michaelhummel 12/21/2023

:Padlet

CHEM-E2155 Biopolymers 2024

Introduce yourself

Introduce yourself in Padlet

1. Introduce yourself within the group in your breakout room
2. Discuss the term “Biopolymer”
3. Write a short introduction of your group and summarize your discussion. Paste a screenshot of your Zoom screen to capture your faces
4. Save your introduction as picture or pdf file
5. After that, go to the Padlet webpage and upload your file in the first column:

   https://padlet.com/michaelhummel/CHEME2155_2024

Biopolymers introduction summary

What does “Biopolymers” mean?

- Materials made out of living organisms instead of petroleum.
- Examples of biopolymers are things like polysaccharides, cellulose, lignin.
- Usually, renewable materials are preferred.

<u>Group members info (room 4):</u>

Donatoni Giorgia (left upper):

- Biomedical engineering, 5-year student, biopolymers are familiar because they are used in different applications to be compatible with the human body.

Rasmus Huttunen (right upper):

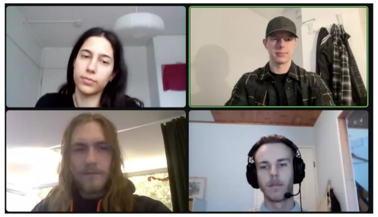
- 4-year student, major in Fiber and Polymer engineering, bachelor’s degree in Natural Materials Technology.

Jamkin Nikita (left bottom):

- Major functional materials, 5-year student.

Jere Pätsikkä (right bottom):

- 4-year student, major in Fiber and Polymer engineering, bachelor’s degree in bioproducts.



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Biopolymers introduction summary

Room 2

Introduction: Sara Hautojärvi, Chamodya Perera, Andrea Bonvini, Helmi Hanninen

Majors: Functional materials, chemistry and materials science, materials engineering, Biomass Refining

Biopolymers

Can be found in living organisms

Biodegradeable

They have monomer units like other synthetic polymers

Consist of biobased sources

Originated from renewable sources make them more environmentally friendly

Examples: Cellulose, lignin, PLA (lactic acid), Proteins found in cells and tissues

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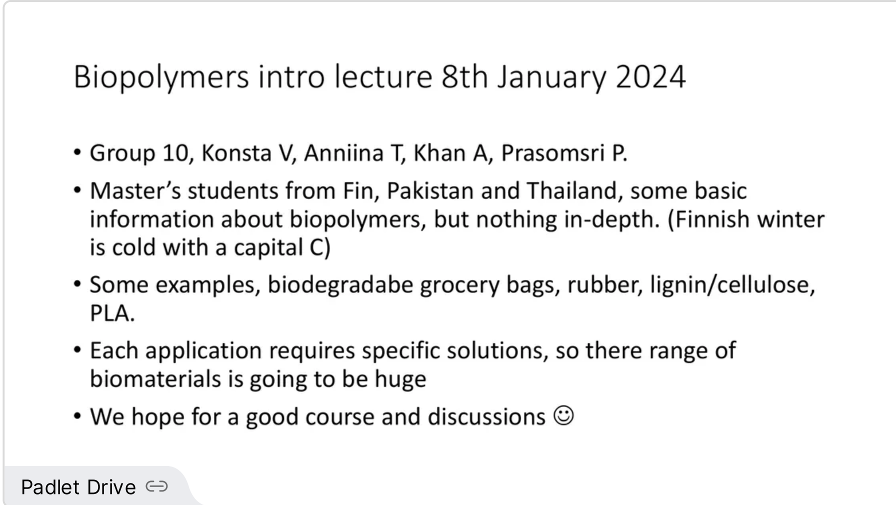
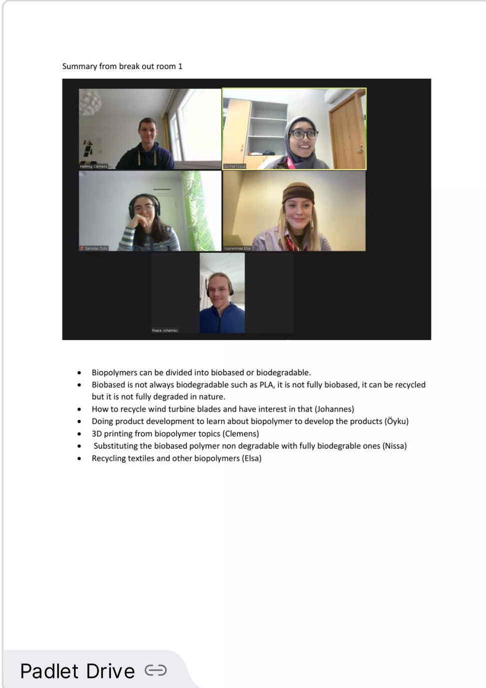
Room 2 introduction

Room 10 intro



Intro lecture room 10

Biopolymers Intro Room 1



Summary from break out room 1

- Biopolymers can be divided into biobased or biodegradable.
- Biobased is not always biodegradable such as PLA, it is not fully biobased, it can be recycled but it is not fully degraded in nature.
- How to recycle wind turbine blades and have interest in that (Johannes)
- Doing product development to learn about biopolymer to develop the products (Öyku)
- 3D printing from biopolymer topics (Clemens)
- Substituting the biobased polymer non degradable with fully biodegrable ones (Nissa)
- Recycling textiles and other biopolymers (Elsa)

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Summary from room break out 1 (08-01-2024)


Sampsa Mäenpää, Yücel Can, Feng Jianhui, Eveliina Palo

Biopolymers 8.1.2024

Sampsa Mäenpää: Functional materials major, 1st year Masters, interested in biopolymers.

Yücel Can: Fiber and polymer engineering major, 1st year, interested in polymers.

Feng Jianhui: Biomolecular material, PHD student, interested in biomaterial, coatings.

Eveliina Palo: Biomass refining major, 2nd year, interested in replacing fossile based materials with renewable materials.

- Polymers are repeating structures from building blocks called monomers
- Biopolymers are polymers of biological origin
- Degradable bioplastics?
- Examples of biopolymers:
  - Carbohydrates
    - Cellulose
    - Hemicelluloses
    - Glycogen
    - Chitin
  - Proteins
    - Gelatin
    - Enzymes
    - Keratin
  - Natural rubbers
- Biocompatibility
- Important in medical fields
- Sustainability, renewable sources

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Biopolymers

Biopolymers introduction session

Introduction Session

- Students in the group:

Kantelinen Jan, Krisnadewi Suciati and Fatemeh Yahyaeian Balouchi

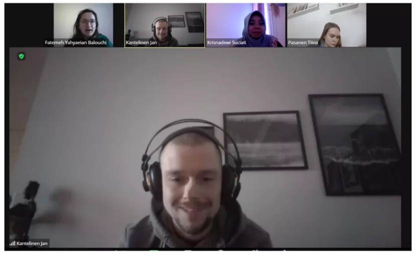
Fiber and polymer engineering master's students. Kris also stated that she was interested in knowing more about materials and their applications and this is why she is having this course, which was the same purpose for all members of the group.

Tiina Pasanen

Student in biomass refining.

- Biopolymers

Generally, biomaterials are everywhere and can be used in many different places, and this term is applied to materials that are made from natural materials totally or are biosynthesized by a natural organism, and are biodegradable. This is why the bio part is available in their names. PLA is an example, which has many applications and is used a lot. They are also usually recyclable and environment friendly, and can also be used pharmaceutical. Cellulose is another example, and its properties and applications are known from all other courses.



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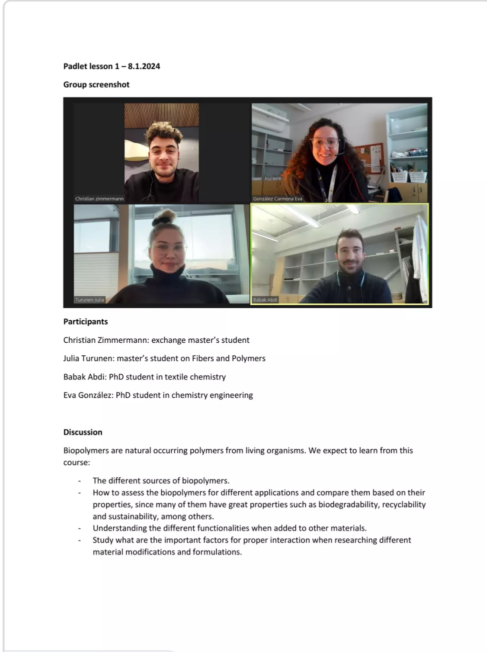
Group Discussion



Padlet lesson 1 – 8.1.2024

Group screenshot

Participants

Christian Zimmermann: exchange master's student

Julia Turunen: master's student on Fibers and Polymers

Babak Abdi: PhD student in textile chemistry

Eva González: PhD student in chemistry engineering

Discussion

Biopolymers are natural occurring polymers from living organisms. We expect to learn from this course:

- The different sources of biopolymers.
- How to assess the biopolymers for different applications and compare them based on their properties, since many of them have great properties such as biodegradability, recyclability and sustainability, among others.
- Understanding the different functionalities when added to other materials.
- Study what are the important factors for proper interaction when researching different material modifications and formulations.

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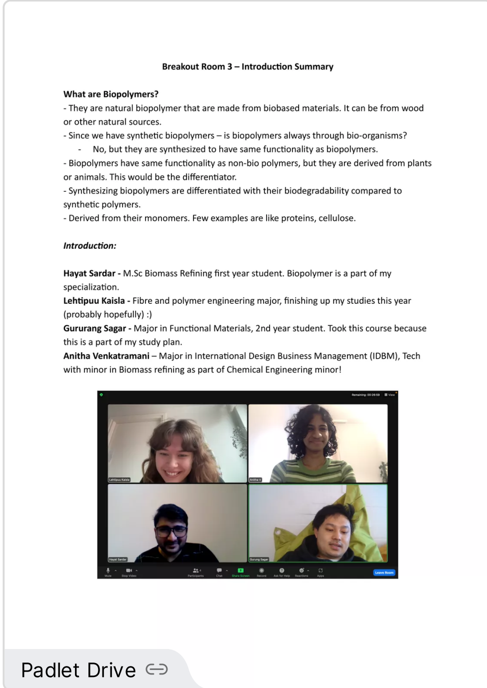
Padlet lesson 1

Introduction Summary - Room 3



Breakout Room 3 – Introduction Summary

What are Biopolymers?

- They are natural biopolymer that are made from biobased materials. It can be from wood or other natural sources.
- Since we have synthetic biopolymers – is biopolymers always through bio-organisms?
    - No, but they are synthesized to have same functionality as biopolymers.
- Biopolymers have same functionality as non-bio polymers, but they are derived from plants or animals. This would be the differentiator.
- Synthesizing biopolymers are differentiated with their biodegradability compared to synthetic polymers.
- Derived from their monomers. Few examples are like proteins, cellulose.

Introduction:

Hayat Sardar - M.Sc Biomass Refining first year student. Biopolymer is a part of my specialization.
Lehtipuu Kaisla - Fibre and polymer engineering major, finishing up my studies this year (probably hopefully) :)
Gururang Sagar - Major in Functional Materials, 2nd year student. Took this course because this is a part of my study plan.
Anitha Venkatramani – Major in International Design Business Management (IDBM), Tech with minor in Biomass refining as part of Chemical Engineering minor!

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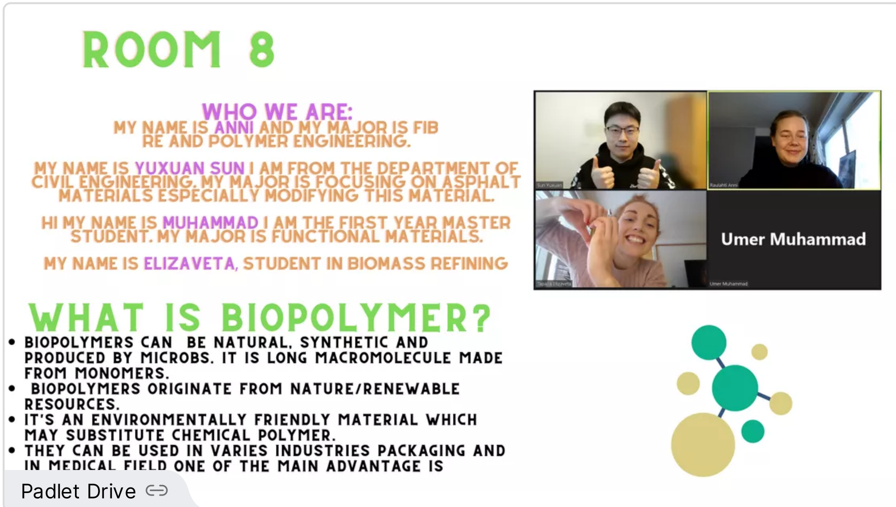
Introduction_Summary____Room_3.pdf



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Room 8

Biopolymers D Group 9

Biopolymers D

First Padlet Session Group 9

Emilia Ikävalko:

I'm Emilia and my major is Fiber and Polymer Engineering. I am doing my 1st year of master's studies. I'm from Finland and also did my bachelor's degree here in Aalto University. I'm interested in bio based polymers and replacing plastics with more sustainable.

