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**“The Story Behind Defective Airbags”**

*April/May 2018*

**Teacher’s Guide**



**Teacher's Guide for**

***“The Story Behind Defective Airbags”***

**April/May 2018**

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# Connections to Chemistry Concepts

|  |  |
| --- | --- |
| **Chemistry Concept** | **Connection to Chemistry Curriculum** |
| **Reaction rates** | While studying the factors that affect the rate of a reaction, you can use the change in state of ammonium nitrate in compromised airbags to illustrate how a change in physical state (solid to solution—and back again) and surface area (pellets cracked, making smaller particles, possibly even powder) caused the unexpected increase in reaction rate in the TAKATA airbags. |
| **Gas properties** | The compressibility of gas is the property most responsible for the effectiveness of airbags reducing injuries in crashes. The air inside the bag compresses when the bag is hit by a body. This can be pointed out when introducing the properties of a gas. |
| **Gas laws** | The airbag reactions would be good examples to use while studying gas laws. The Ideal Gas Law is useful in calculating the moles of the gas required to inflate the airbags to a predetermined volume and pressure. |
| **Stoichiometry** | Calculating the amount of sodium azide or other gas-generating reactant needed to fully inflate an airbag is a useful example for a stoichiometry problem. |
| **Decomposition reactions** | The reactions mentioned in the article that produce the gas for the airbags are decomposition reactions. These could be used as examples while teaching a unit on types of chemical reactions. |
| **Reaction kinetics** | All of the reactions that are used to inflate airbags, once initiated, occur at astounding speeds. These reactions could be used while studying reaction kinetics. |
| **Green chemistry** | Airbags using sodium azide (NaN3) include KNO3, to react with the elementary sodium produced in the reaction; and SiO2, to convert the alkali metal oxides produced in the azide reaction to a silicate glass, all of which makes the final products of the reaction more environmentally friendly. This is an example of respecting the principles of Green Chemistry during the design of a product. |

# Teaching Strategies and Tools

## Standards

* Links to **Common Core Standards for Reading**:
  + **ELA-Literacy.RST.9-10.1:** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
  + **ELA-Literacy.RST.9-10.5**: Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).
  + **ELA-Literacy.RST.11-12.1**:Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
  + **ELA-Literacy.RST.11-12.4:** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.
* Links to **Common Core Standards for Writing**:
  + **ELA-Literacy.WHST.9-10.2F**: Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).
  + **ELA-Literacy.WHST.11-12.1E**: Provide a concluding statement or section that follows from or supports the argument presented.

## Vocabulary

**Vocabulary** and **concepts** that are reinforced in the April/May 2018 issue:

Food Chemistry

Structural Formulas

Chemical Reactions

Reaction Rates

Oxidation & Reduction

Distillation

Environmental chemistry

* Some of the articles in this issue provide information to help students consider their impact on the environment.
* Consider asking students to read “Open for Discussion: Weighing in on calories” to learn about calories in food prior to reading the article “The Protein Myth: Getting the Right Balance.”
* Students may find the infographic on page 19, “As a Matter of Fact: The Aroma of the Seaside” interesting after reading the article “Toxic Shorelines: The Science of Algal Blooms.
* To help students engage with the text, ask students which article **engaged** them most and why, or what **questions** they still have about the articles.
* You might also ask them how information in the articles might affect their choices regarding food or water use. Also, ask them if they have questions about some of the issues discussed in the articles.

# Reading Supports for Students

The pages that follow include reading supports in the form of an Anticipation Guide, a Graphic Organizer, and Student Reading Comprehension Questions. These resources are provided to help students as they prepare to read and in locating and analyzing information from the article.

The borders on these pages distinguish them from the rest of the pages in this Teacher’s Guide—they have been formatted for ease of photocopying for student use.

* **Anticipation Guide (p. 8):** The Anticipation Guide helps to engage students by activating prior knowledge and stimulating student interest before reading. If class time permits, discuss students’ responses to each statement before reading each article. As they read, students should look for evidence supporting or refuting their initial responses.

***NEW!!!***

Instead of using the Anticipation Guide, consider these ideas to engage your students in reading.

**The Story Behind Defective Airbags**

* Before reading, ask students to describe how they think airbags work, including how they inflate, then compare their ideas to the information in the article.
* Ask students what questions about airbags they would like to have answered in the article.
* **Graphic Organizer (p. 9):** The Graphic Organizer is provided to help students locate and analyze information from the article. Student understanding will be enhanced when they explore and evaluate the information themselves, with input from the teacher, if students are struggling. Encourage students to use their own words and avoid copying entire sentences from the article. The use of bullets helps them do this.

