



**Eat the Wrapper?!  
An Edible Solution  
for Wasteful Packaging**

*(February/March 2018 Issue)*

<http://www.acs.org/chemmatters>

**Teacher’s Guide**



**Teacher's Guide for**

***“Eat the Wrapper?!  
An Edible Solution for Wasteful Packaging”***

**February/March 2018**

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# Connections to Chemistry Concepts

|  |  |
| --- | --- |
| **Chemistry Concept** | **Connection to Chemistry Curriculum** |
| **Chemical bonding** | During a unit on chemical bonding, you can use the example of the divalent linkages of calcium ions to sodium alginate in Ooho! spheres to show one type of ionic bonding. |
| **Intermolecular forces** | You can use the examples of hydrogen bonding in the agar gels of LOLIWARE, and the London dispersion forces that link the tiny fibers together in edible paper in a discussion about intermolecular forces. |
| **Polymers** | In teaching about polymers, the starches used in edible paper, as well as the polysaccharides in agar used for LOLIWARE, can serve as examples of the use and action of polymers. |
| **Ions** | When a divalent calcium ion replaces a monovalent sodium ion in sodium alginate multiple alginate ions are linked together in a more complex compound that becomes a gel. This can be used as an example when discussing ionic reactions. |
| **Limiting reagents** | In a discussion about limiting reactants, you can use the description of the spherification process to ask students to determine the limiting reactant in the process as it is presented. The reaction only occurs in the presence of alginate, and the reaction is stopped by removing the spheres from the alginate solution. |
| **Biochemistry** | Since humans lack the enzymes to digest cellulose but can digest starch, the use of amylose and amylopectin molecules in making edible paper could be discussed in a biochemistry unit where these molecules are studied. |

# 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.

In addition to the writing standards above, consider asking students to debate issues addressed in some of the articles. Standards addressed:

* **ELA-Literacy.WHST.9-10.1B.** Develop claim(s) and counterclaims fairly, supplying data and evidence for each while pointing out the strengths and limitations of both claim(s) and **counterclaims** in a discipline-appropriate form and in a manner that anticipates the audience’s knowledge level and concerns.
* **ELA-Literacy.WHST.11-12.1.A.** Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence.

## Vocabulary

**Vocabulary** and **concepts** that are reinforced in this issue:

Physical properties

States of Matter

Structural Formulas

pH

Oxidation & Reduction

Enzymes

Intermolecular forces

* Some of the articles in this issue provide information about carbon dioxide and its role in the environment.
* 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 consumer choices. 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 aforementioned anticipation guide, consider this idea to engage your students in reading.*

Ask students if they can provide examples of edible packaging they have used.

* **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.

|  |  |  |
| --- | --- | --- |
| **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.

“Eat the Wrapper?! An Edible Solution for Wasteful Packaging”, *ChemMatters*, February/March 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. Edible skins are made of organic molecules from food including oranges and chocolate. |
|  |  | 1. There is currently no way to protect edible skins from surface contamination. |
|  |  | 1. Compostable materials can be broken down by fungi and bacteria. |
|  |  | 1. Edible, compostable drinking cups made of agar have been developed. |
|  |  | 1. Making new plastic water bottles requires oil that could be used to generate electricity. |
|  |  | 1. Gel water spheres that you bite into are one possible solution to the plastic water bottle problem. |
|  |  | 1. Calcium ions can form three bonds linking alginate molecules together. |
|  |  | 1. The packaging waste added to landfills has gone down substantially since 2005. |
|  |  | 1. Edible paper is made of starch, not cellulose, so that it is digestible. |
|  |  | 1. Principles from molecular gastronomy can help solve the food packaging waste problem. |

## Graphic Organizer

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

“Eat the Wrapper?! An Edible Solution for Wasteful Packaging”, *ChemMatters*, February/March 2018

**Directions**: ***As you read***, complete the graphic organizer below to compare different forms of edible packaging.

|  |  |  |
| --- | --- | --- |
|  | **How they are made** | **Chemicals involved** |
| ***Edible skins*** |  |  |
| ***Edible cups*** |  |  |
| ***Water spheres*** |  |  |
| ***Edible cupcake paper*** |  |  |

**Summary:** On the back of this paper, use your knowledge of chemistry to write a short email to a friend explaining why you would or would not use edible packaging.

