



# ECOTOXICOLOGY OF IONIC LIQUIDS

## AP Biology Semester Project

By Jason Sutton

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# Volatile Organic Compounds - VOCs

## What are VOCs?

Volatile Organic Compounds (VOCs) are chemicals that evaporate easily at room temperature. The term "organic" indicates that the compounds contain carbon. VOC exposures are often associated with an odor while other times there is no odor. Both can be harmful. There are thousands of different VOCs produced and used in our daily lives. Some examples are:

- Benzene
- Toluene
- Methylene Chloride
- Formaldehyde
- Xylene
- Ethylene glycol
- Texanol
- 1,3-butadiene

## Where do VOCs come from?

Many products emit or "off-gas" VOCs. Some examples of VOC emission sources are:

- Paints
- Varnishes
- Moth balls
- Solvents
- Gasoline
- Newspaper
- Cooking
- Cleaning Chemicals
- Vinyl floors
- Carpets
- Photocopying
- Upholstery Fabrics
- Adhesives
- Sealing Caulks
- Cosmetics
- Air Fresheners
- Fuel Oil
- Vehicle Exhaust
- Pressed wood furniture
- Environmental Tobacco Smoke (Secondhand smoke)

## What levels of VOC are typical in the home?

As of July, 2003 neither Minnesota nor the federal government have set standards for VOC levels in non-occupational settings. However, some guidelines are available. MDH has established Health Risk Values (HRVs) for some contaminants in air for several different exposure situations. For more information on these HRVs go to MDH Health Risk Values Website.

Many studies have shown VOC levels are higher in indoor air than outdoor air. The U.S. Environmental Protection Agency (EPA) Total Exposure Assessment Methodology (TEAM) studies have found indoor VOC levels that were 2 to 5 times higher than outdoors.

Levels of VOC exposure in indoor air vary widely depending on:

- the volume of air in the room/building
- the rate at which the VOC is off-gassed
- the building ventilation rate
- outdoor concentrations

Along with the concentration of VOCs in a given environment, the time an individual spends in that environment is important in determining exposure.

## What are the health effects of VOC exposure?

### Acute

- Eye irritation / watering
- Nose irritation
- Throat irritation
- Headaches
- Nausea / Vomiting
- Dizziness
- Asthma exacerbation

### Chronic

- Cancer
- Liver damage
- Kidney damage
- Central Nervous System damage.



Indoor Air Unit  
P.O. Box 64975  
St. Paul, MN, 55164-0975  
651-201-4601 or 800-798-9050  
[www.health.state.mn.us/divs/eh/air](http://www.health.state.mn.us/divs/eh/air)

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Most studies to date have been conducted on single chemicals. Less is known about the health effects of combined chemical exposure. The best health protection measure is to limit your exposure to products and materials that contain VOCs when possible. If you think you may be having health problems caused by VOC exposure consult an occupational/environmental health physician who specializes in this area

Are some people at greater risk from VOC exposure than others?

Persons with respiratory problems such as asthma, young children, elderly, and persons with heightened sensitivity to chemicals may be more susceptible to illness from VOC exposure.

How can I tell what levels of VOC are in my home?

Some home screening kits are available to measure total volatile organic compound (TVOC) levels, and some individual VOCs. These home sampling kits should be viewed as providing “ballpark” amount of VOCs in the indoor air. Conditions such as ventilation, temperature and humidity can cause VOC concentrations to fluctuate daily

Prior to testing conduct an inspection of your home for some common sources of VOCs such as:

- New carpeting
- New furniture
- Idling automobile in attached garage
- Recent painting
- Chemicals stored in the home
- Recently applied adhesives
- New plastic or electronic devices

Once you determine the probable source of VOCs, steps can be taken to reduce your exposure. If you are unable to determine the source, a professional indoor air quality investigator / industrial hygienist can be consulted. MDH has a service provider list along with recommendations on selection. MDH also has a guidance document that can be used for investigating possible VOC contamination entitled “Indoor Air Sampling at VOC contaminated sites”

How do I reduce the levels of VOCs in my home?

Most products containing VOCs will off-gas within a short period of time although some will continue to give off trace amounts of VOCs for a long period of time. The best means of reducing VOC exposure is to eliminate products containing VOCs or use low emitting VOC products.