If you use the aforementioned organizers to evaluate student performance, you may want to develop a grading rubric such as the one below.

|  |  |  |
| --- | --- | --- |
| **Score** | **Description** | **Evidence** |
| 4 | Excellent | Complete; details provided; demonstrates deep understanding. |
| 3 | Good | Complete; few details provided; demonstrates some understanding. |
| 2 | Fair | Incomplete; few details provided; some misconceptions evident. |
| 1 | Poor | Very incomplete; no details provided; many misconceptions evident. |
| 0 | Not acceptable | So incomplete that no judgment can be made about student understanding |

* **Student Reading Comprehension Questions (p. 10-11):** The Student Reading Comprehension Questions are designed to encourage students to read the article (and graphics) for comprehension and attention to detail, to provide the teacher with a mechanism for assessing how well students understand the article and/or whether they have read the assignment, and, possibly, to help direct follow-up, in-class discussion, or additional, deeper assignments.

Some of the articles in this issue provide opportunities, references, and suggestions for students to do further research on their own about topics that interest them.

To help students engage with the text, ask students which article **engaged** them most and why, or what **questions** they still have about the articles. The “Web Sites for Additional Information” section of the Teacher’s Guide provides sources for additional information that might help you answer these questions.

“The Story Behind Defective Airbags,” *ChemMatters*, April/May 2018

Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

## Anticipation Guide

“A Close-up Look at the Quality of Indoor Air” (*ChemMatters*, April/May 2016 Issue)

**Directions: *Before reading the article*,** in the first column, write “A” or “D,” indicating your agreement or disagreement with each statement. As you read, compare your opinions with information from the article. In the space under each statement, cite information from the article that supports or refutes your original ideas.

|  |  |  |
| --- | --- | --- |
| **Me** | **Text** | **Statement** |
|  |  | 1. Almost all of the defective airbags manufactured by the Takata Corporation have been replaced. |
|  |  | 1. Frontal airbags reduce fatalities only when used with seat belts. |
|  |  | 1. Airbags have sensors that detect rapid deceleration. |
|  |  | 1. To inflate an airbag, a tank containing air at high pressure releases its content. |
|  |  | 1. The airbag should be deflating when it contacts a person’s head or torso. |
|  |  | 1. A typical sodium azide airbag generates 70 liters of nitrogen gas at standard temperature and pressure. |
|  |  | 1. Sodium azide is nontoxic. |
|  |  | 1. Ammonium nitrate is unaffected by temperature changes or moisture. |
|  |  | 1. Greater surface area of reactants in airbags produces gas faster. |
|  |  | 1. The chemicals used in airbags all contain nitrogen. |

## Graphic Organizer

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

“The Story Behind Defective Airbags,” *ChemMatters*, April/May 2018

**Directions**: As you read the article, complete the graphic organizer below to describe the chemicals and chemical reactions used in airbags.

|  |  |  |  |
| --- | --- | --- | --- |
| **Chemicals** | **Formula** | **Chemical Reaction in Airbags** | **Drawbacks** |
| **Sodium azide** |  |  |  |
| **Ammonium nitrate** |  |  |  |
| **Guanidine nitrate** |  |  |  |

**Summary:** In the space below, or on the back of this paper, write a short explanation of why the Takata airbags were defective, including the chemicals used.

## Student Reading Comprehension Questions

“The Story Behind Defective Airbags,” *ChemMatters*, April/May 2018

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Name

**Directions**: Use the article to answer the questions below.

* 1. From 1987 through 2015, how many lives are estimated to have been saved by airbags?
  2. How have airbags changed in regards to their activation system?
  3. How are airbags inflated?
  4. In order to adequately protect the occupant of a vehicle involved in a crash, how much time does the airbag have to deploy?
  5. How long does an airbag remain inflated before it starts to deflate?
  6. Why should an airbag be deflating, instead of inflating, when the head or torso hits it?

**Student Reading Comprehension Questions, cont.**

“The Story Behind Defective Airbags,” *ChemMatters*, April/May 2018

* 1. Besides sodium azide (NaN3), what two other substances are included in this type of airbag, and what is the purpose for each?
  2. How much nitrogen does the reaction in a typical airbag generate at standard temperature and pressure?
  3. What is one of the drawbacks to using sodium azide in airbags?
  4. What is the chemical reaction that inflated the airbags manufactured by Takata?
  5. What was causing the canisters in the airbags made by Takata to explode?
  6. Since the problem with the Takata airbags, what chemical reaction is now being used to generate the gas needed to inflate an airbag?

