compounds
  ✓ exposure routes, biological response, toxicokinetics/toxicothermodynamics
Laboratory Exercise

Week 1 Pre-lab Activity
• Read New York Times article on increasing incidence of vitamin toxicity due to overconsumption of supplements and fortified foodstuffs
• Consult toxicological database (EPI Suite) for toxicological information on common vitamins: A, B12, C, D, E, and K
• Calculate toxic dosage of A, D, E, and K for their body weight
• Review article on vitamin metabolism and its effects on the liver
• Answer a series of questions related to vitamin toxicity, the NYT article, etc.
Laboratory Exercise

Week 1 Experimental
• Prepare solutions of each fat-soluble vitamin
• Create a broth of healthy hepatic cells and measure concentration
• Inoculate samples of hepatic cell broth culture with vitamin solutions
• Incubate for 1 week
Laboratory Exercise

Week 2

• Retrieve inoculated hepatic cell broth solutions
• Complete colorimetric assay (e.g., MMT or LDH) to determine cell survival/death ratio
• Upload each lab section’s data on course website
• Data analysis
• Draw conclusions about toxicological effects of fat-soluble vitamins on hepatic cells
Have you ever been concerned about the harmful effects of the chemicals you have used in any of your laboratory experiments while at SDSU?

Student Survey

<table>
<thead>
<tr>
<th>Number of Students</th>
<th>Beginning of semester</th>
<th>End of semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>never</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>7</td>
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<tr>
<td>quite often</td>
<td>0</td>
<td>1</td>
</tr>
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</table>
In your opinion, how aware are chemists of the inherent hazard associated with a chemical?

How aware are you personally of the inherent hazard with the chemicals you used in your classes or in research laboratories you may have worked?
In your opinion, how aware are chemists of ways to minimize their exposure to hazardous chemicals in the laboratory?

How aware are you personally of the ways to minimize your exposure to hazardous chemicals in your classes or in research laboratories you may have worked?

Student Survey
If you desire to find out more information about the toxic effects of a specific chemical, how would you proceed?
Common products we use every day contain chemicals that are known, or suspected, to have toxic effects. In your opinion, who is most responsible for minimizing the toxic hazard and/or exposure of the public to these chemicals?

**Student Survey**

Beginning of semester

End of semester

Govt. Regulatory Agencies

Chemists that create these chemicals

Companies that use these chemicals

Individual consumers should be educated and aware
Common products we use every day contain chemicals that are known, or suspected, to have toxic effects. In many cases, a company wishes to use a chemical for which that have only limited knowledge of the toxic effects. Should the toxicity of a chemical be well-characterized before it is used in a consumer product and, if so, who should have the responsibility for performing this characterization?

Student Survey

Beginning of semester
End of semester

[Graph showing student survey results]
Survey Results

• Students have increased concern regarding chemicals used at SDSU

• Students increased their awareness of chemical hazards

• Students more knowledgeable of how to avoid/minimize chemical exposure

• Students would rely more on scientific journals than MSDS to learn of chemical hazards
Moving Toxicology into Other Courses

• Second Semester Organic
  ✓ Synthesis of drug compound, brine shrimp assay
  ✓ EPI Suite activity

• Analytical
  ✓ Green chemistry assessment
  ✓ Extraction and analysis of environmental toxin

• Environmental Chemistry

• Chemical Toxicology
Green assessment - profile

Health  Safety
Environmental  Waste
Energy
## NEMI methods for PAH in water

<table>
<thead>
<tr>
<th>Method</th>
<th>Chemicals</th>
<th>Energy uses</th>
<th>Waste</th>
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</thead>
<tbody>
<tr>
<td>550</td>
<td>Sodium Thiosulfate Methylene chloride</td>
<td>Evaporating 200 mL organic solvent LC</td>
<td>335 g</td>
</tr>
<tr>
<td></td>
<td>Acetonitrile Sodium Sulfate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>610</td>
<td>Sodium thiosulfate Methylene chloride</td>
<td>Evaporating 200 mL organic solvent GC</td>
<td>290 g</td>
</tr>
<tr>
<td></td>
<td>Acetonitrile Sodium Sulfate</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cyclohexane Pentane Methanol Acetone</td>
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<td></td>
</tr>
<tr>
<td>525.2</td>
<td>Methylene chloride Methanol Sodium sulfate Toluene</td>
<td>Evaporating 10 mL organic solvent GC-MS</td>
<td>52 g</td>
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<tr>
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<td>Ethyl acetate Acetone HCl, 6N</td>
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<tr>
<td>70620</td>
<td>Methanol HCl, 1.0N</td>
<td>immunoassay</td>
<td>1.2 g</td>
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<tr>
<td>A00156/</td>
<td>Sulfuric acid, 2M Methanol</td>
<td>immunoassay</td>
<td>4.3 g</td>
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Method comparison

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<tr>
<th></th>
<th>550</th>
<th>610</th>
<th>525.2</th>
<th>70620</th>
<th>A00156/A00157</th>
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Shift Emphasis of Chemical Toxicology

• More mechanistic
• Experiential
Conclusion

Working toxicology material into existing course content provides an alternative to the addition of more coursework and helps develop an awareness of toxicological implications as part of the normal practice of chemistry.