

## Case Study 2 - Greener Plastics: Addressing Single-Use Plastics

### Week 2: End-of-Life Part 1

#### Scenario:

Your team works as scientific advisors for your local congressperson. An [NPR podcast](#) has recently caused an uproar for your boss' constituency. The podcast highlighted the shortcomings of the current recycling programs for single-use plastics. The constituency is demanding action from the congressperson.

Understanding the limitations of their knowledge of the problem, the congressperson has tasked their scientific advisors (you and your group) to develop a **Policy Paper**. The paper should provide **background information on what plastics are**, the **scope of the plastic pollution problem**, and evidence used to argue in support of **one of two competing legislative proposals** (shown below):

- 1) Fixing problems associated with the **beginning-of-life (synthesis and sourcing)** of single-use plastic polymers.
- 2) Addressing problems with the **end-of-life (recycling/disposal)** of single-use plastic polymers.

## Overall Goals for Case Study 2

During Case Study 2, your group will engage in a number of science and engineering practices using your knowledge of chemistry and the tools and data we have provided. Over the next four weeks, you will accomplish each of the following:

1. **Construct a molecular-level explanation of how and why** each polymer-forming reaction scheme occurs using your understanding of chemistry.
2. **Define the beginning-of-life problem** faced by the **polymer manufacturing** companies and **evaluate the strengths and weaknesses** to possible solutions to the problem.
3. **Define the end-of-life problem** faced by the **chemical recycling** companies and **evaluate the strengths and weaknesses** to possible solutions to the problem.
4. **Define the end-of-life problem** faced by the **chemical decomposition** companies and **evaluate the strengths and weaknesses** to possible solutions to the problem.
5. **Design a solution** to the congressperson's problem and communicate your group's solution through a **Policy Paper** that outlines an **evidence-based argument** of your choice of **which legislative proposal to support**.

# Goals for Case Study 2 Week 2

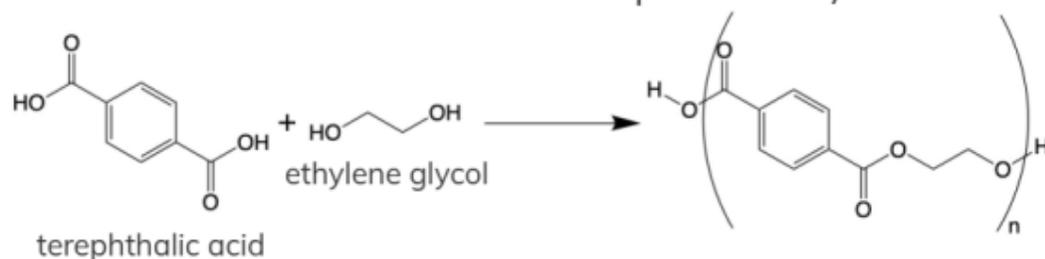
## Defining the Problem and Evaluating Solutions

3. **Define the end-of-life problem** faced by the **chemical recycling** companies and **evaluate the strengths and weaknesses** to possible solutions to the problem.

In case study 2 part 1, you explored the science and sustainability of monomer sourcing, the beginning-of-life solution. **In case study 2 part 2, you'll explore the end-of-life solution: recycling or decomposition.**

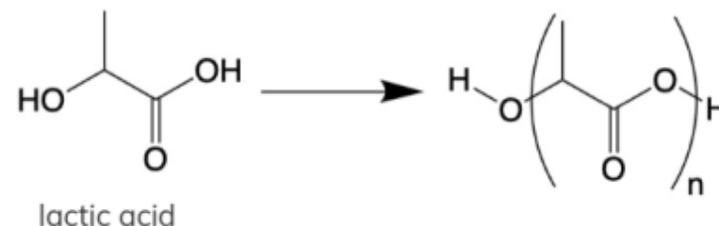
Poly(ethylene terephthalate) (PET):

- Traditional plastic for single-use drink bottles
- Oil based monomers
- Non-renewable feedstocks (raw materials needed for production)



Poly(lactic acid):

- Potential PET replacement
- Monomer is isolated from plants like corn and sugarcane
- renewable feedstocks





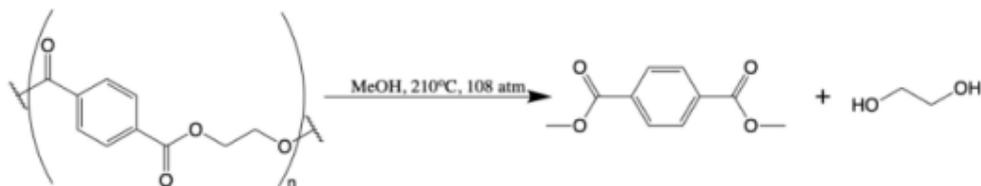
There are **two classes of recycling: mechanical and chemical**. Mechanical recycling involves the **shredding of the product into smaller pieces** that can be used in other materials such as carpet. **Most recycling** that occurs on an industrial scale can be classified as **mechanical recycling**. For a short overview of the process you can read the following [link](#).