## Answers to Student Reading Comprehension Questions

1. **From 1987 through 2015, how many lives are estimated to have been saved by airbags?**

*From 1987 through 2015, the addition of frontal airbags to cars saved an estimated 44,869 lives.*

1. **How have airbags changed in regards to their activation system?**

*Newer airbags contain electronic accelerometers contained within a microchip, while the older airbags relied more on a mechanical system made up of springs or magnets connected to a metal ball. When the car’s brakes were applied, the metal ball broke free and activated an electronic sensor.*

1. **How are airbags inflated?**

*Airbags are inflated as the result of a very rapid chemical reaction.*

1. **In order to adequately protect the occupant of a vehicle involved in a crash, how much time does the airbag have to deploy?**

*An airbag must deploy in 40 milliseconds or less to protect the occupant of a vehicle involved in a crash.*

1. **How long does an airbag remain inflated before it starts to deflate?**

*An airbag starts to deflate immediately after it is inflated.*

1. **Why should an airbag be deflating, instead of inflating, when the head or torso hits it?**

*The airbag should be deflating instead of inflating when a body hits it because a deflating airbag provides more cushioning to the body or head than an inflating airbag does.*

1. **Besides sodium azide (NaN3), what two other substances are included in this type of airbag (uninflated), and what is the purpose for each?**

*Other substances included in a sodium azide airbag are:*

* 1. *Potassium nitrate (KNO3)—converts the sodium produced in the reaction to less harmful products and produces more nitrogen to further inflate the airbag,*
  2. *Silicon dioxide—converts the toxic byproducts potassium oxide (K2O) and sodium oxide (Na2O) into inert silicate glass.*

1. **How much nitrogen does the reaction in a typical airbag generate at standard temperature and pressure?**

*The typical airbag generates 70 liters of nitrogen gas at standard temperature and pressure.*

1. **What is one of the drawbacks to using sodium azide in airbags?**

*One of the drawbacks to using sodium azide in airbags is that sodium azide is about as toxic as cyanide compounds and can cause serious health conditions in persons exposed to it.*

1. **What is the chemical reaction that inflated the airbags manufactured by Takata?**

*The thermal decomposition of ammonium nitrate into water vapor and nitrous oxide is the reaction that Takata used to inflate the airbags that eventually were recalled.*

1. **What was causing the canisters in the airbags made by Takata to explode?**

*The canisters that held the ammonium nitrate exploded when the ammonium nitrate within them had been physically changed in a way that caused the reaction to proceed faster than the airbag designers intended. Those changes happened when the ammonium nitrate was exposed to moisture that dissolved some of the ammonium nitrate or to temperature changes that caused the ammonium nitrate pellets to crack into smaller pieces. Both changes increase the reaction rate such that the gas cannot be released into the airbag fast enough, and so pressure builds up inside the canister itself until it explodes.*

1. **Since the problem with the Takata airbags, what chemical reaction is now being used to generate the gas needed to inflate an airbag?**

*The decomposition of guanidine nitrate [C(NH2)3]NO3 is the reaction used by most companies that currently produce airbag inflators.*