## Student Reading Comprehension Questions

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

Name

“Eat the Wrapper?! An Edible Solution for Wasteful Packaging”, *ChemMatters*, February/March 2018

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

* 1. What is molecular gastronomy?
  2. Give three reasons why WikiCell is an attractive alternative to traditional food packaging.
  3. What inspired Chelsea Briganti and Leigh Ann Tucker to create LOLIWARE?
  4. How does agar form a gel suitable for making cups?
  5. What makes LOLIWARE cups capable of holding soda without dissolving?
  6. Out of the 50 billion plastic water bottles disposed of in the United States, how many are recycled? Show your work.

**Student Reading Comprehension Questions, cont.**

“Eat the Wrapper?! An Edible Solution for Wasteful Packaging”, *ChemMatters*, February/March 2018

C

* 1. Why are many skeptical about the widespread use of edible packaging?
  2. How do calcium ions help form Ooho! edible water spheres?
  3. What materials are used to make edible paper?
  4. If cellulose and starch are both natural polymers, why is starch used instead of cellulose to make edible baking paper?
  5. In 2013 alone, how much food packaging ended up in landfills?
  6. Besides edible food wrappers, cite three other examples mentioned in the article that involve the development of compostable and biodegradable materials to replace food packaging.

## Answers to Student Reading Comprehension Questions

1. **What is molecular gastronomy?**

*Molecular gastronomy is "the study of the physical and chemical transformations of ingredients that occur when cooking food.”*

1. **Give three reasons why WikiCell is an attractive alternative to traditional food packaging**.

*Three reasons that WikiCell is an attractive alternative to traditional food packaging are:*

1. *it has no known negative environmental impacts,*
2. *it shields food from bacterial contamination, and*
3. *it provides extended shelf life for food.*
4. **What inspired Chelsea Briganti and Leigh Ann Tucker to create LOLIWARE?**

*Briganti and Tucker were inspired to create LOLIWARE as a solution to the wasteful consumption of plastic cups at parties and other gatherings—the problem of 25 billion plastic cups ending up in landfills and never decomposing.*

1. **How does agar form a gel suitable for making cups?**

*In hot water, agar is in solution as random coils and can be poured into molds for shaping. As the agar solution cools, agar gels due to the formation of hydrogen bonds that cross-link galactin chains. Further cooling leads to a firmer gel that can be dried to make cups.*

1. **What makes LOLIWARE cups capable of holding soda without dissolving?**

*LOLIWARE is capable of holding soda without dissolving because soda is served cold and the cups are only water soluble at near-boiling temperatures of 95–100 °C.*

1. **Out of the 50 billion plastic water bottles disposed of in the United States, how many are recycled? Show your work.**

*Out of the 50 billion plastic water bottles disposed of in the United States, 23% or 12 billion are recycled. There are two ways this answer can be calculated from the information in the article*

*50 billion plastic water bottles used*

*– 38 billion bottles in landfills*

*12 billion bottles recycled*

*Or*

*50 billion bottles used x 23 bottles recycled = 11.5 billion bottles recycled,*

*100 bottles used*

*rounded to 2 significant figures = 12 billion bottles recycled*

1. **Why are many skeptical about the widespread use of edible packaging?**

*Many are skeptical about using edible packaging because it could get contaminated as it passes from hand to hand during the shipping and storage journey. To keep it germ-free would require using some external packaging, thus completely negating the “packaging-free” mission.*

1. **How do calcium ions help form Ooho! edible gel water spheres?**

*“Calcium ions are divalent and can thus form two bonds. A single calcium ion from calcium lactate can form a bond between two sodium alginate molecules, effectively linking them together. As calcium ions join the alginate molecules, a solid gel sphere forms around the water in the bath.”*