Daniel Schröfl:

Hello, my name is Daniel and I am an exchange student from Austria who is studying chemical process engineering. I chose this course because I mainly know about the major Biopolymers (Cellulose, Lignin, DNA) and want to learn more about other biopolymers.

Mimi Tran:

Hi! My name is Mimi, 1st year master's student in the Fiber and Polymer Engineering major. I'm from Finland. I'm interested about biobased and biodegradable packaging solutions for cosmetics packaging.

Asle Hammer Berget:

My name is Asle, PhD-student from NTNU, Norway. I will research biobased and biodegradable food packaging options, and I think this course will help broaden my horizon of possible biopolymers for this application.

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Biopolymers_D_First_Session_Group_9

Reading Assignment 1

Reading 1 discussion

Title: Biopolymers: overview of several properties and consequences on their applications
Authors: K. Van de Velde & P. Kiekens
Polymer Testing **2002**, 21, 433–442

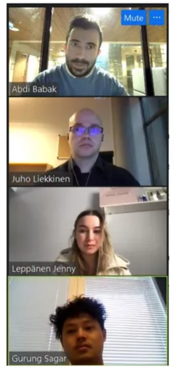
Discussion items:

- Which (main) polymers are discussed in this article and how are the similar or how do they differ chemically rom each other?
- Which material properties are discussed? How do they correlate with each other?
- How are those properties important for composite materials?

Instructions:
Write your names, summary and updated figures in e.g. PowerPoint. Save the text as image file (.jpg) and upload it to the Padlet page:
https://padlet.com/michaelhummel/CHEME2155_2024

Reading 1 Group1

Names:
Juho Liekkinen
Leppänen Jenny
Sagar Gurung
Babak Abdi



Questions:

1. In this paper four basic polymers, two copolymers, and also two optically active polymers were selected which were all polyester-based polymers. However, the main polymers compared in this article included PLA, PGA, PCL, and PHB. These polymers show different structural formations due to the difference in main monomer unit length, and chemical structure.
2. The properties discussed in this article included: Physical properties (density, water uptake), mechanical properties (tensile strength, young modulus, elongation), and thermal properties (glass transition, melting point, degradation temperature, processing temperature). The thermal and mechanical properties are affected by the physical properties of the polymers. However, there is no direct correlation between these properties.
3. It can be concluded that temperature and density play a crucial role in limiting criteria for choosing the proper polymer for specific applications. For example, it was stated that in the matric state, the mechanical properties of the polymers do not play a crucial role in affecting the mechanical properties of the final composite.

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Biopolymers 2

DISCUSSION 1- GROUP 2

1) Which (main) polymers are discussed in this article and how are the similar or how do they differ chemically rom each other?

In the paper they are discussing thermoplastic biopolymers for a flax fiber reinforced composite.
They chose to evaluate 6 polymers:

- PLA (two optically active forms)
- PGA
- DL-PLA/PGA (two different copolymers)
- PCL
- PHB

All these polymers are polyesters and biodegradable.
Their differences depend on the monomers in the chemical structure, in the degree of polymerization and in type and concentration of additives.

2) Which material properties are discussed? How do they correlate with each other?

Physical properties:

- **Density**: lower densities are preferred for lightweight applications
- **Water uptake**: low water uptake if favorable for flax reinforcements
- **Degradation time**: Generally as short as possible keeping in mind the mean life of the product

Thermal properties:

- **Melting temperature**: high enough for applications and low enough for energy saving production. Preferably not close to degradation temperature.
- **Glass transition temperature**: passage between glass material and rubber like material. Considering the application Tg must be accordingly placed (es. For elastomers Tg has to be low and for amorphous plastics it has to be high).

Mechanical properties:

- **Tensile properties** (E, UTS (UltimateTensileStrength), elongation):
  - tensile properties correlate with the density of the material.
    Higher the density, higher the tensile properties.
    An equilibrium as to be found between good tensile properties and low.
  - High water uptake leads to weaker mechanical properties, especially for flax reinforced materials.
  - Glass temperature has an impact on mechanical properties (young's module decreases substantially when the temperature increases surpassing Tg)

3) How are those properties important for composite materials?

The object of creating a composite material is to enhance its characteristics to be better than either one of its parts. Therefore, a composite materials properties should be, at least in preferred categories, higher or lower (based on preference) than the properties of either the matrix or the reinforcement part of the material.
The properties of any material must be decided with its end use in mind. For composite material specifically,

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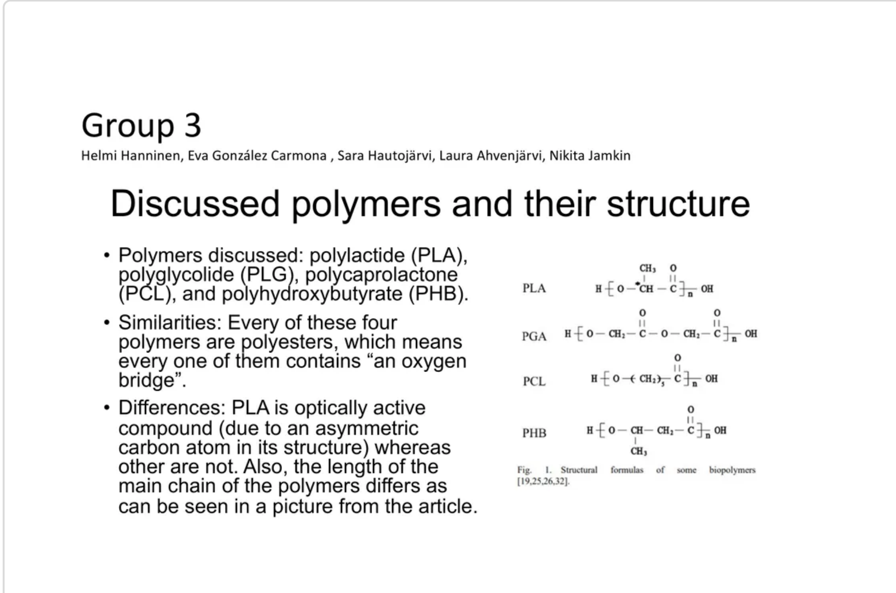
Discussion_1_group_2



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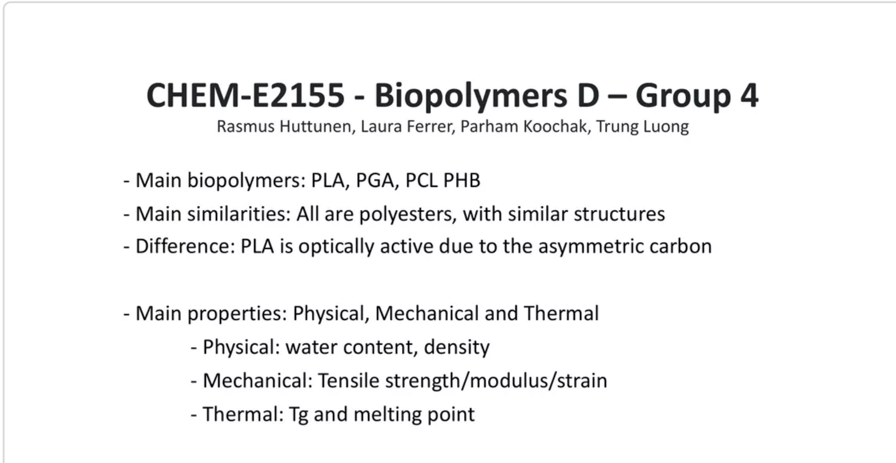
Room 3 discussion 1



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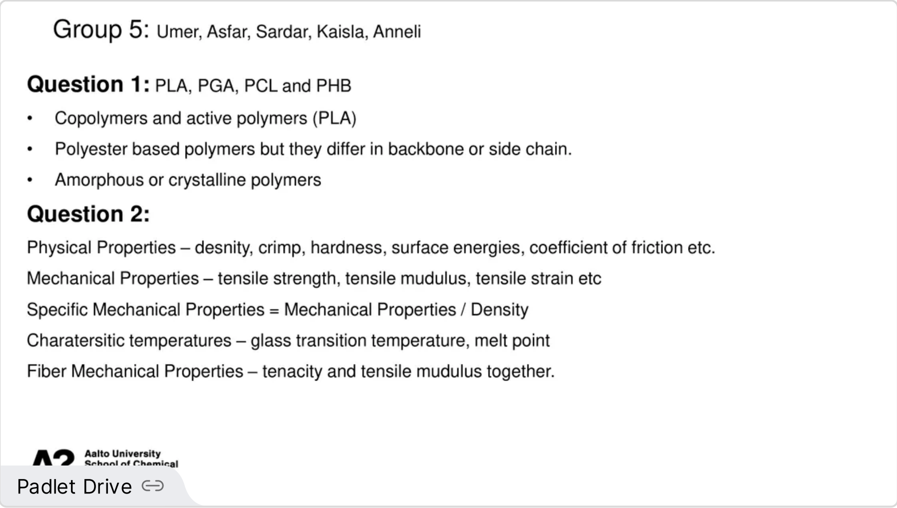
Discussion 1 - Biopolymers - Group 4

Group 5



Group 5: Umer, Asfar, Sardar, Kaisla, Anneli

Question 1: PLA, PGA, PCL and PHB

- Copolymers and active polymers (PLA)
- Polyester based polymers but they differ in backbone or side chain.
- Amorphous or crystalline polymers

Question 2:

Physical Properties – desnity, crimp, hardness, surface energies, coefficient of friction etc.

Mechanical Properties – tensile strength, tensile mudulus, tensile strain etc

Specific Mechanical Properties = Mechanical Properties / Density

Charatersitic temperatures – glass transition temperature, melt point

Fiber Mechanical Properties – tenacity and tensile mudulus together.

Aalto University School of Chemical

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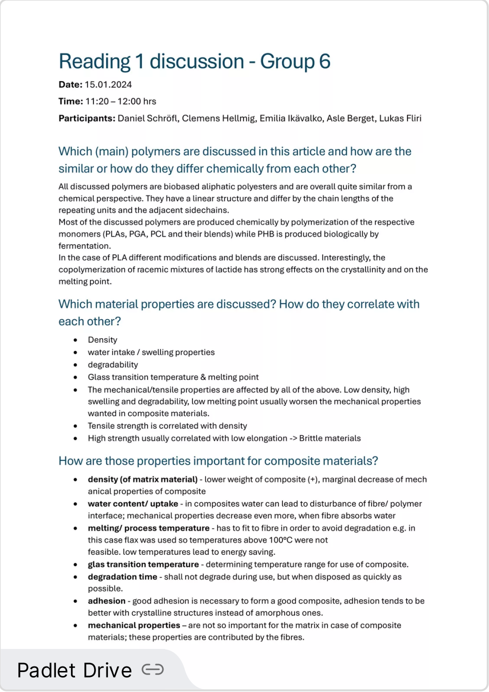
Reading1-Group5

Reading 1 discussion - Group 6



Reading 1 discussion - Group 6

Date: 15.01.2024

Time: 11:20 – 12:00 hrs

Participants: Daniel Schröfl, Clemens Hellmig, Emilia Ikävalko, Asle Berget, Lukas Fliri

Which (main) polymers are discussed in this article and how are the similar or how do they differ chemically from each other?

All discussed polymers are biobased aliphatic polyesters and are overall quite similar from a chemical perspective. They have a linear structure and differ by the chain lengths of the repeating units and the adjacent sidechains.
Most of the discussed polymers are produced chemically by polymerization of the respective monomers (PLAs, PGA, PCL and their blends) while PHB is produced biologically by fermentation.
In the case of PLA different modifications and blends are discussed. Interestingly, the copolymerization of racemic mixtures of lactide has strong effects on the crystallinity and on the melting point.