*[Students may give the reaction as*

*[C(NH2)3]NO3 (s) 🡪 3 H2O (g) + 2 N2 (g) + C (s).]*

# Possible Student Misconceptions

1. **“During a crash, the driver would be protected by an inflating airbag, not a deflating airbag.”** *When a car suddenly stops, the persons in the car continue to travel forward. An airbag prevents the driver from hitting the steering wheel or windshield during this forward motion. If the airbag is inflating, the person will be hit by an object that is traveling toward them at a speed of 200 mph. When the airbag is deflating it becomes like a pillow that can be compressed by a person’s body. (*[*https://www.popsci.com/how-airbags-are-supposed-to-work*](https://www.popsci.com/how-airbags-are-supposed-to-work)*)*
2. **“It is not as important to use my seat belt because the airbags will stop me from being thrown forward during a collision.”** *Actually, it is the seat belt that keeps your body from being thrown forward during a collision*. *Airbags and seat belts used together help protect you during a crash. The seat belt keeps the driver in the seat, while an airbag simply protects the head by keeping it from hitting the steering wheel, dashboard, or windshield. For airbags to work the way they are intended, the drivers and passengers must be using their seat belts correctly. Airbags that are standard equipment on all cars are designed for frontal crashes and are activated by a sudden impact of 12 miles per hour or more. These airbags do not protect the driver in rear-impact, side-impact, or rollover crashes, while a seat belt will help protect the driver and passengers in these types of accidents. Some cars are equipped with additional airbags that help prevent injuries in side-impact crashes and rollovers but these airbags also are designed for passengers who are using a seat belt.*
3. **“I was in an accident once where the airbag went off and the car filled up with smoke afterward. I thought the car was catching on fire.”** *This most likely was a talc powder instead of smoke. Airbags contain talc or a corn-based powder inside to ensure that the airbag unfolds smoothly when it is deployed. As the airbag deflates, the powder can be seen floating throughout the car. The powder is non-toxic and should not harm the persons inside the car. An exception would be persons with asthma or other breathing problems where the lungs are compromised. It is an interesting side effect that persons who have been in a car when the airbags deployed will test positive for blood alcohol on a breathalyzer test that is given immediately after the accident. The small particles of powder remain in the lungs for a while and are present in the breath, making the breath a colloid. When the person blows into a breathalyzer that uses infrared light shown through the sample chamber, the light is scattered due to the Tyndall effect, and the results of the test will be falsely elevated. In this situation, a blood test is the best method for securing an accurate blood alcohol level. (*[*http://gaduiblog.com/2006/08/07/breath-test-after-airbag-deployment/*](http://gaduiblog.com/2006/08/07/breath-test-after-airbag-deployment/)*)*
4. **“I heard that if your car is 10 years old or older you should probably have the airbags replaced.”** *Airbags are designed to be maintenance free for the life of the vehicle, unless it deploys in a crash. Some manufacturers put a date stamp on the bags for a while that said to check after 10 or 15 years but that is generally not considered necessary anymore. Airbags have a warning light that should come on if there is a problem with the wiring to the airbag. In 1992, the Insurance Institute for Highway Safety conducted a demonstration test on the original frontal airbags of a 1973 Chevrolet Impala, one of the first 1,000 cars equipped with an airbag. Even though the clock and radio no longer worked and the car had over 100,000 miles on the odometer, the airbags deployed properly, when the car was driven into a barrier at 25 mph. (*[*https://www.autoblog.com/2013/07/30/should-car-owners-replace-airbags-in-older-cars/*](https://www.autoblog.com/2013/07/30/should-car-owners-replace-airbags-in-older-cars/)*)*

# Anticipating Student Questions

1. **“How do they adjust the force that expands an airbag?”** *The force with which an airbag inflates is due to the pressure exerted by the amount of gas that is generated by the chemical reaction in a short amount of time. This can be adjusted by the amount of gas-generating compound, such as sodium azide, tetrazole, or ammonium nitrate that is used. It is a stoichiometry problem and an ideal gas law problem combined. If you know the volume of the airbag at full inflation and you calculate the desired pressure in the bag when inflated with a gas traveling at a speed of 200 mph, you can calculate the amount of gas (in moles) required using the Ideal Gas Law. From here, it becomes a stoichiometry problem where you solve for the number of grams of the gas-generating compound required to produce the calculated number of moles of nitrogen gas. (*[*http://www.chemistry.wustl.edu/~edudev/LabTutorials/Airbags/airbags.html*](http://www.chemistry.wustl.edu/~edudev/LabTutorials/Airbags/airbags.html)*)*
2. **“Why haven’t all the airbags that have been recalled been replaced?”** *There are several factors that are affecting the number of cars being returned to the dealer to have airbags replaced. Some car owners do not know about the recall or have not received notification that their car has an airbag that should be replaced. Many who have received notice, have not acted upon it. In implementing the recall, the National Highway and Transportation Safety Administration (NHTSA) has subdivided the United States into three zones according to the weather. NHTSA has ordered manufacturers to replace the inflators in the oldest cars, equipped with the faulty inflators, located in warm humid states like Florida and Alabama before replacing them in newer cars garaged in states with moderate or cold climates. Zones with high temperature and humidity have been given priority because those are the conditions that cause the ammonium nitrate in the airbag initiator to deteriorate. Zones where the climate is cold and dry have been prioritized last for the recall. The availability of replacement parts is also affecting the speed of the repairs. Takata has been given until December 2019 to replace all its airbags still in cars. A list of the states in each zone, including a timeframe for ignitor replacement in those zones, can be found here: (*[*http://www.iihs.org/media/cea05d99-4187-42e9-bdc6-2958ce5adfbb/nAVMcw/QAs/Airbags/IIHS\_Advisory\_40.pdf*](http://www.iihs.org/media/cea05d99-4187-42e9-bdc6-2958ce5adfbb/nAVMcw/QAs/Airbags/IIHS_Advisory_40.pdf)*)*
3. **“What are accelerometers?”** *An accelerometer is similar to a speedometer that measures how fast your car is going, only an accelerometer measures how the speed of your car is changing in a given amount of time. Acceleration can be measured two ways: it can be measured by clocking the change in speed and dividing by the amount of time that speed change took; or it can be measured by using the laws of physics, where*