Some steps you can take to reduce your exposure to VOC in the home are:

- Source control
  - eliminate products from home that have high levels of VOCs
  - purchase new products that contain low or no VOCs (environmentally preferable purchasing)
- Ventilation – open doors and windows, use fans.
- Control climate – as temperature and humidity increase some chemicals will off gas more.
- Treat the source – airtight sealers can be used to coat over some products. However, caution is advised in choosing the coating product as this could introduce new VOCs into the air while controlling for others.
- Air cleaners – look for ones with activated charcoal filtration designed to remove chemicals from the air.
- Remove unused chemicals from the home. Check with city or county for household hazardous waste collection sites.
- Perform renovations when home is unoccupied.

For more information on VOCs or other Indoor Air Quality Issues Contact:

**The Minnesota Department of Health  
Indoor Air Unit**

625 Robert Street North, PO Box 64975  
St. Paul, MN 55164-0975  
651/201-4601 or 800/798-9050

View the Air Quality web page at:  
[www.health.state.mn.us/divs/eh/air](http://www.health.state.mn.us/divs/eh/air)

To require this document in another form contact:  
Call 651/201-4601. TTY: 651/201-5797 or Minnesota Relay  
Service TTY: 1- 800/627-3529.



Posted on Thu, Jun. 12, 2008

## **Vinyl shower curtains contain potentially harmful toxins**

By TAMI ABDOLLAH  
The Los Angeles Times

Vinyl shower curtains sold at major U.S. retailers emit toxic chemicals linked to serious health problems, according to a report released Thursday by a national environmental organization.

The curtains, sold at Bed Bath & Beyond, Kmart, Sears, Target and Wal-Mart, among other major retailers, contained high concentrations of chemicals that are linked to liver damage as well as damage to the central nervous, respiratory and reproductive systems, said researchers for the Virginia-based Center for Health, Environment & Justice.



The organization commissioned the study about two years ago to determine what caused that “new shower curtain smell” familiar to most consumers.

“This smell can make you feel sick, give you a headache, make you feel nauseous or (cause) other health effects,” said Michael Schade, a co-author of the report.

Researchers tested the chemical composition of five unopened polyvinyl chloride, or PVC, plastic shower curtains purchased from Bed Bath & Beyond, Kmart, Sears, Target and Wal-Mart. One of these curtains was then tested to determine the chemicals it released into the air.



The study found that these shower curtains contained high concentrations of phthalates, which have been linked to reproductive effects, and varying concentrations of organotins, which are compounds based on tin and hydrocarbons. One of the curtains tested released measurable quantities of as many as 108 volatile organic compounds into the air, some of which persisted for nearly a month.

Seven of these chemicals have been identified by the Environmental Protection Agency as hazardous air pollutants, said Stephen Lester, the Center for Health, Environment & Justice's science director and a co-author of the report.



Potential health effects included developmental damage; and harm to the liver and the central nervous, respiratory and reproductive systems.

Vinyl chloride, which is a major building block of PVC, is a known human carcinogen that causes liver cancer, Lester said.

Representatives of the companies marketing the shower curtains were not immediately available for comment.

Little information on toxicity is available for 86 of the 108 chemicals detected in the curtains, Lester said.

"Nobody really looked to see what these chemicals were or whether they were toxic, and what risk they posed," he said.

The EPA has tested vinyl shower curtains, and in 2002 said that it had found many of the same chemicals were released.

Many companies that carry these vinyl shower curtains, including most of those whose products were used to compile the report, have been working to phase out the use of PVC curtains, Schade said.

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## What is Ecotoxicology?

According to Merriam-Webster Online:

*“a scientific discipline combining the methods of ecology and toxicology in studying the effects of toxic substances and especially pollutants on the environment”*

To put it bluntly, ecotoxicology tries to determine if a substance is bad for organisms and the environment. And, if the substance really is bad, then just how bad is it?

An ecotoxicologist could take any of the 108 volatile organic compounds found in vinyl shower curtains, mentioned in the preceding article, and try to quantify and relate how harmful they may be. This is what we are going to do for our semester research project.



## Ecotoxicology Project

You will work in groups of three and design an experiment to test toxicity of a compound or product on a test organism.

There will be four major parts to your project:

1. PLAN your experiment
2. PERFORM your experiment
3. PAPER (write your research report)
4. PRESENT your work as a PowerPoint to the Public in December



## Grading

Your Ecotoxicology project will serve as your Semester Exam grade for the Fall semester.