What are the **strengths and challenges** you can think of about **mechanical recycling**? What happens to the **quality of the polymer**?

**Strengths:** Describe **one strength** of mechanical recycling and **explain what happens to the quality** of the polymer.

**Challenges:** Describe **one challenge** with mechanical recycling and **explain what happens to the quality** of the polymer.

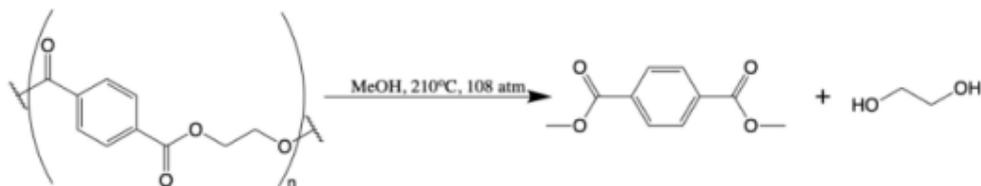
The other class, **chemical recycling**, involves **breaking the chemical bonds** holding the polymer together with the end goal being to recover the monomers so that new polymers can be made.



**Chemical recycling of PET:** Clean chips of PET were added to a pressurized reaction vial containing methanol. The chamber was pressurized to 108 atm and heated to 210°C. The reaction was stirred overnight. Once there were no visible PET chips remaining the reaction was depressurized and excess methanol and ethylene glycol were distilled off.

Using the [12 Principles of Green Chemistry](#), identify one aspect of chemical recycling that is **green**. In the box below, explain your reasoning for why this aspect is green.

The other class, **chemical recycling**, involves **breaking the chemical bonds** holding the polymer together with the end goal being to recover the monomers so that new polymers can be made.