*force = mass x acceleration.*

*If you know the force and the mass involved, acceleration can be calculated as*

*acceleration = force / mass.*

*In most accelerometers, this is the mathematics that is used to measure acceleration. When you are in an airplane that is taking off you, feel like you are being pressed into your seat. This force is caused by the plane pushing you forward while you are stationary. You might also experience these forces when you are in a car or an elevator. Accelerometer microchips in airbags are designed internally with a small gap between electrodes. When the force acting on the electrodes reduces the distance between the electrodes greater than a predetermined set point, an electrical signal is generated that activates the airbags. Accelerometers in cellphones and handheld gamepads use gravitational force and are programmed to detect the movement of the device in order to reorient the screen. (*[*http://www.explainthatstuff.com/accelerometers.html*](http://www.explainthatstuff.com/accelerometers.html)*)*

1. **“What is sodium azide and what else is it used for?”** *Sodium azide is a fast-acting, potentially deadly, odorless white solid. It reacts with water to form toxic hydrozoic acid which often escapes as a gas upon reaction. Sodium azide is used as a chemical preservative in hospitals and labs, and it is used for pest control in agriculture. If sodium azide is breathed in or absorbed through the skin, it begins acting on the body by preventing the body’s cells from using oxygen. Since the brain and the heart use more oxygen than most other organs of the body, these two organs are affected most by sodium azide poisoning. Survivors of sodium azide poisoning are often left with heart and brain damage. (*[*https://emergency.cdc.gov/agent/sodiumazide/basics/facts.asp*](https://emergency.cdc.gov/agent/sodiumazide/basics/facts.asp)*)*
2. **“What happens to the sodium azide in cars whose airbags are still intact when they are disposed of?”** *This is a good question that doesn’t have a single answer***.** *The Environmental Protection Agency (EPA) has taken the position to let the individual states decide how they want to handle it. Because of the explosive nature of the material in airbags, they are classified as hazardous waste in some states and should be disposed of as a hazardous material. This can be expensive for the car dealer, who must bear some of the cost and maintain responsibility for the material, even after it is disposed of in a designated landfill. It used to be that the intact airbags were either removed from the cars before they were salvaged and then sold as replacement airbags, or they were detonated before the cars were shredded. Depending on the state, this may still be the policy. Sometimes a car would be pressed and shredded with the airbag intact, which caused the release of sodium azide into the environment. Recently, recycling is becoming a preferred way to handle old airbags. There are now companies that will reclaim the parts from airbags, as 95% of the airbag can be safely reused. (*[*https://www.hazardouswasteexperts.com/airbag-hazardous-waste/*](https://www.hazardouswasteexperts.com/airbag-hazardous-waste/)*), (*[*https://earth911.com/general/can-you-recycle-car-airbags/*](https://earth911.com/general/can-you-recycle-car-airbags/)*)*
3. **“Why is moist ammonium nitrate more reactive than the solid form?”** *Ammonium nitrate readily absorbs moisture, which makes the ammonium nitrate pellets, or prills, melt and stick together. The ammonium nitrate cakes, and its configuration in the airbag canister changes. This change in phase and volume also changes the reaction rate and explosive nature of the material. The caked ammonium nitrate becomes explosive rather than being a controlled, fast, gas-producing reaction.**One of the ways that Takata is fixing its defective airbags is to simply add a desiccant to the ammonium nitrate to keep it dry.*
4. **“How does a change in temperature cause the crystal structure of ammonium nitrate to shift?”** *All materials change phase at various temperatures specific to the material. Solid materials can also be affected by thermal expansion. You may have seen a demonstration of this in a previous science class, where the instructor showed a metal ball on a stick that would easily fit through a metal ring on another stick. After placing the ball in a flame, it expanded and would no longer fit through the ring. During phase transitions the volume of the material changes. As the molecules within respond to these temperature changes, their alignment shifts.**The following is an excerpt from a patent application for a new material for the gas generator in airbags. The material was a mixture of nitroguanidine and phase-stabilized ammonium nitrate.*

A problem with the use of pure ammonium nitrate is that the compound undergoes a series of structural phase transformations over the typical operating range of automobile airbag inflators. In pure AN, structural phase transitions are observed at -18° C., 32.3° C., 84.2° C. and 125.2° C. The phase transition at 32.3° C. is particularly problematic during temperature cycling because of a large change in the associated volume, on the order of 3.7% by volume. Generally, any volumetric change is detrimental and it is desired to limit any volumetric change as much as possible.