1. **What materials are used to make edible paper?**

*Edible paper is usually produced with rice or tapioca, both of which contain large amounts of starch.*

1. **If cellulose and starch are both natural polymers, why is starch used instead of cellulose to make edible baking paper?**

*Starch is used to make edible paper rather than cellulose because humans lack enzymes to digest cellulose, but they do have the enzymes required to digest starch.*

1. **In 2013 alone, how much food packaging ended up in landfills?**

*In 2013 the U.S. Environmental Protection Agency reported that 36,720 tons of food packaging ended up in landfills.*

1. **Besides edible food wrappers, cite three other examples mentioned in the article that involve the development of compostable and biodegradable materials to replace food packaging.**

*Three other examples in the article that involve the development of compostable and biodegradable materials to replace traditional food packaging are:*

1. *Eco-Products offers plates, cups, bowls, and flatware that can be composted to rapidly degrade and used to enrich soil.*
2. *Ecovative introduced compostable packaging made from mycelium from mushrooms.*
3. *“Cellulose, starches, and polyesters produced by bacteria can also be used to make biodegradable plastic bags and wrappings.”*

# Possible Student Misconceptions

1. **“Water bottles and plastic bags decompose in landfills over time.”** *Plastic has only been around commercially a little over 70 years and nearly all of it is still present in the environment. It is unknown how long it will take for plastic to decompose but it is longer than this. Some sources state 1000 years, while others report a more modest 400 years. This is a long lifetime for something like food packaging that fulfills its purpose in a matter of hours to a couple of years. Recently some plastics have been made to decompose when exposed to sunlight. However, plastic buried deep within a landfill or in the ocean does not get enough light exposure to decompose.*
2. **“Food packaging is there only to make the food look good, to sell more of it.”** *From a marketing standpoint, you are exactly right. How a product looks to the consumer will definitely influence whether they purchase it. There would be no need to use tinted cellophane that makes meat look redder if the attractiveness of a product did not matter. However, that same cellophane also protects the meat from germs. The most important purpose of packaging is to extend the shelf life of the food it contains by preventing its premature exposure to microorganisms and the oxygen and humidity in the air. Oxygen is required for many of the reactions that cause food to spoil. Another purpose of packaging is to protect the product from physical damage. Bags of chips are filled with air to keep the chips from getting crushed. Packaging serves as the container for products like milk that must have it. Packaging is primarily for cleanliness, protection, and convenience, but it also provides a place for marketing.*
3. **“Everybody is recycling these days, so food packaging doesn’t typically get to landfills anyway. So, why worry about it?”** *Actually, everyone is not recycling. In the U.S. alone, 22% of materials added to landfills come from food packaging waste. A recent global study cited by* National Geographic *shows that in the past 60 years, 8.3 billion metric tons of plastic has been produced. Of that, 6.3 billion metric tons has become plastic waste. Only nine percent has been recycled. Food packaging materials do not account for all discarded plastic, but they represent a portion that consumers can reduce. The United States recycles less than any developed nation. Europe recycles 30% of its plastics and China recycles 25%, but recycling in the U.S. has remained at 9% since 2012. The majority of plastic waste has ended up in landfills. Some of it is finding its way into the oceans, where it either sinks to the bottom, washes up on shores, or remains floating in vast gyres of waste, mid-ocean. Plastic waste is hazardous to the wildlife that consumes it, or that gets caught in it. Beyond that, microscopic plastic fibers can now be found in the majority of drinking water throughout the world. In a global study of drinking water, 84% of the samples contained plastic fibers. 94% of the U.S. samples contained plastic fibers, while 72% of the European water samples contained plastic fibers. There were also more fibers per sample found in the U.S. samples compared to those in other countries. The physiological problems associated with plastic in the food chain is unknown at this time. Any efforts we can make to contain plastic’s presence in our environment could be to our advantage.* (<https://news.nationalgeographic.com/2017/07/plastic-produced-recycling-waste-ocean-trash-debris-environment> and <https://www.theguardian.com/environment/2017/sep/06/plastic-fibres-found-tap-water-around-world-study-reveals>)