- ◆ 80% of the project grade will be your own individual grade, based on your written project report. Though you plan and perform the experiment in a group, each individual must write their own paper which will be graded individually.
- ◆ 20% of the project grade will be a common, group grade and this grade will be based upon your group presentation in December.

The total project grade will count as **20%** of your Fall semester grade.



# Project Outline Checklist

## PLAN Your Experiment

- Get a **lab notebook** in which everything relating to your project will be written and recorded. (English composition notebook only, no pockets, no 3-rings or spirals)

- Identify your group's **problem** for the experiment.

What household product/VOC will you work with?

What test organism?

(We will only work with microorganisms or aquatic invertebrates. NO vertebrates. Of course, people are a vertebrate so NO PEOPLE!!!)

- Identify the **relevance** of your problem to people, to the environment, or to science.

- Develop a **testable hypothesis** that relates to your problem.

- **Review** the scientific literature. In other words, find work that scientists have already done and describe what they did and how it relates to your work.

Each group will need **six references** for papers from scientific journals. We'll take a day in the library to get this done.

- **Design** your experiment.

- How will you apply your treatment (chemical) and in what concentrations?
- What is your test organism?
- How many replicates will you need? (at least 10)
- How will you set up your control(s)?
- How are you going to get data? What are you counting, measuring, or observing?
- Check to make sure your experiment seems **logical** and **repeatable**.
- Write with enough detail that anyone could use your paper to repeat what you've done.

(You don't need to explain things that a reasonable person should know how to do. For example, you might be recording temperatures as part of your work. Most people know how temperature is measured so explaining that would be unnecessary.)



### PERFORM Your Experiment

- ❑ Create **data tables** to keep data organized and easy to read for later use
- ❑ Make sure your trials provide **enough data to be confident** in your results
- ❑ Perform trials following all **safety guidelines and techniques**
- ❑ Use **consistent methods** throughout experiment
- ❑ After experiment is complete **calculate statistical means** from raw data
- ❑ **Create graphs and tables** to report data in paper and presentation
- ❑ Throughout experiment, **take digital photographs** of experimental setup or any points of interest. These will be very valuable for your paper and presentation at the end of the semester.



Write your PAPER

I will grade each student's individual paper using the following rubric, adapted from the Greater Kansas City Science and Engineering Fair.

Senior Experimental and Engineering Guide  
Greater Kansas City Science and Engineering Fair  
(adapted for AP Bio Ecotoxicology Project Research Papers)