(<https://patents.google.com/patent/US5545272A/en?q=Stabilized&q=ammonium+nitrate&q=airbags&oq=Stabilized+ammonium+nitrate+for+airbags>)

1. **“What is tetrazole and what else is it used for?”** *Tetrazole is a synthetic cyclic structured compound, composed of a ring of one carbon atom and four nitrogen atoms. Tetrazole derivatives are used in the pharmaceutical industry both as drugs and in biochemical assays, like tests of cell respiration and DNA assays. Tetrazole itself and   
   5-aminotetrazole are stable and have combustive properties that make them suitable to use as a component of gas generators in automobile airbags. The tetrazole reaction produces non-toxic reaction products such as water and nitrogen. (*<https://en.wikipedia.org/wiki/Tetrazole>)

# Activities

**Labs and demos**

**Demonstration of the thermal decomposition of nitrates:** Write a message on absorbent paper with a solution of sodium nitrate. When the paper is dry, hold a glowing splint where the message begins and the message will burn, but the paper will not. (<http://www.rsc.org/learn-chemistry/resource/res00000712/the-thermal-decomposition-of-nitrates-writing-with-fire>)

**“It’s a Crash Test, Dummy Student Lab”:** In this two-part lab, students determine how much sodium bicarbonate to use to inflate a zip-lock baggie and, in the second part, they use their “inflated airbags” to conduct an egg-drop experiment, measuring the height at which they dropped the egg’s container. (<http://sciencenetlinks.com/student-teacher-sheets/its-crash-test-dummy-student-lab/>) The teacher support materials for this lab are found here: http://sciencenetlinks.com/lessons/its-a-crash-test-dummy/.

**Simulations**

**Kinetic theory of gases applet:** This applet gives students a visual experience at the molecular level of how gases behave at different temperature settings. The student can observe the movement of up to three gases while varying the temperature and the number of molecules displayed. (<http://www.falstad.com/gas/>)

**Media**

**”Airbag Design” video (3:04):** The video gives a brief history of airbags and shows clips of early trials while the airbag was being developed. It could be shown as an introduction to the Rohrig article. (<https://www.pbslearningmedia.org/resource/eng06.sci.engin.systems.airbag/air-bag-design/#.WnNM2ojwbDc>)

**“The Alkali Metals: 13 Compounds of Sodium and Nitrogen-Sodium Azide” video (4:28):** From the Royal Society of Chemistry’s *Learn Chemistry* Web page, this clip is taken from Professor Wothers’ lecture series on the alkali metals. In it, the professor discusses the chemistry of the sodium azide decomposition reaction, followed by a demonstration of a car airbag exploding. (<http://www.rsc.org/learn-chemistry/resource/res00001249/the-alkali-metals-part-2>)

A clip of just the demonstration of the car airbag can be found here: <http://www.rsc.org/learn-chemistry/resource/res00001247/its-a-gas-part-3#!cmpid=CMP00002435>.

**Lessons and lesson plans**

**“Creating an Effective Airbag”:** This lesson, which includes applicable teaching standards, uses the scenario of creating an airbag to explore the difference between a strong acid and a weak acid. Students are provided with hydrochloric and acetic acids to react with baking soda, in order to see which one reacts faster to inflate an airbag. The lesson includes the applicable teaching standards. (<https://teacherknowledge.wikispaces.com/Anthony+Thomas+-+Creating+An+Effective+Airbag>)

**“The Chemistry of Airbags”:** In this two-part lesson, students first read about airbags and answer questions from the provided text; while in the second part of the lesson, students design an airbag based on the sodium bicarbonate reaction with acetic acid. Two lesson extensions address the environmental and social issues concerning airbags. (<http://umanitoba.ca/outreach/crystal/resources%20for%20teachers/The%20Chemistry%20of%20Airbags%20C11-2-09.doc>; The *Scientific American* article referenced in the student material can be found here: <https://www.scientificamerican.com/article/how-do-air-bags-work/>.