Which material properties are discussed? How do they correlate with each other?

- Density
- water intake / swelling properties
- degradability
- Glass transition temperature & melting point
- The mechanical/tensile properties are affected by all of the above. Low density, high swelling and degradability, low melting point usually worsen the mechanical properties wanted in composite materials.
- Tensile strength is correlated with density
- High strength usually correlated with low elongation -> Brittle materials

How are those properties important for composite materials?

- **density (of matrix material)** - lower weight of composite (+), marginal decrease of mech anical properties of composite
- **water content/ uptake** - in composites water can lead to disturbance of fibre/ polymer interface; mechanical properties decrease even more, when fibre absorbs water
- **melting/ process temperature** - has to fit to fibre in order to avoid degradation e.g. in this case flax was used so temperatures above 100°C were not feasible. low temperatures lead to energy saving.
- **glas transition temperature** - determining temperature range for use of composite.
- **degradation time** - shall not degrade during use, but when disposed as quickly as possible.
- **adhesion** - good adhesion is necessary to form a good composite, adhesion tends to be better with crystalline structures instead of amorphous ones.
- **mechanical properties** – are not so important for the matrix in case of composite materials; these properties are contributed by the fibres.

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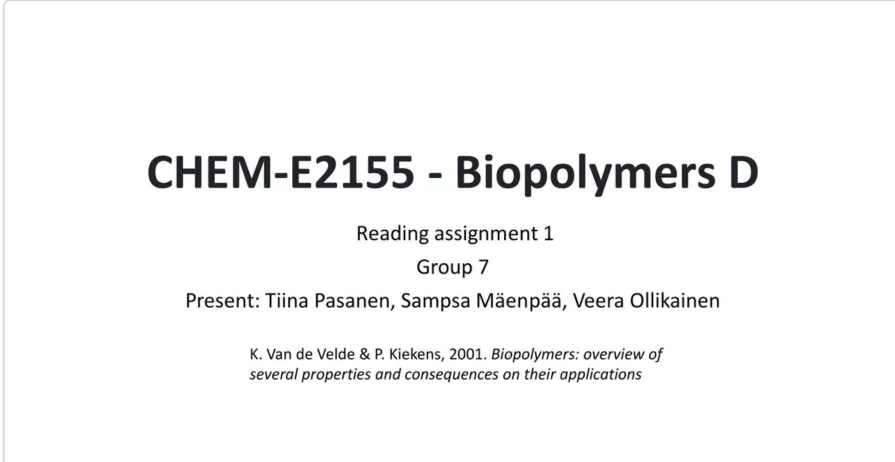
Reading 1 discussion



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CHEM-E2155 - Reading 1, Group 7

Group 8

Group 8
Johannes Peace
Ilari Peltonen
Sayoojya Prasad
Tiinamari Seppänen
Nissa Solihat

Discussion items:
Which (main) polymers are discussed in this article and how are the similar or how do they differ chemically from each other?
PLA: Polylactic acid or polylactide. → optically active
PGA: Polyglycolic acid or polyglycolide.
PCL: Poly--caprolactone.
PHB: Polyhydroxybutyrate.
The similarity: polyester, water uptake
Differences: the mechanical strength, PGA is easily eliminated as a candidate for composite matrix (with flax) use as its density and melting point are too high in order to be energy saving.

Which material properties are discussed? How do they correlate with each other?
Density, tensile properties, temperature. Relevant properties for composites as a matrix, flax was as a reinforcement. Molecular mass correlates with tensile, as well as density. Tg and Tm related mechanical properties.

How are those properties important for composite materials?
How light and strong (mechanical properties), volume fraction of composites, proper glass transition temperature, biodegradability, water update (bad for mechanical properties if fiber moist), composite structure.

Group 9: Reading assignment 1

Oona Hanska, Eveliina Palo, Joona Pystynen, Eetu Varttila, Luka Louhi

Q1 PLA, PGA, PCL, PHB. Similarities: all are polyesters. Differences: different chain lengths of monomers, PCL monomers only have one carbonyl group, PLA and PHB monomers have one carbonyl group and one methyl group. PGA compared to the others has one "extra" ester group in the middle of the monomer.

Q2 Density, Tensile properties (strength, tensile modulus, ultimate strain), Characteristics (glass transition and melt temperature).

Density is used to calculate the "specific properties" e.g. the specific tensile strength and tensile modulus ranges.

Q3 Thermal characteristics(T_g & T_m) and density are more important than mechanical properties, as fibers strengthen the composite, as the goal is to find the lightest composite possible. Thermal characteristics are important when discussing composites with flax reinforcement, because the properties of flax will be degraded when exceeding certain temperatures. Degradation time should be as low as possible, while making sure that proper corrosion resistance still exists.

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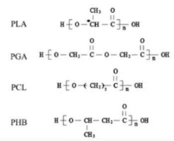
Reading assignment 1, Biopolymers group 9

Group 10: Reading discussion 1

1. Which (main) polymers are discussed in this article and how are the similar or how do they differ chemically rom each other?

- PLA (Polylactic Acid)
- PGA (Polyglycolic Acid)
- PCL (Polycaprolactone)
- PHB (Polyhydroxybutyrate)

Structural similar: Aliphatic polyesters
Differ in specific monomers



2. Which material properties are discussed? How do they correlate with each other?

- Density, tensile strength, tensile modulus, ultimate tensile strain, specific tensile strength, specific tensile modulus , glass transition temperature, and melting temperature.
- They are significant for the design and performance of composite materials:
- ✓ Cost- density
- ✓ Melting point- degradation
- ✓ Plasticity- glass transition
- ✓ Water absorption- tensile strength
- ✓ Process temperature- cost

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group 10

Reading 1 Group 11

Reading 1 discussion group 11

Anni Raulahti, Anniina Tamminen, Mimi Tran, Elsa Vuorenmaa

The main polymers discussed are **PLA, PGA, PCL and PHB**.
All four are polyesters. PLA has an asymmetric carbon unlike the others.
PLA and PGA can be made from the original acid as well as from the cyclic lactide or glycolide.

The studied properties were:
- Polymer density
- Tensile strength
- Tensile modulus
- Ultimate strain
- Specific tensile strength
- Specific tensile modulus
- Glass transition temperature
- Melt point
- Crystallinity
- Water content/ water uptake
- Degradation time

How do the properties correlate with each other?
- Tensile properties are best for the densest polymers, especially for PGA. PCL seemed to be the weakest.
- Specific properties are the mechanical properties divided by the density.
- Only crystalline polymers have a melting point.
- Water uptake can notably negatively affect mechanical properties.

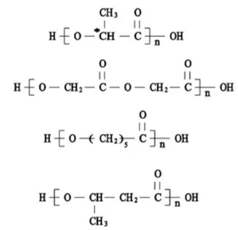

Fig. 1. Structural formulas of some biopolymers [19,25,26,32].

Importance for composites:
- Weaker matrix polymer -> lighter the resulting composite, mechanical properties not so crucial.
- The application temperature (Tg, Tm) of the product should be quite low (e.g. max. 100°C) due to the possible degradation of flax.
- ...in the polymer improve the adhesion with a reinforcing fibre.

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Reading 1 Group 11

Group 12

WHICH (MAIN) POLYMERS ARE DISCUSSED IN THIS ARTICLE AND HOW ARE THE SIMILAR OR HOW DO THEY DIFFER CHEMICALLY ROM EACH OTHER?

1. PLA (Polylactic Acid or Polylactide)i
l-PLA (Poly-l-lactic Acid)
2. dl-PLA (Poly-dl-lactic Acid)
3. PGA (Polyglycolic Acid or Polyglycolide)
4. Copolymers:
   - dl-PLA/PGA 50/50 (50% dl-PLA and 50% PGA)
   - dl-PLA/PGA 75/25 (75% dl-PLA and 25% PGA)
5. PCL (Poly-ε-caprolactone)
6. PHB (Polyhydroxybutyrate)

Each of these polymers offers distinct properties, making them suitable for specific applications, especially in areas where biodegradability and biocompatibility are importanti

All biodegradable

PGA is synthesized through ring-opening polymerization of glycolide.
Copolymers (dl-PLA/PGA 50/50 and dl-PLA/PGA made by copolymerizing dl-lactic acid and glycolic acid in different ratios.
PCL is synthesized through ring-opening polymerization of ε-caprolactone.
PHB is produced by bacterial fermentation of sugars or lipids.

PLA contains an asymmetrical carbon atom in its structural unit.
L-PLA and DL-PLA are derivatives of PLA

Group 12
Ranawaka ArachchigeChamodya
Elizaveta Tapaila
Konsta Vainikainen
Anitha Venkatramani
Moa Vesterlund

Padlet Drive

Which (main) polymers are discussed in this article and how are the similar or how do they differ chemically rom each other (1)

15.1.2024

Group 13

Anastasia Tervo

Timo Tuoresjärvi

Julia Turunen

Fatemeh Yahyaeian Balouchi

Can Yücel

Which (main) polymers are discussed in this article and how are the similar or how do they differ chemically from each other?

The polymers discussed were: Pylyglycolic acid (PGA), Poly-e-caprolactone (PCL), Polyhydroxybuturate (PHB), and Polylactic acid (PLA)

- All are hydrophilic polyesters and biopolymers
- PLA has chiral carbon atom → has stereochemistry (optically active, as well as other lactides) L-PLA and DL-PLA are isotactic and DL-PLA/PGA (50/50 and 75/25) are co-polymers
- PLA (and PGA) can be made from the original acid as well as from the cyclic lactide (or glycolide)
- PLC and PHB can be obtained by intermolecular splitting of water from the acids

Figure 1 below depicts the chemical formulas of the discussed polymers.

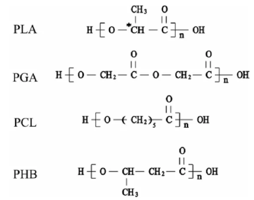

Fig. 1. Structural formulas of some biopolymers [19,25,26,32].

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Polymeeri2

Reading Assignment 2

Reading 2 discussion

Chapter title: Biopolymer-Based Sustainable Food Packaging Materials: Challenges, Solutions, and Applications
By Perera *et al.*
From: *Foods* 2023, 12, 2422

Discussion items:

- **What are important material properties for packaging?**
- **Which ones are difficult to achieve with biopolymers and why?**
- **Pick an oil-based packaging and propose (a combination of) biopolymers that could potentially substitute it.**

Instructions:
Write your summary in e.g. PowerPoint. Save the text as image file (.jpg) and upload it to the Padlet page:
https://padlet.com/michaelhummel/CHEME2155_2024

Group 1 discussion 2

Group number 1
Names:
Carl-Alfons Antson
Sagar Gurung
Jenny Leppänen
Juho Liekkinen
Babak Abdi

Questions:

1. Barrier properties (water vapor transmittance, air permeability, oxygen transmittance, etc.), mechanical properties (tensile strength, elongation), thermal properties, chemical resistance toward acidic media. However, now factors like recyclability, biodegradability, bio-based source materials, and mainly bio-plastic polymers are gaining more interest in packing applications.
2. Mechanical properties, barrier properties(water vapor properties), and hydrophilic nature of the biopolymers in some specific cases, and these shortcomings come back to the natural properties of these polymers
3. PET, PETE, polystyrene, and polypropylene were previously used for the production of cups, plates, and cutlery. However, recently starch blends like thermoplastic starch could potentially replace these materials instead.

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Group 1 discussion 2

Group 2

READING 2 DISCUSSION - GROUP 2

Group 3

Reading Discussion 2 – Group 4 (Luong Trung Hieu, Ferrer Pascual Laura)

1. What are important material properties for packaging?

- Barrier properties: Gas permeability; Oxygen barrier properties; Water vapor barrier properties; UV barrier properties
- Mechanical properties are essential to secure the food during stressful conditions.
- Chemical resistance because the food in the package may be acidic and combine with the packaging material.
- Thermal properties allow to store and transport the food packaging at the temperature essential for the food products.