# Anticipating Student Questions

1. **“The article states, “Entrepreneurs and scientists want to apply the principles of molecular gastronomy”. What are the principles of molecular gastronomy?** *The principles of molecular gastronomy are simply the principles of scientific inquiry. Experimentation in molecular gastronomy starts in the kitchen, where chefs study how food tastes and behaves under different temperatures, pressures, and other scientific conditions. The same principles that guide the “scientific method” are utilized by cooks and scientists practicing molecular gastronomy. Many of the tools and equipment that are used look as though they belong in a chemistry lab. Some food scientists use infrared spectroscopy to determine the structure of various food molecules in order to decide how to blend them for a specific taste experience. These same principles are used as scientists experiment with food to produce edible packaging.*
2. **“Could edible packaging be detrimental to my health?”** *It is unlikely that the materials used in edible packaging will be detrimental to your health. The materials used in making the packaging are already molecules that are in the human diet. Actually, we may have more to worry about the health effects of current plastic packaging made from petroleum products. It has been shown that some compounds like bisphenol A and phthalates leak into the food that is stored in plastics made with them. Due to recent regulations in some U.S. states, Canada, and European countries, most children’s cups and bottles are made of plastic that is BPA-free. Even plastic-lined paper used to wrap hamburgers may leach chemicals into our food. It is not yet known what the effects on human health of these chemicals associated with plastics might be, but some hypothesize that they may contribute to infertility, obesity, breast cancer, prostate cancer, heart disease, and diabetes.* *(*<https://www.choice.com.au/food-and-drink/food-warnings-and-safety/plastic/articles/plastics-and-food>*)*
3. **“Why have an edible skin if you still have to wrap the food in cellophane to protect it from germs?”** *Some of the edible wrappers that are being developed can be washed, just like you would wash the edible skin of an apple or grape before eating them. For those items that would require additional disposable packaging, hopefully, that packaging will be biodegradable as well. Some of the edible packaging actually extends the shelf life of the product because it is not permeable to oxygen. Oxygen is responsible for adverse changes in many foods, changing their flavor or speeding up their decay. With decreased exposure to oxygen, foods last longer and taste fresher.*
4. **“How are plastic bottles recycled?”** *Once collected, the plastic bottles are sorted according to the type of plastic they contain. At this point, they undergo several cleaning and further sorting steps before they are shredded into flakes. The flakes are then washed and can be sold as is or melted into pellets or roll stock to be made into more plastic products. Using recycled plastic stock reduces the amount of carbon consumed, as well as the amount of plastic that is landfilled. A video of this process can be found here:* <https://makezine.com/2011/06/16/how-plastic-bottles-are-recycled-video/>.
5. **“How big are the Ooho! water spheres, and how much water can they hold?”** *The Ooho! water spheres can be made to hold various volumes but are generally small, since they do not have a lid. Typically, the ideal volume is one sip to a few sips, depending on the application. At a marathon, the size might be 50 mL, while at a place like Starbucks, it might be 150 mL. The marketing idea for the Ooho! spheres is that they can be made on the spot in a machine similar to a coffee-making machine.*
6. **“How do you make edible paper?”** *Edible paper is made by creating a slurry with rice and potato flours and water. The slurry is spread into a thin layer and dried in an oven, microwave, or air-dried. Some edible paper has been produced using seaweed.*
7. **“What about current recycling programs—aren’t they working to keep things out of landfills?”** *Current recycling programs do keep some packaging out of landfills, but only a small portion of packaging makes it to the recycler. A lot of other countries seem to be doing a better job at recycling than the U.S. The U.S. population is not well educated about recycling, nor disciplined to recycle. Plus, facilities that collect recyclable materials are not evenly distributed geographically. For a recycling program to work well, there has to be an easy and convenient way to properly dispose of recyclable materials, and there must be a market for the recycled material. It also has to be cheaper to use stock from recycled goods than to make the packaging from its raw ingredients. Many plastics cannot be recycled, and those that can are subject to fluctuating markets. Plastic bags are a good example. They can be recycled, but the cost of recycling them is often more than it costs to make new bags from scratch, especially when the price of oil (the raw material for this plastic) is low. A lot of bags that are sent to a recycling facility end up being incinerated as a result. But at least that keeps them out of landfills and waterways.*