**Engineering and testing an airbag:** Students calculate the amount and cost of the sodium bicarbonate needed for the reaction with acetic acid to create an airbag that doesn’t burst yet will protect an egg in a drop test. While two of the links within the lesson plans are no longer active, the material contained in the pdf is more than adequate to conduct these well-designed and annotated lessons. (<http://studylib.net/doc/7631587/air-bags--lesson-plan->)

**Projects and extension activities**

**“Save the Drama: Wear a Seat Belt”:** While a seat belt increases the effectiveness of an airbag, statistically teens are the age group with the lowest rate of seat belt use. This *Youth Traffic Safety Month Lesson Plan* makes students aware of this statistic as they work in cooperative learning groups to prepare a skit and prepare discussion questions about four different seat belt-use scenarios. ([http://fcclainc.org/pdf/seat belt.pdf](http://fcclainc.org/pdf/seatbelt.pdf))

Information that complements this lesson plan can be found here: <https://www.cdc.gov/motorvehiclesafety/teen_drivers/teendrivers_factsheet.html>.

**“Air Bags R Us”:** Students are challenged to design airbags for baby carriages. The lesson gives background information on stoichiometry and comes with well-written instructions for this inquiry activity: ([www.iasd.cc/cms/lib07/pa01916506/centricity/domain/371/airbaglab.doc](http://www.iasd.cc/cms/lib07/pa01916506/centricity/domain/371/airbaglab.doc))

# References

**The references below can be found on the *ChemMatters* 30-year DVD, which includes all articles   
published from the magazine’s inception in October 1983 through April 2013; all available Teacher’s Guides, beginning February 1990; and 12 *ChemMatters* videos. The DVD is available from the American Chemical Society for $42 (or $135 for a site/school license) at this site:** [**http://ww.acs.org/chemmatters**](http://www.acs.org/chemmatters)**. Click on the “Teacher’s Guide” tab to the left, directly under the “*ChemMatters Online"* logo and, on the new page, click on “Get the past 30 Years of *ChemMatters* on DVD!” (the icon on the right of the screen)**

**Selected articles and the complete set of   
Teacher’s Guides for all issues from the past three   
years are available free online at the same Web site, above. Click on the “Issues” tab just below the logo, *“ChemMatters Online”*.**



***30* Years of *ChemMatters !***

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In “Airbags—Chemical Reaction Saves Lives”, author Marsella describes the sodium azide reaction used in airbags in 1997. She includes several equations for the multi-step process, from the initial reaction to the final conversion to inert glassy products. (Marsella. G. Airbags—Chemical Reaction Saves Lives. *ChemMatters.* 1997, *15* (1), pp 4–5)

The Teachers Guide for the February 1997 *ChemMatters* article above contains additional information about the physics related to impulse (force x time) in designing airbags. The guide discusses the differences in the force exerted on the head when it hits the steering wheel versus hitting an airbag.

# Web Sites for Additional Information

**History of airbags**

Extensive information about airbags is located in the *Airbag Wiki*. Besides the history of airbag use, statistics about deaths caused by airbags are also reported. (<https://en.wikipedia.org/wiki/Airbag>)

Besides explaining how an airbag works and the physics behind it, this article also has a section on the history of the airbag—complete with the initial drawings from John Hetrick’s 1953 patent application. The article contains helpful links to even more explanation about various parts of the airbag, like accelerometers. (<http://www.explainthatstuff.com/airbags.html>)

**Chemistry of airbags**

“Gas Laws Save Lives: The Chemistry Behind Airbags—Stoichiometry and the Gas Constant Experiment “is a college tutorial containing extensive information about the chemistry and physics used in an airbag. The tutorial uses the sodium azide reaction and provides good information for a teacher or upper-level chemistry students during a unit on gas laws and gas stoichiometry. (<http://www.chemistry.wustl.edu/~edudev/LabTutorials/Airbags/airbags.html>)

This cartoon-illustrated tutorial on chemical reactions contains information about chemical equations, synthesis reactions, decomposition reactions, displacement reactions, and combustion reactions. The section on decomposition reactions uses the airbag reaction as an example. (<https://www.shmoop.com/chemical-reactions/>)

**Takata airbag recall**

An Advisory Notice from the Insurance Institute for Highway Safety (IIHS) contains information specific to the Takata airbag recall. The “Recall Strategy” section identifies how the states were prioritized for the recall. (<http://www.iihs.org/media/cea05d99-4187-42e9-bdc6-2958ce5adfbb/nAVMcw/QAs/Airbags/IIHS_Advisory_40.pdf>)

The article “The True Lesson of an Airbag Disaster” provides an analytical view of the Takata airbag failure and the lessons that can be learned from it in shaping the success of any business. It is a thoughtful article that would make it fun for students to discuss the merits of success and failure and how both contribute to the health of a company. (<https://www.strategy-business.com/blog/The-True-Lesson-of-an-Airbag-Disaster?gko=bcbc1>)

A January 2018 news report and video (0:31) on the Takata airbag disaster and the additional number of cars that are being recalled can be found here: <https://www.cbsnews.com/news/takata-air-bags-recall-expands-to-3-3-million-vehicles/>.