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Reading 2 - Group 4

Reading 2 – biopolymers in packaging

Important material properties for packaging: barrier properties (gas, moisture and oxygen permeability), non-toxicity, mechanical properties, antimicrobial properties, thermal properties, lightweightness, odorless+tasteless material

Properties which are hard to achieve for biopolymers: Barrier properties (especially with moisture) and mechanical properties

- For example, starch by itself is brittle due to the inter- and intramolecular interactions, but these weaknesses can be overcome through modification and by adding plasticizers and compatibilizers
- Irregular and complex structure also explains weaknesses

Substituting oil-based packaging: using bio-based PE instead of PE for e.g. bags, containers, bottles – the only difference is the source

Kaisla Lehtipuu, Muhammad Umer, Asfar Khan, Sardar Hayat, Group 5

Padlet Drive

Group 5 reading 2 discussion

Reading 2 discussion - Group 6

Date: 22.01.2024

Time: 11:25 – 12:00 hrs

Participants: Daniel Schröfl, Clemens Hellmig, Emilia Ikävalko, Asle Berget, Lukas Fliri

What are important material properties for packaging?

- barrier properties (gases, moisture, aroma, lipids, vapor, oxygen)
- elongation
- sensitivity to moisture
- melting point (processibility, use case)
- biodegradability
- density (lightweight)
- non-toxic
- impact resistance
- antimicrobial activity
- transparency

Which ones are difficult to achieve with biopolymers and why?

- barrier properties
  - water barrier -> a lot of biopolymers are hydrophilic
  - gas barrier -> density of biopolymers is low
- elongation -> brittleness
- base mechanical properties -> e.g. moisture absorbance
- antimicrobial activity -> contra productive for biodegradation

Pick an oil-based packaging and propose (a combination of) biopolymers that could potentially substitute it.

single use plastic bags (HDPE) – significant properties:

- tensile strength
- elongation
- nontoxic

potential substitute: PHAs (according to given paper)

- good tensile strength
- nontoxic
- good oxygen and water barrier properties
- biodegradable

commercially used: PLA – Starch blends (not in paper)

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Reading 2 discussion - Group 6

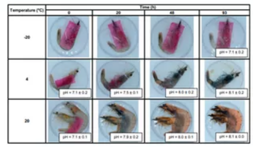
GROUP 7

GROUP 7: Veera Ollikainen, Tiina Pasanen, Mikael Nortes, Sampsa Mäenpää

1, Important properties for packaging:
- non-toxic, barrier properties (gas, oxygen, lipid), water resistance, mechanincal properties (toughness), low cost, abundance, processability, transparent, tasteless, thermal resistance

2. Difficult to achieve with biopolymers and why:
- water resistance: hydrophilic chemical structure, e.g. cellulose and starch
- mechanical properties: chemical structure, use of plasticizer reduces brittleness but decreases other mechanical propertie
- barrier properties for water vapor: hyrdrophilic structures
- low cost: requires intensive processing, no available large scale industrial processes available

3. Propose (a combination of) biopolymers that could potentially substitute oil-based polymers:
- Polymer to substitute: **LDPE**
  - used for sea-food packaging
- Proposed substitute: Chitosan-polyvinyl alcohol anthocyanins:
  - improved mechanical, hydrophobic and barrier properties compared to pristine chitosan
  - intelligent indicator film through color change: monitors shrimp freshness
  - expensive, though could be applicable for more high-end foods, e.g. shrimp



SOURCES

Perera et al. (2023) Biopolymer-Based Sustainable Food Packaging Materials: Challenges, Solutions, and Applications

Merz et al. (2020) A novel colorimetric indicator film based on chitosan, polyvinyl alcohol and anthocyanins from jambolan (Syzygium cumini) fruit for monitoring shrimp freshness

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Group 8
Johannes Peace
Ilari Peltonen
Sayoojya Prasad
Tiinamari Seppänen
Nissa Solihat

Discussion items:
1. What are important material properties for packaging?
Biodegradability, mechanical properties, barrier properties (oxygen, gas, water, UV), anti-bacterial properties, thermal properties, price.

2. Which ones are difficult to achieve with biopolymers and why?
Weak mechanical strength (due to the chemical bonds and interactions), high sensitivity to moisture, higher production cost, low optical properties, poor thermal stability.
This is because of hydrophilic structure, low degree of polymerization lead to weak interchain interaction, less reproducibility, structure created low thermal stability.

3. Pick an oil-based packaging and propose (a combination of) biopolymers could potentially substitute it.
EPS packaging materials could be replaced with cellulose-based materials made for example via foam forming. To increase mechanical properties and water resistance e.g. chitosan can be used, and for antimicrobial properties e.g. essential oils.

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Group 8-2nd meeting

Group 9

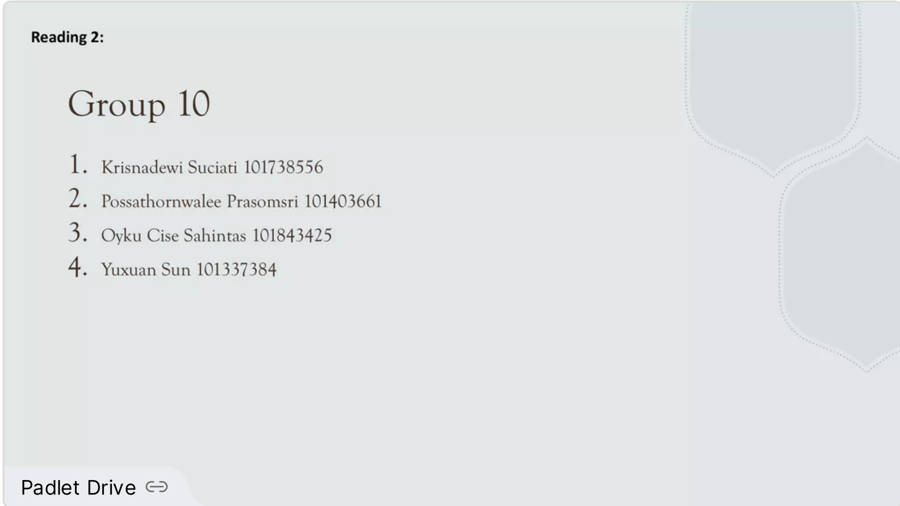
CHEM-E2155 - Biopolymers

Reading assignment 2
Group 9
Oona Hanska, Eveliina Palo, Joona Pystynen, Eetu Varttila, Luka Louhi

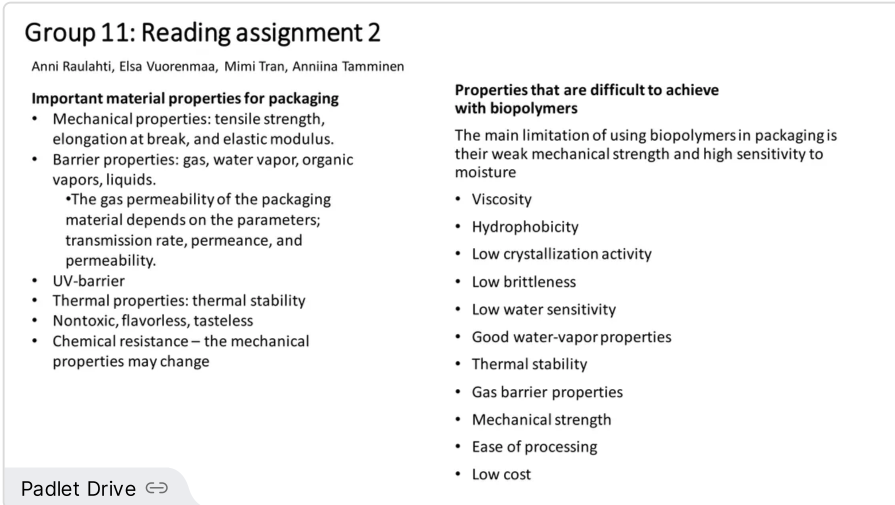
Padlet Drive

Group 9 Reading 2

Group 10

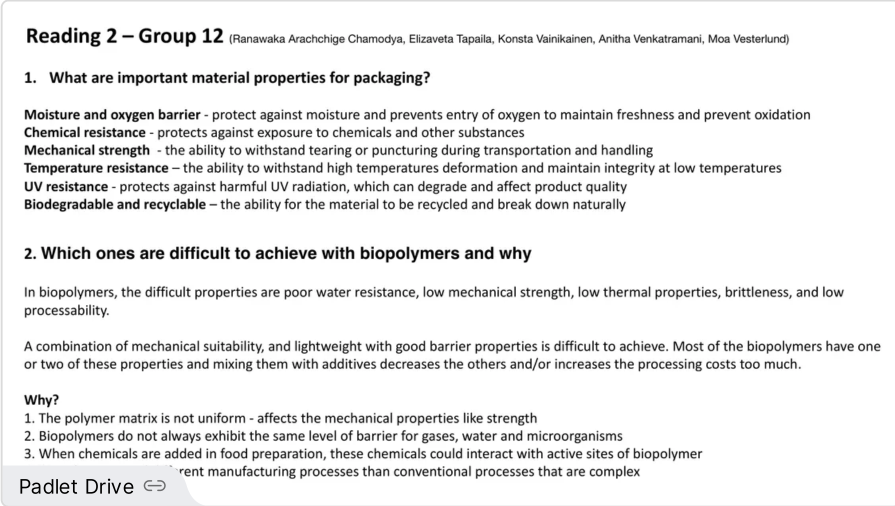


Reading 2 group 10



Reading 2

Group 12



Reading 2 – Group 12 (Ranawaka Arachchige Chamodya, Elizaveta Tapaila, Konsta Vainikainen, Anitha Venkatramani, Moa Vesterlund)

1. **What are important material properties for packaging?**

Moisture and oxygen barrier - protect against moisture and prevents entry of oxygen to maintain freshness and prevent oxidation
Chemical resistance - protects against exposure to chemicals and other substances
Mechanical strength - the ability to withstand tearing or puncturing during transportation and handling
Temperature resistance – the ability to withstand high temperatures deformation and maintain integrity at low temperatures
UV resistance - protects against harmful UV radiation, which can degrade and affect product quality
Biodegradable and recyclable – the ability for the material to be recycled and break down naturally

2. Which ones are difficult to achieve with biopolymers and why

In biopolymers, the difficult properties are poor water resistance, low mechanical strength, low thermal properties, brittleness, and low processability.

A combination of mechanical suitability, and lightweight with good barrier properties is difficult to achieve. Most of the biopolymers have one or two of these properties and mixing them with additives decreases the others and/or increases the processing costs too much.

Why?
1. The polymer matrix is not uniform - affects the mechanical properties like strength
2. Biopolymers do not always exhibit the same level of barrier for gases, water and microorganisms
3. When chemicals are added in food preparation, these chemicals could interact with active sites of biopolymer
rent manufacturing processes than conventional processes that are complex

Reading 2 - Group 12

Discussion 2 - Group 13

Discussion 2 – Group 13
Anastasia Tervo, Timo Tuoresjärvi, Julia Turunen, Fatemeh Yahyaeian Balouchi, Can Yücel

1. What are important material properties for packaging?

Water resistance, barrier properties (Gas, water vapor, aroma, lipids, UV, etc.), processing, brittleness, high mechanical, chemical and thermal properties, non-toxicity.

2. which ones are difficult to achieve with biopolymers and why?

They have low mechanical strength, thermal and barrier properties, are moisture sensitive, and are expensive to produce and develop. This is because synthetic polymers are easier to process if we consider the steps needed and the years of research and production experience behind them, because they have been produced for so many years and the process is well developed. But bio-based polymers are new, so it takes money to research them, make perfect blends and add additives to reinforce the composites, so it will be more expensive. They are brittle, some are hydrophobic, and there might be the possibility of methane gas production during their biodegradation process. Methane production is for anaerobic degradation and normal degradation produces water and carbon dioxide.

Some of the materials in bio-based polymers are porous, so they have these pores that are not tight enough, so they hold water inside their structure. So, the polymer might swell and the composite might degrade. They also have high viscosity which might lead to process difficulties. If they are hydrophobic then they do not have pores, and they will get denser.

3. Pick an oil-based packaging and propose (a combination of) biopolymers that could potentially substitute it.

Instead of HDPE we can use a mixture of PBAT, which is flexible, chemically inactive, does not stand alone well but is very good in mixing, and is expensive, and PLA, which is pretty similar to PE. It is brittle and tough, strong mechanical strength, cheap, weak elasticity. This mixture can be used in plastic bottles, for storing harsh chemicals. The application is for acids and containers.