# Activities

**Labs and demos**

**“Molecular gastronomy in the science classroom”:** Three applications of spherification are used to teach about acid-base reactions, chemiluminescent redox reactions, and thermal convection in a reaction with a thermochromic effect. Instructions and videos are supplied for each activity, any/all of which could be used as a class lab activity or as a teacher demonstration. (<http://www.scienceinschool.org/content/molecular-gastronomy-chemistry-classroom>)

**“Juice Balls: The Science of Spherification”:** The information for this lab to make juice balls, which could be done in the classroom or assigned as a home project, is organized under tabs labeled Background, Materials, Procedure, and Make it Your Own. The instructions contain a short video that shows how the juice spheres are made. (<https://www.sciencebuddies.org/science-fair-projects/project-ideas/FoodSci_p074/cooking-food-science/juice-balls-science-of-spherification#summary>)

**Media**

**Video (2:02)—Making a food coating from milk casein:** This short, ACS-sponsored video shows the production of a food film made from casein. While it may best be used for dairy products and items already containing milk to protect people with milk allergies, the film could also be sprayed on breakfast cereal to prevent soggy cereal. (<https://www.youtube.com/watch?v=wt32GgQGTcI&feature=youtu.be>)

A Fox interview (4:51) with the scientists developing this casein film can be found here: <https://www.youtube.com/watch?v=0K_udXd-rx4>.

**Video (3:50)—“How to Make an Edible WATER ‘BOTTLE’”:**  The presenter provides instructions on how to make water spheres like the ones referenced in the Bricker-Anthony article. This video could be used as a resource for making water spheres in class, or at home as an enrichment activity. (<https://www.youtube.com/watch?v=YLjzsfgk198>)

**Motivational video (3:55)—reducing plastic consumption:**  “Open Your Eyes”, from the Plastic Pollution Coalition, seeks to educate and motivate people to use less plastic. This could be shown to initiate a discussion about the need for finding solutions to the waste plastic problem. (<http://www.plasticpollutioncoalition.org/>)

**Lessons and lesson plans**

**Using techniques from molecular gastronomy in class:**  This lesson plan gives instructions for a class of high school students to explore molecular gastronomy by making olive oil powder and juice spheres. The instructions are well written and the plan provides suggestions for discussion questions, as well as ideas for further exploration.

( <https://fromseedtoshelf.files.wordpress.com/2015/12/dowd2.pdf>)

**Molecular gastronomy unit plan:**  Students explore molecular gastronomy while studying basic chemistry content knowledge in this 13-lesson unit that uses NGSS and Understanding by Design principles and culminates in a snack food competition. All teacher materials and student materials are provided. (<https://sites.google.com/a/wgu.edu/instructional-portfolio-mg-engineering/kindergarten>)

A copy of the paper describing this lesson plan, presented at an ASEE’s conference can be found here: <file:///C:/Users/Owner/Downloads/the-recipe-for-a-gourmet-snack-ngss-nae-and-steam-fundamental%20(1).pdf>.

**Projects and extension activities**

**Making edible paper in class or at home:**  This site contains a simple recipe for an edible paper that uses rice flour, potato starch, salt, and water. This could be a fun activity to do in class or at home and could become an open inquiry activity by challenging the students to experiment with the amounts of each ingredient to determine its role in the quality of the final product. (<https://makezine.com/projects/make-edible-paper-3-easy-steps/>)

**Design a new edible wrap:**  Divide the students into small design groups to come up with creative, yet reasonable uses for edible packaging. For example, they may suggest mustard flavored paper napkins for the big hot pretzels sold in the mall. As a follow-up activity, you could assign them the task of researching their idea to see if it is currently being developed.