**How airbags work**

“How Airbags Work” explains the science behind airbags, how they work, what their problems are, and recent innovations in airbag technology. The explanations are nicely illustrated. (<https://auto.howstuffworks.com/car-driving-safety/safety-regulatory-devices/airbag.htm>)

This *Popular Science* article, “How Airbags Work and How They Can Fail”, discusses how airbags accelerometers, as well as other components, work together to protect the driver and passenger. The article discusses the failures of the Takata airbags, supplementing with pictures and video. (<https://www.popsci.com/how-airbags-are-supposed-to-work>)

**How airbags are made**

Great background material and in-depth details on how airbags are manufactured can be found in “Air Bag,” at this *How Products are Made* site: <http://www.madehow.com/Volume-1/Air-Bag.html>.

**Frequent questions about airbags**

This site contains eight questions with answers about how airbags work, the kinds of airbags and recent innovations, the effectiveness of airbags, injuries due to airbags and their prevention, airbags that fail to deploy, and the reuse of airbags from salvaged cars. The site uses videos of crash tests to illustrate the answer to some of the questions. (<http://www.iihs.org/iihs/topics/t/airbags/qanda>)

**Common injuries caused by airbags**

In “Airbags and the Skin,” the author details several types of injuries from airbag deployment commonly seen by doctors. The article includes descriptions of injuries to the eyes and ears as well. (<https://www.medscape.com/viewarticle/490128_1>)

This site on airbag injuries and fatalities examines the cause of several gruesome injuries caused by deploying airbags. It includes forensic evidence, including pictures and x-rays that illustrate the dangers of airbags, and it begins with a brief history of the airbag. (<http://what-when-how.com/forensic-sciences/airbag-related-injuries-and-deaths/>)

**Pitfalls of sodium azide**

This short article, “The deadly poison lurking in your car’s airbags,” describes the health and environmental hazards of sodium azide. (<https://www.naturalnews.com/035643_air_bags_sodium_azide_toxic_chemical.html>)

TheCDC Fact Sheet contains general information about sodium azide. In bullet points, it lists how sodium azide is used, how it works, the signs and symptoms of sodium azide poisoning, and precautions to take for protection from sodium azide exposure. (<https://emergency.cdc.gov/agent/sodiumazide/basics/facts.asp>)

**Infographic or poster**

“The top 5 things you should know about buckling Up” by NHTSA is an infographic on driver and passenger car safety that could be used as a classroom poster. “Airbags are designed to supplement seat belts, not replace them” is the second bullet point in the graphic. (<http://cpsboard.org/cps/wp-content/uploads/2018/01/13331-seat_belt_top_5_flyer_101317_v2_tag.pdf>)

**Interesting information**

You might register a positive breathalyzer test after being in a car where an airbag deployed, due to the Tyndall effect that the powder particles in your lungs have on the testing medium.

(<http://gaduiblog.com/2006/08/07/breath-test-after-airbag-deployment/>)

**Fun video**

“How far can an airbag launch a football?” (6:04) is a short YouTube video of a series of experiments with airbags and a football on a football field. Students will see why they need to make contact with the airbag when it is deflating rather than inflating. (<https://www.youtube.com/watch?v=fgLfhInA6-c>)

# About the Guide

Teacher’s Guide team leader William Bleam and editors Pamela Diaz, Steve Long and Barbara Sitzman created the Teacher’s Guide article material.

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Articles from past issues of *ChemMatters* and related Teacher’s Guides can be accessed from a DVD that is available from the American Chemical Society for $42. The DVD contains the entire 30-year publication of *ChemMatters* issues, from February 1983 to April 2013, along with all the related Teacher’s Guides since they were first created with the February 1990 issue of *ChemMatters*.

The DVD also includes “Article”, “Title”, and “Keyword” indexes that cover all issues from February 1983 to April 2013. A search function (similar to a Google search of keywords) is also available on the DVD.

The *ChemMatters* DVD can be purchased by calling 1-800-227-5558. Purchase information can also be found online at <http://tinyurl.com/o37s9x2>.