PET can also be replaced by a mixture of PBAT and starch (to add flexibility) for the same application as above, and for water storage.

Polystyrene can be replaced by starch foam packaging. This is because starch is hydrophilic, and degrades with moisture. Therefore, a mixture of mentioned materials can be used to make it rigid and hydrophobic. Physical and chemical modifications can also be done for better results. A mixture of starch and cellulose nanofiber (CNF)-thymol can also be used for antibacterial packaging, or they can be blended with natural rubber or gums, which theoretically have high flexibility and can be a suitable alternative.

Discussion 2 biopolymers

Reading 3 discussion

Title: Starch-based biodegradable materials: Challenges and opportunities
From: Jiang et al. *Advanced Industrial and Engineering Polymer Research* 2020, 3, 8-18

Discussion items:
- **Discuss and summarize the advantages and challenges of starch as packing material addressed in this research article**

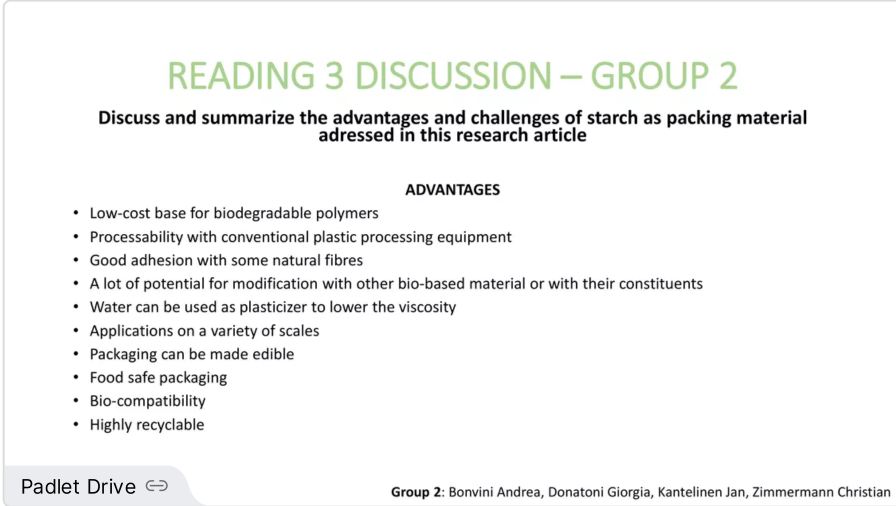
Instructions:
Write your names, summary and updated figures in e.g. PowerPoint. Save the text as image file (.jpg) and upload it to the Padlet page:
https://padlet.com/michaelhummel/CHEME2155_2024

Reading 3-group 1

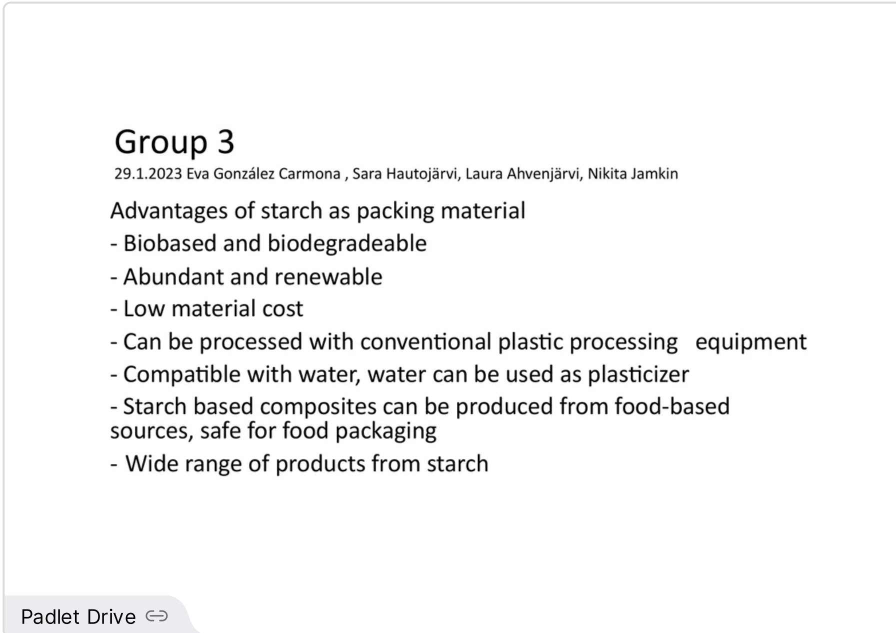
Abdi Babak
Carl-Alfons Antson
Jenny Leppänen
Juho Liekkinen
Gurung Sagar

- Advantages:
  - Bio-degradable, bio-based, low-cost, compatible with other type of materials to improve qualities (same chemical unit), edible, compostable at home, ability to be processed by modern and traditional processing techniques, low cost of transportation, abundant in nature. Properties can be improved by adding natural polymer composites like cellulose-based fibers (Mechanical properties)
- Challenges:
  - Mechanical properties, water permeability, moisture sensitivity, improving the properties by combining with other materials reduces the biodegradability (balance with moisture sensitivity and biodegradability), reducing the cost of final product, competition with food production (if food sources are used for production)

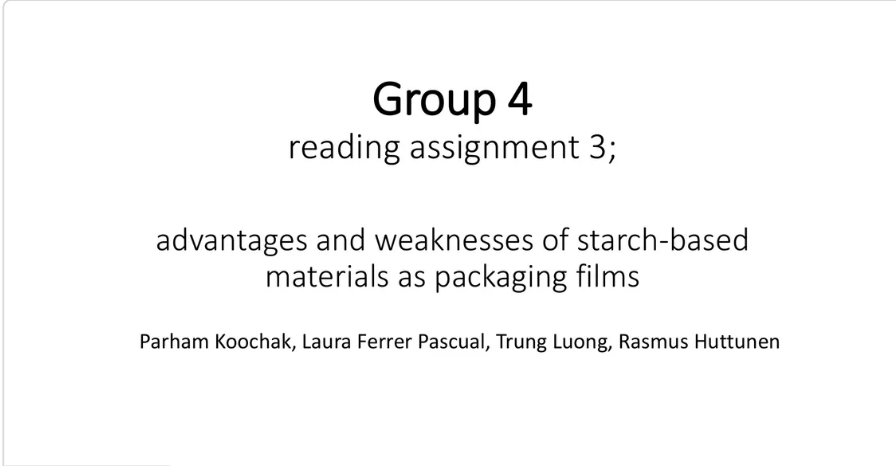
Group 2



READING 3 DISCUSSION-GROUP 2



Group 3



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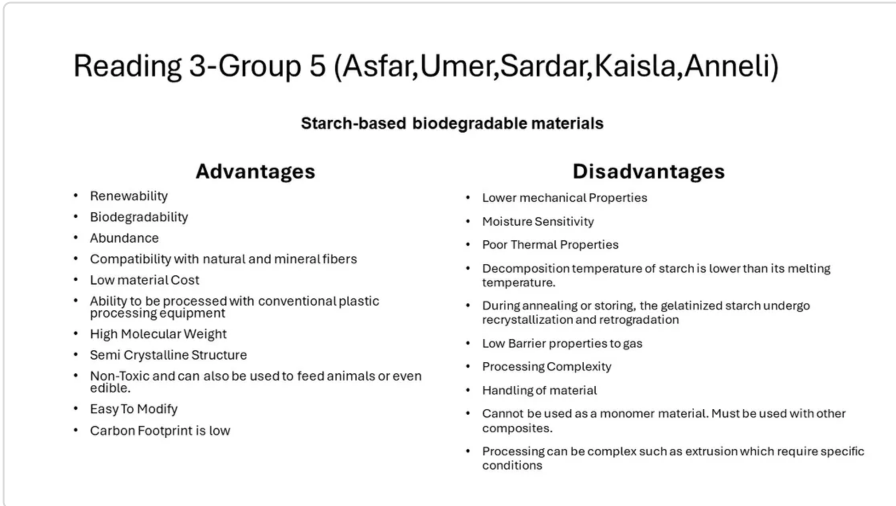
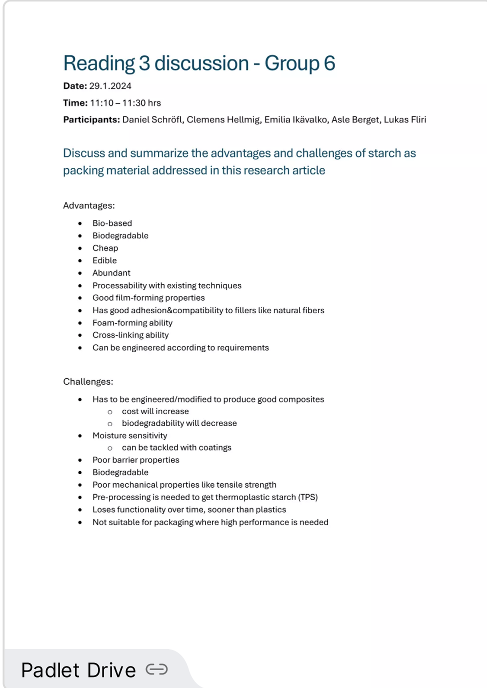
Reading assignment 3



Group 6


Reading 3 discussion - Group 6

Date: 29.1.2024

Time: 11:10 – 11:30 hrs

Participants: Daniel Schröfl, Clemens Hellmig, Emilia Ikävalko, Asle Berget, Lukas Fliri

Discuss and summarize the advantages and challenges of starch as packing material addressed in this research article

Advantages:

- Bio-based
- Biodegradable
- Cheap
- Edible
- Abundant
- Processability with existing techniques
- Good film-forming properties
- Has good adhesion&compatibility to fillers like natural fibers
- Foam-forming ability
- Cross-linking ability
- Can be engineered according to requirements

Challenges:

- Has to be engineered/modified to produce good composites
    - cost will increase
    - biodegradability will decrease
- Moisture sensitivity
    - can be tackled with coatings
- Poor barrier properties
- Biodegradable
- Poor mechanical properties like tensile strength
- Pre-processing is needed to get thermoplastic starch (TPS)
- Loses functionality over time, sooner than plastics
- Not suitable for packaging where high performance is needed

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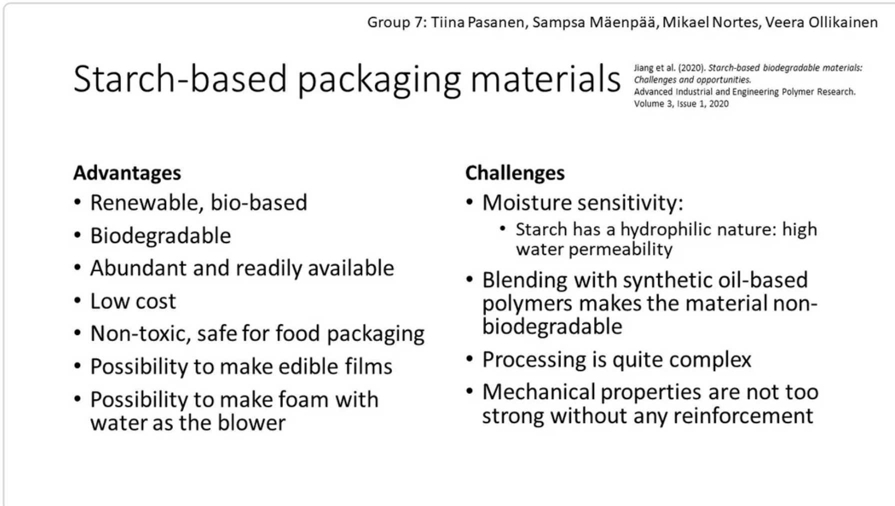
CHEM-E2155 Reading 3 Discussion Group 6



Group 8

Summarize the advantages and challenges of starch as packing material addressed in this research article

Tiinamari Seppänen
Nissa Solihat
Johannes Peace

Advantages	Challenges
Environmentally friendly due to their biodegradability	Moisture Sensitivity: Starch materials are generally more sensitive to moisture, affecting their durability and range of applications.
Abundance: renewable resource, offering a sustainable alternative to petrochemical polymers	Lower Mechanical Properties: Pure starch materials often have inferior mechanical properties compared to conventional plastics.
Widely available, making it a readily accessible material	Processing Challenges: The processing of starch-based materials, such as extrusion, can be complex and require specific conditions
Reduced Environmental Impact: These materials contribute to reduced plastic pollution and lower carbon footprint	Cost-Effectiveness: While improving, the cost-effectiveness of starch-based materials still needs further development to compete with traditional plastics.
Can be scaled up without causing trouble to the food crop production	Still some challenges to tackle to meet the properties of the current solutions
Non-toxic	
Consumer acceptance towards sustainable solutions	