**Sponsor a school-wide recycling campaign:** Challenge students to launch a recycling campaign to educate their schoolmates about the need to reduce the amount of plastic in the environment and the amount of waste going to landfills. They might make posters to hang on the wall throughout the school, serve as guest speakers in other classes to present public service announcements, write a thought-for-the-day to be read over the intercom during schoolwide announcements, or sponsor a school-wide recycling challenge. If your school does not have a recycling program, the students may want to meet with the principle to try to start one.

# 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 !***

Available Now!

Author Brian Rohrig explores the chemical factors that affect food spoilage, while presenting several types of food packaging, from oxygen-permeable films to steel cans. At the end of the article is a set of four experiments students can conduct that compare a 16-oz. aluminum can and a 16-oz. plastic bottle for chill factor, size, amount of material, and strength. (Rohrig, B. Food Packaging—Wrapping up Freshness. *ChemMatters*, 2000, *18* (3), pp 9–11)

The October 2000 Teacher’s Guide to the above article contains a description of the different plastic-packaging materials. There are also instructions for performing a demonstration of the small amount of material in a Styrofoam® cup that involves “dissolving” cups in acetone.

In her article "Edible Wraps—Safe, Strong, and Delicious", author Mahoney addresses the research aspect of developing edible packaging. She discusses polymers and compares plant-derived polymers vs petroleum-derived polymers, and the hydrophilic nature of edible food wraps. (Mahoney, M. Edible Wraps—Safe, Strong, and Delicious. *ChemMatters*, 2003, *21* (2), pp 14–16)

The April 2003 Teacher’s Guide to the above article gives information about the amount of food packaging found in landfills, as well as information about plastic recycling processes and more information about edible wraps and biodegradable plastics. Suggestions for student activities include research reports, keeping a list of the types and amounts of packaging they discard at school and at home, and searching for examples of packaging “waste”.

The following issues of *ChemMatters* contain articles about recycling packaging materials, should you want to pursue that aspect of environmentally-friendly actions.

* Author Borchardt presents the chemistry of paper recycling. (Borchardt, J. Old News, New Paper. *ChemMatters* 1993, *11* (2), pp 12–14)
* An article about PET recycling presents the process of recycling plastic from soft drink bottles. The insert “Making and Unmaking of PET” within the article provides the overall chemical equation for this process. (Plummer, C. PET Recycling: “It’s Not Easy Getting New Shirts from Old Bottles”. *ChemMatters* 1994, *12* (3), pp 7–9)
* Poverty in India drives its populace to recycle nearly every piece of plastic they can find. The article discusses the process of how plastic is recycled in India. (Husband, T. Recycling to Survive. *ChemMatters* 2011, *29* (1), pp 5–7)
* Another article from author Husband presents the chemistry and social impact of aluminum recycling in India. (Husband, T. Recycling Aluminum: A Way of Life or a Lifestyle? *ChemMatters* 2012, *30* (2), pp 15–17)
* Author Tinnesand shows that the answer to the question “paper or plastic?” is not so simple when the energy required to produce each type of material is taken into consideration. Tinnesand, M. It’s Not Easy Being Green—Or Is It? *ChemMatters* 2014, *32* (1), pp 12–13)
* In the article “Recycling Plastic Bags”, author DeAntonis discusses the chemistry of making plastic bags and the process of recycling them. (DeAntonis, K. *ChemMatters* 2017, *35* (2), pp 8–9)

# Web Sites for Additional Information

**Edible packaging**

The *National Geographic* blog article “Food Packaging: Have Your Cake and Eat the Wrapper, Too” outlines several innovations in edible food packaging, including LOLIWARE and WikiCell. Links in the article make it easy to find more information on each innovation. (<http://theplate.nationalgeographic.com/2015/07/21/food-packaging-have-your-cake-and-eat-the-wrapper-too/>)