Senior High	Full Accomplishment 4	Substantial Accomplishment 3	Partial Accomplishment 2	Little or no Accomplishment 1
<b>Lab Notebook</b>				
Is there a <b>lab notebook</b> ?	Yes, it is detailed, complete and clear.	Yes, but some details are missing.	No, but there was an attempt to keep notes.	No, there is no notebook.
<b>Introduction</b>				
Is the <b>Background Literature Reviewed</b> ?	Yes, it demonstrates a thorough search and discussion of background	Yes, but some areas are not addressed.	No, but some sources are used.	No, background material is missing.
Is the <b>problem identified</b> and precisely stated?	Yes, it is realistic and appropriate limits have been established.	Yes, but the way it is stated may lead to erroneous conclusions.	No, but the reader has some idea of what is being attempted.	No, or it is stated in a way that was confusing to the reader.
Is the <b>problem relevant</b> ?	Yes, it has meaning in today's scientific climate.	Yes, but its relevancy may not be apparent.	No, but the problem does generate interest.	No, it has little or no relevancy.
Does the <b>hypothesis</b> relate to the problem?	Yes, it is a logical outgrowth of the stated problem.	Yes, but it may contain some illogical ideas.	No, but information allows the reader to assume a hypothesis.	No, it is missing, or it does not lead to the experiment that follows.
Is the <b>hypothesis testable</b> ?	Yes, it is testable and makes predictions.	Yes, but may not lead to predictions.	No, but an attempt was made.	No, a hypothesis was not included.
<b>Materials/Methods</b>				
Does the investigation <b>test the hypothesis</b> ?	Yes, the method directly address the hypothesis.	Yes, but there may be some question as to its reliability.	No, but there is an awareness of the hypothesis.	No, the stated hypothesis wasn't tested.
Are the following clearly identified? <b>*dependent variable</b> <b>*independent variable(s)</b> <b>*control group</b> <b>*important constants</b>	Yes, all are identified clearly and correctly.	Yes, they are all identified but there may be inaccuracies in some of them.	No, some are not identified and some may be inaccurate.	No, only one or none of them are identified correctly.
Is it clear how <b>data gathering</b> will happen?	Yes, data gathering is addressed clearly.	No, data gathering is addressed but there are some important details missing.	No, data gathering is mentioned without any details on how it will be done.	No, data gathering is not included at all.
Is the procedure <b>logical, repeatable</b> and <b>appropriate</b> to the hypothesis?	Yes, it is clear and could easily be repeated by others.	Yes, but there are some elements that may be difficult to repeat.	No, but the reader has a general idea of what was done.	No, the procedure is very confusing.
<b>Results</b>				
Are there <b>enough data</b> to create confidence?	Yes, there are enough data to be statistically significant. (at least 10 trials)	Yes, but there should have been more.	No, but there was an attempt to collect enough data.	No, too little data were collected.
Is <b>statistical treatment</b> included?	Yes, and it is appropriate for the data collected.	Yes, but there may be a more appropriate treatment.	No, but an attempt was made.	No, there was no attempt.
Are the data presented in <b>graphs</b> and/or <b>tables</b> ?	Yes, the data appear in correctly labeled tables and/or graphs.	Yes, but they are either incomplete or unclear in some details.	No, but there was an attempt to include data in a table.	No, the data were not presented in tables or graphs
Are the <b>results(data)</b> summarized with no attempt at analyzing the results?	Yes, the results are summarized with no attempt at explaining what they mean.	Yes, the results are summarized but attempts are made to explain them	Results are summarized incompletely.	No, there was no summary of the results.
<b>Conclusion/Discussion</b>				
Are <b>inferences</b> and <b>conclusions</b> included about the hypothesis?	Yes, the status of the hypothesis is correctly & logically determined	Yes, but it may not be completely logical or there may be some bias indicated.	No, but there was an attempt to infer relationships which were partly correct.	No, either it was missing or the data were misunderstood.
Are conclusions about the <b>hypothesis stated correctly</b> ?	Yes, the hypothesis is stated as either being supported or not supported.	n/a	Yes, the hypothesis is stated as either supported or not supported but also stated as proven or not proven.	No, the hypothesis is stated as being either proven or disproven.
Is an insightful <b>discussion</b> included?	Yes, it is insightful and demonstrates an understanding of this research to the broader subject at hand.	Yes, but there are areas that were not addressed, or were unclear.	No, there was an attempt to discuss the experiment and its broader implications, but there were many problems.	No discussion was included.

PRESENT your project

I will grade your group project using the following rubric, adapted from the Greater Kansas City Science and Engineering Fair.

Senior Experimental and Engineering Guide  
 Greater Kansas City Science and Engineering Fair  
 (adapted for AP Bio Ecotoxicology Project Presentations)

Senior High	Full Accomplishment 4	Substantial Accomplishment 3	Partial Accomplishment 2	Little or no Accomplishment 1
<b>Powerpoint</b>				
Is the <b>Powerpoint display effective?</b>	Yes, it is clear and easy to read.	Yes, but there are elements that are unclear.	No, but information is presented.	No, little can be understood from the display.
<b>Presentation</b>				
Is the <b>oral presentation</b> clear?	Yes, the student(s) was able to communicate the research clearly and correctly.	Yes, but there were times when the student(s) was unsure or incorrect.	No, but the student(s) had some knowledge of the area being researched.	No, the student(s) didn't appear to understand the research.
Is the presenter able to <b>handle questions?</b>	Yes, the student(s) was able to handle all questions.	Yes, but there were times when the student(s) was unsure or incorrect.	No, but the student(s) has some knowledge of the topics being questioned.	No, the student(s) was not able to answer questions over the research.
Did <b>all students participate</b> in the presentation?	Yes, all members participated.	At least one member was not involved in presenting.	The presentation was mostly performed by only one member.	n/a



# Sample Research Paper

The remainder of this packet is a complete research paper published in 2005. The paper, Effects of Ionic Liquids on the Survival, Movement, and Feeding Behavior of the Freshwater Snail, *Physa Acuta*, should be included as one of your six references needed for your review of the scientific literature. The “Introduction” will provide some background information and the “Materials and Methods” will give you guidance for designing your experiment. The paper is also a good model for the final research report that you will be writing upon completion of your experiment.



Bernot-Physsa paper goes here