Group 9

CHEM-E2155 - Biopolymers

Reading assignment 3
Group 9
Oona Hanska, Eveliina Palo, Joona Pystynen, Eetu Varttila, Luka Louhi

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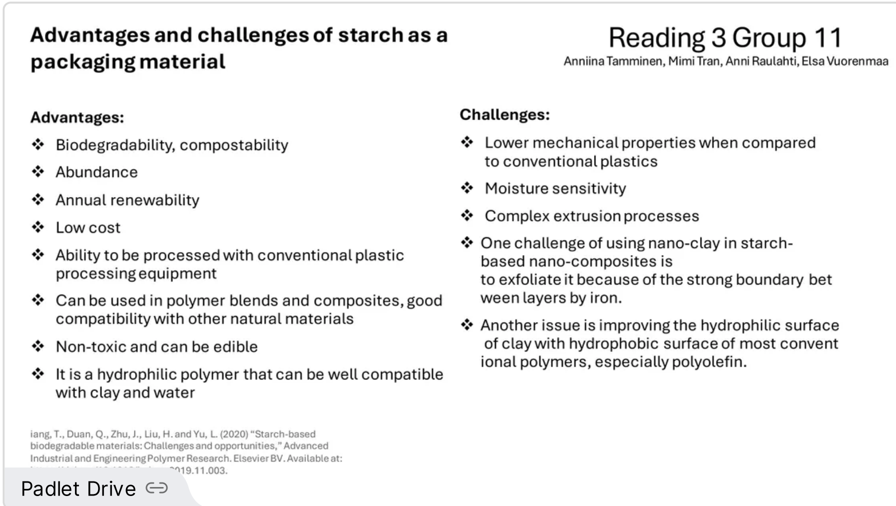
Reading assignment 3 Biopolymers group 9

Group 10

Reading 3 Group 10

Group 11



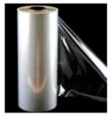
Reading 3

Group 12

Reading 3 – Group 12 (Ranawaka Arachchige Chamodya, Elizaveta Tapaila, Konsta Vainikainen, Anitha Venkatramani, Moa Vesterlund)

1. Advantages of Starch as Packaging Materials

- Renewability: Starch is derived from many plants, is a renewable resource
- Inherent Biodegradability: Starch is a biodegradable material, that can contribute to the reduction of environmental pollution
- Abundance and Low Material Cost: Starch is abundant and cost-effective, making it a viable option for packaging materials
- Processability in the conventional processing equipment: Starch can be processed using various techniques, including extrusion, foaming, and blending with other polymers
- Compatible with natural fillers: Starch is compatible with natural fillers and reinforcement agents, which enhances the mechanical properties
- Can be blended with other natural polymers and produce composites to increase mechanical properties and decrease moisture sensitivity
- With starch is possible to make solutions for various applications - anti-microbial films, edible films, foams , capsules, sheets
- Low environmental burden compared to petroleum-based polymers (low carbon footprint)



Corn starch – PLA film for food packaging

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Reading Assignment 3-Group 12

Group 13

Anastasia Tervo, Fatemeh Yahyaeian Balouchi, Can Yücel 29.01.2024

CHEM-E2155 Discussion 3 Group 13

Advantages

- Biodegradability
- Abundance and cheap
- Improved
- Annual renewability
- Compatibility with different modifications

Challenges

- Moisture sensitivity
- Weaker mechanical properties
- Poor thermal properties
- Short shelf life
  - Poor gas and water barrier

Applications and solutions

- Composite applications
  - Starch-laver is good for food packaging, eatable capsules, and films (medicine, etc.), and improves gas permeability, and proper mechanical properties. Decrease in moisture sensitivity because protein is released out of laver.
  - Cellulose-starch: improved mechanical properties, usage of many cellulose sources, renewability, cheap, lightweight, easy processability, and reactive surface.
- Self-reinforce composite
  - Single-polymer composites allow perfect interfaces, homogeneous material, and reinforced properties. The reinforcing component consisted of crosslinked starch granules, where the crosslinking increased granular thermal stability and moisture resistance.

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Discussion3_Group13

Reading Assignment 4

Reading 4 discussion

Title: Biopolymers Reuse, Recycling, and Disposal. Chapter 3: Reuse
From: Michael Niaounakis, 2013.

Discussion items:

- The 5 subchapters describe different aspects of polymer reuse. Discuss the pros and cons of each strategy and summarize them briefly.
- Which form(s) of reuse might be the most important one(s) and why?

Instructions:
Write your names and summary of your discussion in e.g., PowerPoint. Save the text as image file (.jpg) and upload it to the Padlet page:
https://padlet.com/michaelhummel/CHEME2155_2024

Group 1 – Reading 4

Gurung Sagar, Jenny Leppänen, Carl-Alfons Antson, Juho Liekkinen, Abdi Babak

- Recuperation
  - Pros: No impurities, Direct, granules share the same properties as original
  - Cons: Limited by polymer degradation, poor flow properties limits applications, air bubbles , Removing process materials e.g. ink
- Restabilization
  - Pros: Improves polymers lifespan, protecting recycled materials from thermomechanical degradation during producing
  - Cons: Requires chemical additives that could affect the recyclability

Most important reuse methods in our opinion are blending with other polymer (high volume, minimal resource loss), recuperation (simple and cost effective) and multiple processing (optimization leads to lower degradation and it can be processed with both traditional and modern techniques)

- Blending with other polymers
  - Pros: High volume, Closed-loop recycling model (minimal resource loss), most common industrial method for reuse, improving the material properties
  - Cons: Compatibility with different polymers can affect significantly, blended polymers vary and might be more difficult to reuse
- Chemical modification
  - Pros: Increasing the molecular weight of the polymer chains and improving mechanical and rheological properties, specific applications, functionality of the polymer can be modified, degradability
  - Cons: Costly and often intricate process, limited applications
- Multiple processing
  - Pros: Optimization of process to avoid further degradation, resource efficient
  - Cons: Each cycle have a risk of degradation -> diminished material properties and limited usability

Group 2

READING 4 DISCUSSION – GROUP 2

The 5 subchapters describe different aspects of polymer reuse.
Discuss the pros and cons of each strategy and summarize them briefly.

RECUPERATION

Pros

- Uses industrial scrap
- No new equipment needed (can be directly processed with an extruder)

Cons

- Utilizes virgin materials
- Only possible to limited extent
- Need for pretreatment
- The material mixed with virgin material must have the same quality (Tm)
- Requires composition adjustment and optimization of process
- Reprocessing of some biopolymers can result in the loss of wanted properties (coloration, degeneration etc.)
- Used scrap material needs to be dried, which can be difficult (and not cost effective) for hygroscopic materials
- Inconsistent feeding performance of the production extruder
- Air inclusions in melt that leads to defects
- Difficulty in removing process materials (e.g. ink)

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Group 2:Bonvini Andrea, Donatoni Giorgia, Kantelinen Jan, Zimmermann Christian

READING 4 DISCUSSION - GROUP 2

Group 3

5.2.2023 Eva González Carmona , Sara Hautojärvi, Laura Ahvenjärvi, Nikita Jamkin

Method	Pros	Cons
Recuperation	→Recycling of industrial scraps (melt lumps, defective parts, edge trims, etc) →Reuse of high-cost polymers such as PLA →Other polymers that can be recycled are: starch, PE, PVC, PP and PS	Direct processing of plastic waste is very limited Pretreatment is needed: grounding, agglomeration Heat for agglomeration process can decompose chemically the polymers Harmful gases might be released during heat treatment, preventing the waste to be reused
Restabilization	Protects the polymers from thermo-mechanical degradation → Less further decrease in mechanical properties → Enhances the long-term stability throughout reusage → Prevents from oxidative and moisture caused degradation	No effective recovery of the degraded material

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Group 3

Reading Discussion 4 – Group 4 (Luong Trung Hieu, Ferrer Pascual Laura)

1. The 5 subchapters describe different aspects of polymer reuse. Discuss the pros and cons of each strategy and summarize them briefly.

- 5 subchapters: Recuperation, restabilization, blending recycled biopolymers with other polymers, modification of the chemical structure, multiple processing

Subchapters	Pros	Cons
Recuperation	- Recrystallization of PLA is simple, not require additional post-processing, relatively short time, and yields recrystallized PLA with satisfactory properties. The recrystallized PLA can be easily reprocessed. - Some of the restrains can also be overcome by the processing method since a mild, constant movement of the polymer material can prevent clumping or sticking of the material in the critical temperature range until adequate crystallization of the surface of the particles can prevent individual particles from sticking together.	-Biopolymer can be thermally damaged if the applied heat is above Tm, thermal damage can cause coloration, degeneration, and decrease in molecular weight. -There are restrains in the reuse of biopolymers dues to their hygroscopicity, stickiness at high temperatures, and thermal instability - Problems with reprocessing industrial scrap and virgin biopolymers: (1) inconsistent feeding performance of the production extruder; (2) air inclusions in the melt leads to defects in the finished products; (3) difficulty in removing process materials (printing inks, similar materials).

Padlet Drive

Reading 4 - Group 4

Group 5

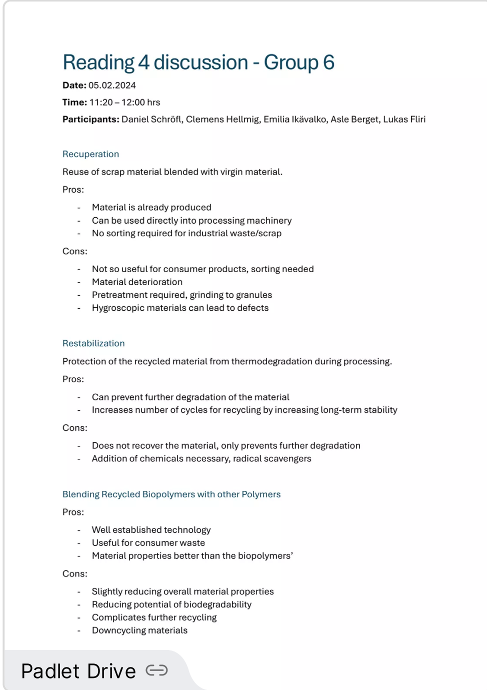
Group 5: Muhammad Umer, Kaisla Lehtipuu, Asfar Khan, Sardar Hayat, Anneli

1. Discuss the pros and cons of each strategy

Method	Pros	Cons
Recuperation	• This method emphasizes the need to prevent thermal damage during agglomeration. • We will have to mix virgin material with recycle material, so we don't use the property of the recycle material • We can reuse the industrial material. • Flow of virgin material can be adjusted.	• They need to have similar properties of processing material with virgin material. • Thermally unstable and release harmful gases • Not all material can be processed with this one.
Restabilization	• Protect recycle material from thermo mechanical degradation • Long term stability	• The process of restabilization, involving the addition of various stabilizers and additives, may introduce complexity to the recycling process. • Some additives used for restabilization, although effective, may have environmental implications.
Blending Recycled Biopolymers with other Polymers	• Blending recycled biopolymers with virgin materials can enhance the mechanical properties of the resulting composite. • Blending allows for the utilization of a variety of polymers, both biodegradable and non-biodegradable. • Versatility in Source Material • Carried in reactor no need to carry out to next process	• Mixing of polymers • Need to be compatible with the polymer • Difficult to recycle blending material • Resins used in this can cause environmental hazard modification of chemical structure
Modification of the Chemical Structure	• The process of chain extension increases the molecular weight of the polymer chains. This results in improved rheological properties and better processability during melt reprocessing. • Chemical modification allows for the tailoring of properties based on the specific requirements of the end product. • Upcycling of Degraded Materials • Application to Bio-Based Polymers • Improved Mechanical Properties	• Achieving optimal chain extension without undesired branching or cross-linking reactions can be challenging. • Process Complexity • Specific Expertise Required • Environmental Impact
Padlet Drive	• This process can help in recyclability of material • Increases oxygen barrier. • Degradation of material can be avoided	• Can deteriorate material properties • Causes changes in structure of polymer during processing.