The article “This Indonesian Company Turns Seaweed into Edible & Biodegradable Packaging” contains information about the products being made by EvoWare, as well as a video (1:45) about these products as told by its founder. (<https://www.treehugger.com/clean-technology/company-turns-seaweed-edible-biodegradable-packaging.html>)

The *Seattle Times* article “Could edible packaging solve three environmental food problems?” discusses some of the types of edible packaging that are currently reaching the marketing stage, and how they may solve some environmental problems. Ecovative and Ooho! are both mentioned. (<https://www.seattletimes.com/life/food-drink/could-edible-packaging-solve-three-environmental-food-problems/>)

**WikiCell**

Information about eating the wrapper, liquid-proof skin, protecting the environment, hygiene, and a biodegradable future is just a click away on this infographic about WikiCell packaging. (<http://viewer.zmags.com/publication/8473aceb#/8473aceb/10>)

A short (1:40) video produced by *Al Jazeera* gives information about WikiCell packaging in the style of an infomercial. It could be used in class to support the *ChemMatters* article. (<http://www.aljazeera.com/programmes/earthrise/2013/10/how-it-works-edible-packaging-201310885639197443.html>)

**LOLIWARE**

Since LOLIWARE is presented in the Bricker-Anthony article, students might enjoy seeing this short, commercial-like video (0:57)about this product after they have read about it. (<https://www.youtube.com/watch?v=Fzdzuzg0d10>)

**Ooho! water spheres**

While this site does not provide a lot of technical information, it does provide the names and pictures of the team of young people behind the Ooho! water spheres. It might be motivational for students to see the young developers behind this product coming out of a lab in England. (<http://www.oohowater.com/>)

**Ecovative—mushroom-based packaging**

The ECOVATIVE Web site contains a wealth of information about their mycelium products. They also have an education link with several articles they have written about the experiments they conduct to test and develop their product. It is a good example of engineering design development. (<https://www.ecovativedesign.com/>)

**Bioplastics**

The article“Biopolymer Materials and Technologies Flourish” in the trade journal *Packaging World* lists several new options for biodegradable packaging materials that are being developed. The author gives extensive information about several polymers made by blending plant-based materials with petroleum-based products. (<https://www.packworld.com/article/sustainability/bioplastics/biopolymer-materials-and-technologies-flourish>)

“The Truth about Bioplastics” discusses the pros and cons of the new bioplastics. The authors present the downside to manufacturing bioplastics, including that not all bioplastics are biodegradable, land used to grow raw materials for bioplastics could be used for food production, and when bioplastics break down in landfills, they produce the greenhouse gas methane; and they also contaminate the recycling stream when they are mistaken for PET. (<https://phys.org/news/2017-12-truth-bioplastics.html>)

**Molecular gastronomy**

This Wikipedia entry for “Molecular Gastronomy” gives the history of this discipline developed by two academics, Nicholas Kurti and Hervé This in 1980. Though it is a recent term, cooks and scientists from the 1800s are cited for their contributions to this discipline. (<https://en.wikipedia.org/wiki/Molecular_gastronomy>)

Many chemistry concepts are increasingly used in the kitchen to provide novel gastronomical experiences. The article “Molecular Gastronomy: A New Emerging Scientific Discipline” contains extensive scientific explanations of food preparation, as well as the human sensual experience of enjoying it; the article would make a great resource if you are planning a unit on food chemistry. (<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2855180/>)

A commentary by one of the originators of the term ‘molecular gastronomy, Hervé This, is an interesting read. This conducted volumes of inquiries into wives’ tales and legends that surrounded certain cooking regimens. He expounds on some of his work in this commentary: <http://www.kitchen-theory.com/wp-content/uploads/2011/10/Herve-This-PDF.pdf>.