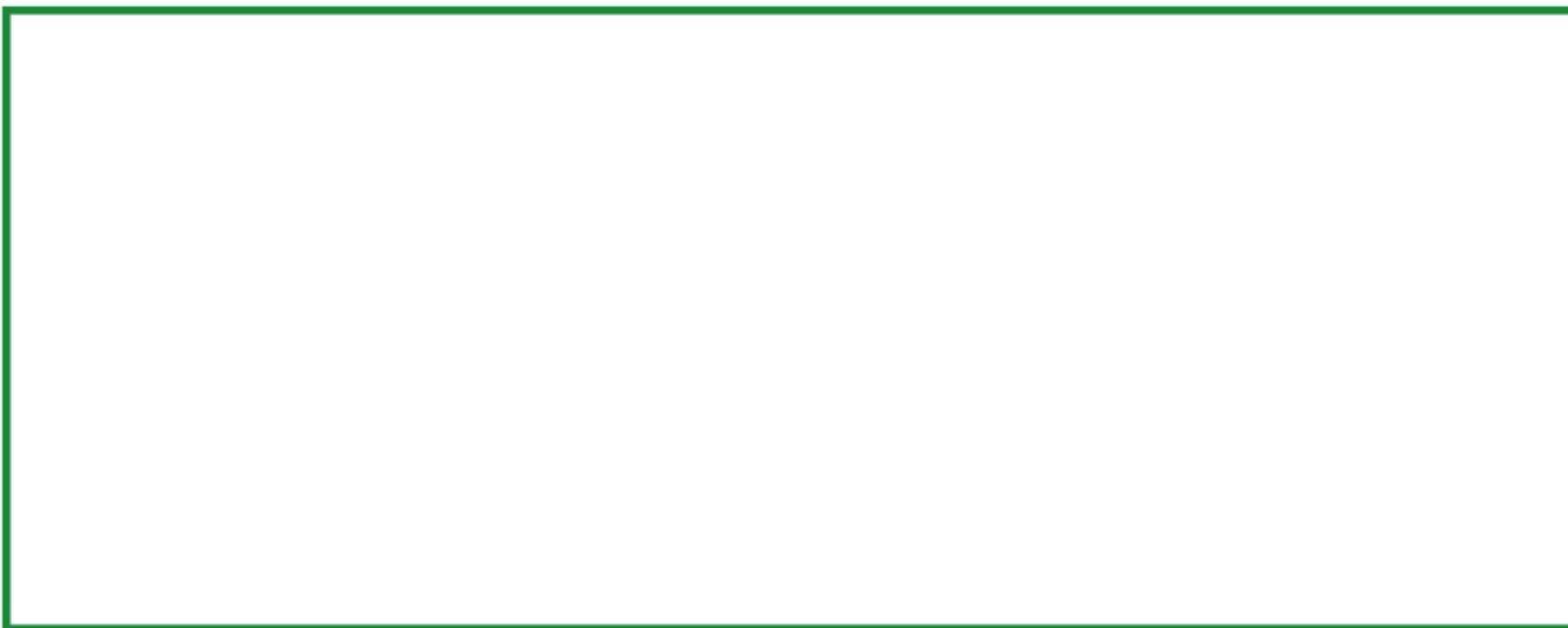


**Chemical recycling of PET:** Clean chips of PET were added to a pressurized reaction vial containing methanol. The chamber was pressurized to 108 atm and heated to 210°C. The reaction was stirred overnight. Once there were no visible PET chips remaining the reaction was depressurized and excess methanol and ethylene glycol were distilled off.

Using the [12 Principles of Green Chemistry](#), identify one aspect of chemical recycling that is **green**. In the box below, explain your reasoning for why this aspect is green.

On the **previous two slides, your group considered** whether or not chemical recycling is a green process. Based on these considerations and what we know about this process, **chemical recycling of PET is NOT commercially viable.**

Referring back to your previous answers on slides 4 and 5, **explain why chemical recycling is not commercially viable.** Be sure to reference any relevant [Principles of Green Chemistry](#) and any other evidence that helps your explanation.





Because **traditional chemical recycling is not viable** and **mechanical recycling does not address the need for new/virgin monomers**, there is great interest in developing alternative recycling methods.

One such method is to **avoid recycling altogether**. Think back to PLA - virgin lactic acid **monomers are sourced from renewable resources (plants)**. As such it is not as important to recover the monomers via recycling. Instead, the **main problem is the accumulation of plastic waste**. PLA is commonly marketed as *biodegradable* or *compostable*.

*Biodegradable* and *compostable* are commonly used interchangeably. Are they really interchangeable? Using [this link](#) for definitions of biodegradable and compostable, **identify the key differences** between the two and **describe these differences** in the box below.

The **PLA Report Tables** (linked on D2L) contains some of the evidence (Tables 7, 12, 13, and 15) used by plastic manufacturers to support **their claim that PLA is compostable**. On these Tables, please refer to the products: **Plant Pot (D)**, **Coffee Capsule (G)**, **Coffee Pad (H)**, and **Teabag (J)**.

In the box below, **list the evidence identified in the PLA Report Tables** and **describe what each piece of evidence tells you about the various PLA products**.



Now that your group has identified each piece of evidence, think specifically about the similarities and differences of our PLA products of interest: **Plant Pot (D)**, **Coffee Capsule (G)**, **Coffee Pad (H)**, and **Teabag (J)**.

In the green box below, **describe the similarities between these PLA products** based on the evidence listed on **Tables 7, 12, 13, and 15**.



In the blue box below, **describe the differences between these PLA products** based on the evidence listed on **Tables 7, 12, 13, and 15**.



Your group has reviewed evidence related to various PLA products, including **Plant Pot (D)**, **Coffee Capsule (G)**, **Coffee Pad (H)**, and **Teabag (J)**, and considered the similarities and differences between these products. Based on your previous answers (slides 8 and 9), **how strong is the claim that PLA is completely compostable?**

In the box below, evaluate this claim by: *1) describing whether or not you support this claim, 2) listing the appropriate evidence supports/refutes the claim, and 3) explaining how this evidence supports/refutes the claim.*





# Defining the Problem

In the **green box** below, describe the end-of-life problem with recycling in Case Study 2 and why it is a problem. In your response, **identify the physical system** (in which the problem is embedded) and **its components**, **specify the stakeholders of interest** to the problem and match each stakeholder to the **criteria/constraints that are important** to consider when designing an acceptable solution.



# Case Study 2 Week 2

List the **team names, MSU emails, and CEM section numbers** of everyone in your group who participated in this week's Case Study activity.

**Leave this blank if you DO NOT intend to turn this in.**

Team Member 1	MSU Email	Section Number
Team Member 2	MSU Email	Section Number
Team Member 3	MSU Email	Section Number
Team Member 4	MSU Email	Section Number

**You must hit "Complete" to earn credit for the assignment.**

Once you hit "Complete" your answers will be submitted to your instructor so make sure they reflect your final responses before hitting "Complete"