Group 5

Reading 4 Group 6



Reading 4 discussion - Group 6

Date: 05.02.2024

Time: 11:20 – 12:00 hrs

Participants: Daniel Schröfl, Clemens Hellmig, Emilia Ikävalko, Asle Berget, Lukas Fliri

Recuperation

Reuse of scrap material blended with virgin material.

Pros:

- Material is already produced
- Can be used directly into processing machinery
- No sorting required for industrial waste/scrap

Cons:

- Not so useful for consumer products, sorting needed
- Material deterioration
- Pretreatment required, grinding to granules
- Hygroscopic materials can lead to defects

Restabilization

Protection of the recycled material from thermodegradation during processing.

Pros:

- Can prevent further degradation of the material
- Increases number of cycles for recycling by increasing long-term stability

Cons:

- Does not recover the material, only prevents further degradation
- Addition of chemicals necessary, radical scavengers

Blending Recycled Biopolymers with other Polymers

Pros:

- Well established technology
- Useful for consumer waste
- Material properties better than the biopolymers'

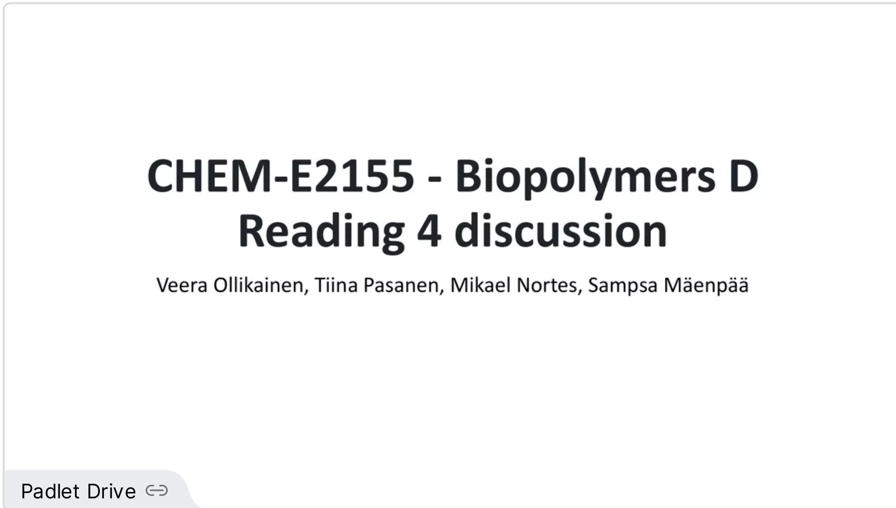
Cons:

- Slightly reducing overall material properties
- Reducing potential of biodegradability
- Complicates further recycling
- Downcycling materials

Padlet Drive

Discussion 4 group 6

Group 7



CHEM-E2155 - Biopolymers D Reading 4

Reading 4 discussion group 8

	Recuperation	Restabilization	Blending Recycled Biopolymers with Other Polymers	Modification of the Chemical Structure	Multiple Processing
Pros	New products through recycling processes have a similar status given to virgin biopolymers. This can all be done without thermal damage to the material, as is required for further technological processing in extruders, pressers, or injection-molding machines.	Prevents further degradation processes that may be catalyzed by the oxidative moieties present in its structure or by moisture. Protects from thermo-mechanical degradation and further degradation process.	Upgrades the properties of recycled materials, increases application potential. Blending recycled polymers with virgin materials is one of the most common and well-established procedures for upgrading the properties of single stream waste polymeric materials. Recycling waste plastic material having a paint film formed from a bio-based coating: does not adversely affect the environment and prevents lowering of physical properties of the regenerated material.	Effectively upgrades properties of recycled polymers, increases molecular weight and can improve mechanical properties.	Provides insights into recyclability and degradation under processing conditions. Multiple processing data can be used to assess the lifecycle and environmental impact of polymers.
Cons	Problems such as hygroscopicity, stickiness at high temperatures,and thermal instability of several biopolymers, must also be taken into consideration. Inconsistent feeding performance of the production extruder; air inclusions in the melt that lead to defects in the finished products; and difficulty in removing process materials like printing inks and similar materials.	Restabilization does not effectively recover the degraded material, Not recovering the degraded material completely. Relies on the availability, cost and environmental impact of the additives Complexity of process	Complexity in achieving the right blend for desired properties Might need additives to achieve the desired properties Heterogeneity of the mixture might be a problem	Process has to be precisely controlled and needs additives. Can lead to undesired extensive branching and cross-linking reactions if chain extenders are used in high concentrations.	May lead to further degradation, affecting the material`s properties The polymers processed again at elevated temperature can be prone to molecular degradation, unwanted polymerization, and reactions due to other materials causing yellowing, haze etc

Blending might be the most important because it can significantly enhance the properties of recycled polymers, making them more versatile for various applications.

Group 9

CHEM-E2155 - Biopolymers

Reading assignment 4

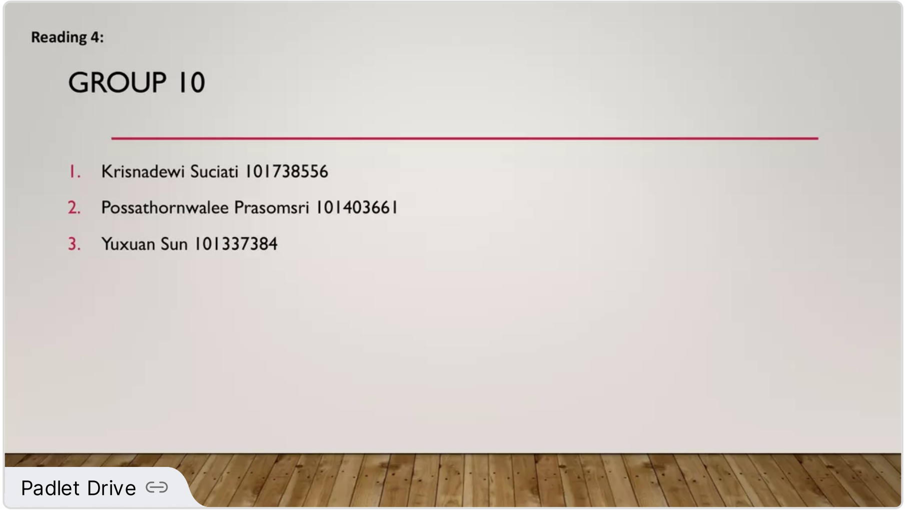
Group 9

Oona Hanska, Eveliina Palo, Joona Pystynen, Eetu Varttila, Luka Louhi

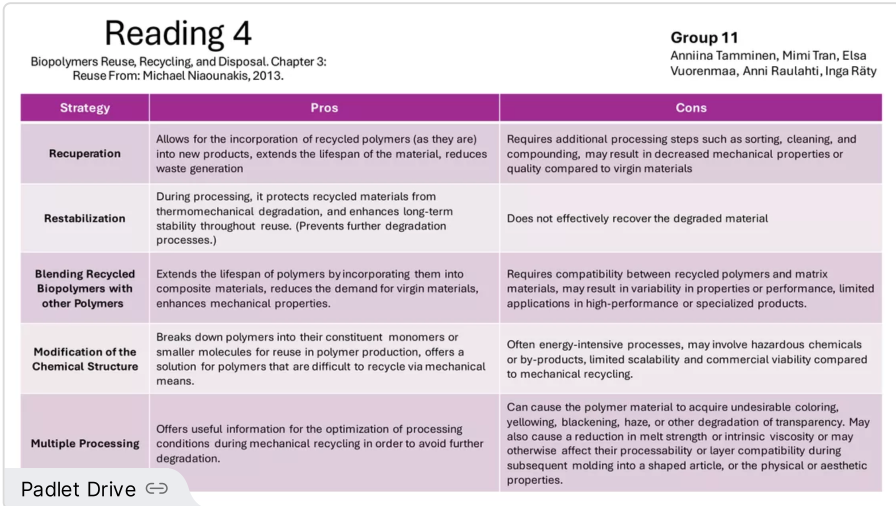
Padlet Drive

Group 9 discussion 4

Group 10



Group 10 Reading 4



Reading 4

Biopolymers Reuse, Recycling, and Disposal. Chapter 3: Reuse From: Michael Niaounakis, 2013.

Group 11

Anniina Tamminen, Mimi Tran, Elsa Vuorenmaa, Anni Raulahti, Inga Räty

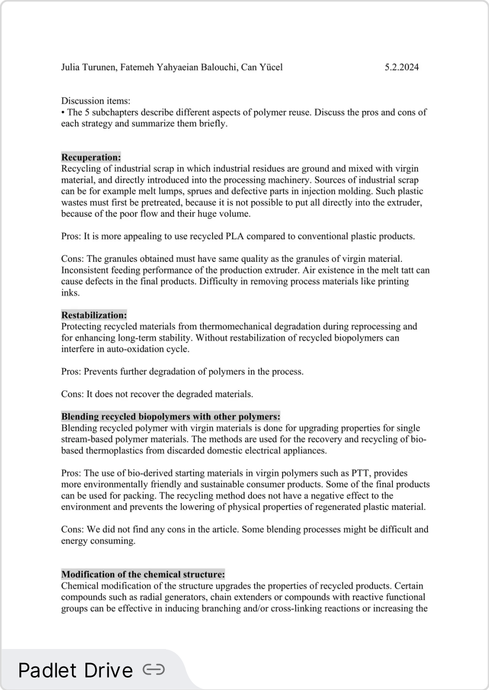
Strategy	Pros	Cons
Recuperation	Allows for the incorporation of recycled polymers (as they are) into new products, extends the lifespan of the material, reduces waste generation	Requires additional processing steps such as sorting, cleaning, and compounding, may result in decreased mechanical properties or quality compared to virgin materials
Restabilization	During processing, it protects recycled materials from thermomechanical degradation, and enhances long-term stability throughout reuse. (Prevents further degradation processes.)	Does not effectively recover the degraded material
Blending Recycled Biopolymers with other Polymers	Extends the lifespan of polymers by incorporating them into composite materials, reduces the demand for virgin materials, enhances mechanical properties.	Requires compatibility between recycled polymers and matrix materials, may result in variability in properties or performance, limited applications in high-performance or specialized products.
Modification of the Chemical Structure	Breaks down polymers into their constituent monomers or smaller molecules for reuse in polymer production, offers a solution for polymers that are difficult to recycle via mechanical means.	Often energy-intensive processes, may involve hazardous chemicals or by-products, limited scalability and commercial viability compared to mechanical recycling.
Multiple Processing	Offers useful information for the optimization of processing conditions during mechanical recycling in order to avoid further degradation.	Can cause the polymer material to acquire undesirable coloring, yellowing, blackening, haze, or other degradation of transparency. May also cause a reduction in melt strength or intrinsic viscosity or may otherwise affect their processability or layer compatibility during subsequent molding into a shaped article, or the physical or aesthetic properties.

Padlet Drive

Group 11

Reading 4 Group 12

Reading 4_Group 12



Julia Turunen, Fatemeh Yahyaeian Balouchi, Can Yücel 5.2.2024

Discussion items:
• The 5 subchapters describe different aspects of polymer reuse. Discuss the pros and cons of each strategy and summarize them briefly.

Recuperation:
Recycling of industrial scrap in which industrial residues are ground and mixed with virgin material, and directly introduced into the processing machinery. Sources of industrial scrap can be for example melt lumps, sprues and defective parts in injection molding. Such plastic wastes must first be pretreated, because it is not possible to put all directly into the extruder, because of the poor flow and their huge volume.

Pros: It is more appealing to use recycled PLA compared to conventional plastic products.

Cons: The granules obtained must have same quality as the granules of virgin material. Inconsistent feeding performance of the production extruder. Air existence in the melt tatt can cause defects in the final products. Difficulty in removing process materials like printing inks.

Restabilization:
Protecting recycled materials from thermomechanical degradation during reprocessing and for enhancing long-term stability. Without restabilization of recycled biopolymers can interfere in auto-oxidation cycle.

Pros: Prevents further degradation of polymers in the process.

Cons: It does not recover the degraded materials.

Blending recycled biopolymers with other polymers:
Blending recycled polymer with virgin materials is done for upgrading properties for single stream-based polymer materials. The methods are used for the recovery and recycling of bio-based thermoplastics from discarded domestic electrical appliances.