**Molecular gastronomy “recipes”**

If you are ready to explore molecular gastronomy, this site provides recipes, plus tutorials on the methods employed. There is a section on both spherification and reverse spherification. The site contains multiple links to a host of recipes, as well as a link to purchase a kit of common supplies. (<http://www.molecularrecipes.com/molecular-gastronomy/>)

**Waste disposal and landfill statistics**

The Environmental Protection Agency links the results of their studies on this Web site. From Table 1 in the “2014 Factsheet”, the most recent report published, it can be seen that out of 33.25 million tons of plastic waste generated, only 3.17 million tons were recycled. (<https://www.epa.gov/smm/advancing-sustainable-materials-management-facts-and-figures-report>)

“Toward a Plastic-Free Future”, published in *Earth Island Journal,* December 2017, emphasizes that simply recycling plastic is not enough. The article cites many of the statistics compiled for the United Nations Environment Program that project the level of plastic pollution by 2050:  **“**By 2050 there will be more plastic in the oceans than fish.” (<http://www.earthisland.org/journal/index.php/elist/eListRead/tquidoward_a_plastic-free_future/>)

**Global initiatives to reduce plastic waste**

The Web site *Verdict* reports on a recent meeting of the United Nations Environment Assembly where several nations joined the initiative to eliminate the use of plastics (e.g.,Kenya has recently banned the manufacture and use of plastic bags).The article presentseight alternatives to plastic that were discussed at the Assembly. (<https://www.verdict.co.uk/plastic-pollution-environment-ministers-pledged-zero-tolerance-alternatives/>)

This report contains a discussion of six of the latest innovations in solving the plastic waste problem, one example of which is that Coca-Cola Bottling Company and IKEA are two companies that are promoting plant-based packaging. Two short videos are embedded in the article, as well as a link to an on-demand webinar. (<https://www.edie.net/news/8/Edible-packaging-and-ocean-plastic-trainers--the-best-innovations-to-combat-the-plastics-problem/>)

**Short video clips about various edible packaging products**

* This short video (1:06), from the Fox News segment “Chew on This”, reports on Wikifoods yogurt pearls: <http://video.foxnews.com/v/3625503179001/?#sp=show-clips>.
* This short clip (3:42) about edible cutlery illustrates the difficulty in marketing a new product. (<https://www.youtube.com/watch?v=r4Cc5zmy0eY>)
* Coffee drinkers might enjoy learning about edible coffee cups. (1:30) (<https://www.youtube.com/watch?v=5jVx1teP0p8>)
* Saltwater Brewery has solved the problem of the sea turtle whose growth has been restricted by a trashed six-pack ring. Edible six-pack rings produced by the brewery can be safely eaten by aquatic wildlife. (1:52) ( <https://www.youtube.com/watch?v=-YG9gUJMGyw>)

**Infographic about edible packaging**

An infographic that contains pictures and basic information about several types of edible packaging that are being introduced to the marketplace can be found here: <http://www.rrpackaging.co.uk/blog-article/examples-of-edible-and-biodegradable-packaging>.

**Spherification**

The article “The Science of Spherification”, besides giving a brief history of this process, discusses the effect of pH on spherification, as well as the effect of the calcium salt chosen. The material could be used on PowerPoint slides for classroom use, or as extra reading material for students who want more information. (<https://www.chefsteps.com/activities/the-science-of-spherification>)

**Health concerns from environmental plastic**

The *Guardian* reports on a global study of plastic in drinking water, showing that 83% of the global samples contained microscopic plastic particles; 94% of the U.S. samples contained plastic fibers, and 72.2% of European samples contained plastic fibers. The article contains a graphic of a world map with the percentages of water samples studied that contained plastic. (<https://www.theguardian.com/environment/2017/sep/06/plastic-fibres-found-tap-water-around-world-study-reveals>)

“Not-so-Fantastic-Plastic” is an article about the chemicals in plastic that can leach out of containers into the food stored in them and the prospective health problems this may cause. The article contains a good chart of the different plastics and how they are used. (<https://www.choice.com.au/food-and-drink/food-warnings-and-safety/plastic/articles/plastics-and-food>)

# About the Guide

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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>.