Pros: The use of bio-derived starting materials in virgin polymers such as PTT, provides more environmentally friendly and sustainable consumer products. Some of the final products can be used for packing. The recycling method does not have a negative effect to the environment and prevents the lowering of physical properties of regenerated plastic material.

Cons: We did not find any cons in the article. Some blending processes might be difficult and energy consuming.

Modification of the chemical structure:
Chemical modification of the structure upgrades the properties of recycled products. Certain compounds such as radial generators, chain extenders or compounds with reactive functional groups can be effective in inducing branching and/or cross-linking reactions or increasing the

Reading 4 discussion Group 13

Reading 5 discussion

Title: US Patent: Polymer compositions
US 4121025, 17.10.1978

Discussion items:
- What does the invention describe?
- How much "metal complex" is described as optimum by the inventor?
- Which concrete metal complexes and which polymers are described?
- What information can be extracted from the "Examples"?

Instructions:
Write your names and summary of your discussion in e.g., PowerPoint. Save the text as image file (.jpg) and upload it to the Padlet page:
https://padlet.com/michaelhummel/CHEME2155_2024

Reading 5- Group 1

Juho Liekkinen, Abdi Babak, Carl-Alfons Antson, Gurung Sagar, Jenny Leppänen

1. Polymer composition designed for controlled degradation using optimized concentration of metal/metal-complexes
2. The optimum concentration of metal was 0,0001 g. atoms / 100g and for metal complexes 0,05%-0,09% by weight based on the weight of the polymer (Claims 3, 4)
3. Metals: Iron, silver, palladium, molybdenum, chromium, tungsten, and cerium. Polymers: polyethylene, polypropylene, vinylpolymers, and polysterine. Metal-complexes: Salicylaldehyde, disalicylidene ethlyne diamiae, 2-hydroxy-4-methyl acetophenome oxine, 2-hydroxyphenylbenztriazole
4. The effect of the addition different metals, metal-complexes, anti-oxidants, dye and polymer complexes to the original polymer, e.g. degradation under UV, color change, Suitable concentration of additives and the optimizations of the formulas

Padlet Drive

Reading 5 -Group 1

Group 2

Andrea Bonvini, Giorgia Donatoni, Christian Zimmermann, Jan Kantelinen

Discussion items:

- What does the invention describe?
- How much "metal complex" is described as optimum by the inventor?
- Which concrete metal complexes and which polymers are described?
- What information can be extracted from the "Examples"?

1. The invention describes thermoplastic polymer compositions which degrade relatively rapidly on exposure to the environment. This mechanism is induced by metal complexes that are sensitive to UV-light.

2. Very small amounts of metal complexes have been found to be effective. It is described that at least 0,001 w-% should be present for an optimal blend.

Padlet Drive

Reading discussion_Group 2

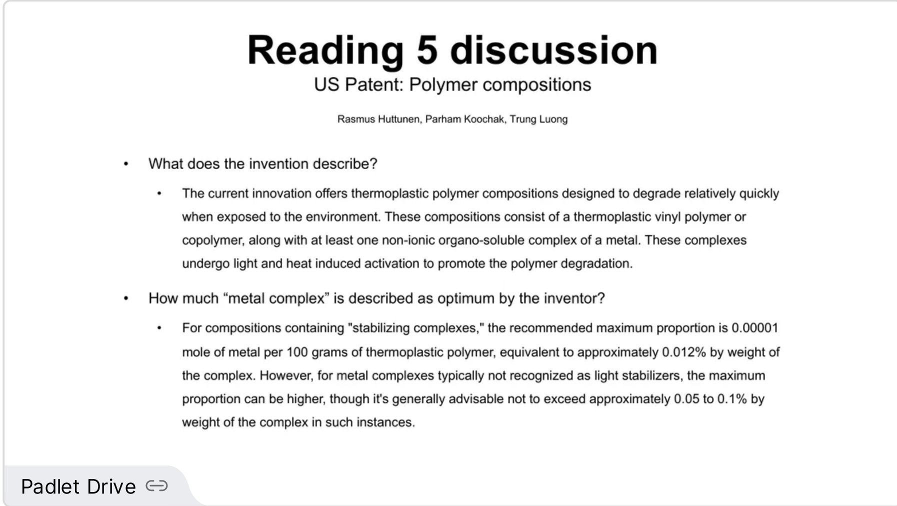
Group 3 12.2.2023 Eva González Carmona , Sara Hautojärvi, Laura Ahvenjärvi, Nikita Jamkin

What does the invention describe?

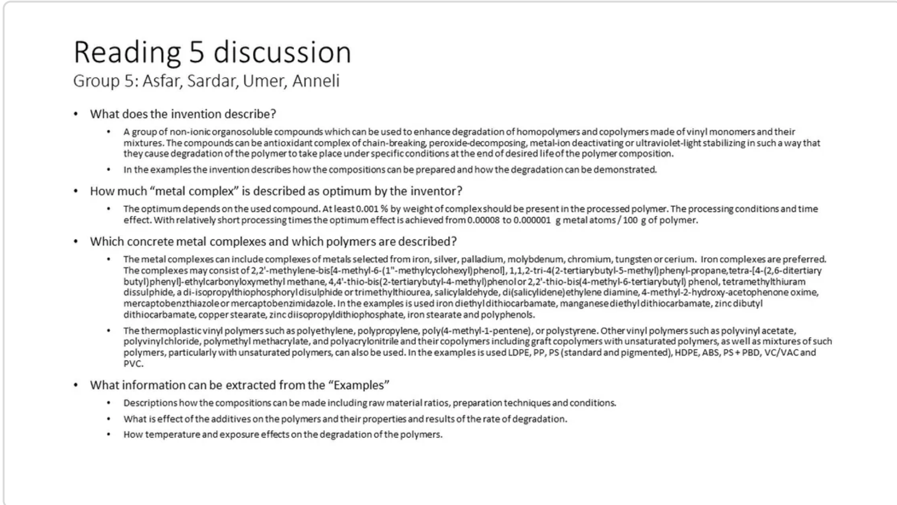
The invention describes thermoplastic vinyl polymer compositions that degrade rapidly when exposed to light and air.
The degradation level can be controlled by adding complexes of a metal with an certain atomic number.
The compositions can be used as degradeable packaging materials, they degrade at rubbish tips and land-fills

Padlet Drive

Group 3



Reading 5 Group 4



Group 5

Reading Discussion Group 6:

Daniel Schröfl, Clemens, Hellmig, Emilia Ikävalko, Asle Berget, Lukas Fliri

• What does the invention describe?

Introducing metal complexes into vinyl polymers (mostly PE discussed, also PP and PS) to activate degradation pathways via radicals generated by light or heat. Patent mentions that only certain wavelengths can activate radical formation, *i.e.,* UV light that is usually absorbed by glass, so that degradation only happens when polymer is disposed of in nature. Also restraining agents can be added so that polymer does not degrade during use outdoors or when exposed to sunlight.

• How much "metal complex" is described as optimum by the inventor?

The inventor mentions an optimum concentration of 0.001 wt% to 0.1 wt% of metal complex in the final polymer mixture in general. Might differ for specific use cases and the used metal complex.

• Which concrete metal complexes and which polymers are described?

- Broad area of different metals (atomic number from 22 to 29, 40 to 47 or 57 to 79) are claimed in the patent. More specifically iron, cobalt, nickel, copper, manganese, silver, palladium, molybdenum, chromium, tungsten and cerium are mentioned. I.e., metals in ionic form, that catalyse the degradation of the said thermoplastic polymers. Probably metals that can activate Fenton like chemistry.
- Also, broad area of complexing agents is claimed. In the examples mostly carbamates or stearates are discussed. In general, complexing agents that have hydrophobic side chains to allow mixing with the discussed polymers - allow for compatibilization.
- Described polymers are vinyl polymers (homo and co polymers). More specific: Polyethylene, polypropylene, poly(4-methyl-1-pentene), or polystyrene. Also mentioned: Other vinyl polymers such as polyvinyl acetate, polyvinyl chloride, polymethyl methacrylate, and polyacrylonitrile and their copolymers including graft copolymers with unsaturated polymers, as well as mixtures of such polymers, particularly with unsaturated polymers.

• What information can be extracted from the "Examples"?

The examples describe many use case scenarios and controls / tests to showcase the applicability of the described invention.

- For incorporation into PE the melt flow index (viscosity) is described. Incorporation of metal complexes does not lead to significant changes.
- For PP and HDPE there are no significant changes in the mechanical properties (brittleness, break time).
- A lot of discussion of disintegration time with simulated light environments (specific wavelengths) and also outdoor tests (outdoors in South Africa).
- Compared different complexes and singled out iron as the most effective catalyst, which is good as it is the cheapest.

Reading 5 discussion

Group 7: Sampsa Mäenpää, Mikael Nortes, Veera Ollikainen, Tiina Pasanen

- **What does the invention describe?**

Invention proposes a way to enhance the degradation of vinyl polymers by adding a specific metal complex that becomes more reactive when exposed to light and possibly heat. It was invented to reduce plastic waste.

- **How much "metal complex" is described as optimum by the inventor?**

Less than 0.1% but more than 0.001%. The amount varies depending on the polymer.

- **Which concrete metal complexes and which polymers are described?**

Complexes include metal salt and complexing agent, and additionally restraining agents are added:

Metal salt: usually iron but other metals can also be used, for example, cobalt, nickel, copper, manganese, silver, palladium, molybdenum, chromium, tungsten and cerium.

Examples of complexing agents: organic molecules containing complexing radicals.

Examples of restraining agents: dithiocarbamic and dithiophos phoric acids and thiols such as mercaptobenzimidazole.

Concrete examples: polypropylene with iron diethyldithiocarbamate, low density polyethylene with manganese diethyldithio carbanate, low density polyethylene with zinc dibutyl dithiocarbamate + copper steatate and high impact polystyrene containing polybutadiene + a bis phenol with iron dibutyldithiocarbamate.

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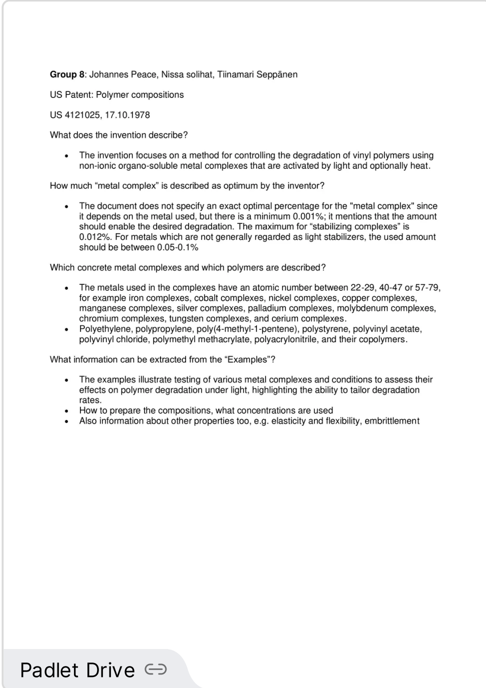
Reading 5 discussion, group 7

Reading assignment 5, group 8



Group 8: Johannes Peace, Nissa solihat, Tiinamari Seppänen

US Patent: Polymer compositions

US 4121025, 17.10.1978

What does the invention describe?

- The invention focuses on a method for controlling the degradation of vinyl polymers using non-ionic organo-soluble metal complexes that are activated by light and optionally heat.

How much “metal complex” is described as optimum by the inventor?

- The document does not specify an exact optimal percentage for the "metal complex" since it depends on the metal used, but there is a minimum 0.001%; it mentions that the amount should enable the desired degradation. The maximum for “stabilizing complexes” is 0.012%. For metals which are not generally regarded as light stabilizers, the used amount should be between 0.05-0.1%

Which concrete metal complexes and which polymers are described?

- The metals used in the complexes have an atomic number between 22-29, 40-47 or 57-79, for example iron complexes, cobalt complexes, nickel complexes, copper complexes, manganese complexes, silver complexes, palladium complexes, molybdenum complexes, chromium complexes, tungsten complexes, and cerium complexes.
- Polyethylene, polypropylene, poly(4-methyl-1-pentene), polystyrene, polyvinyl acetate, polyvinyl chloride, polymethyl methacrylate, polyacrylonitrile, and their copolymers.

What information can be extracted from the “Examples”?

- The examples illustrate testing of various metal complexes and conditions to assess their effects on polymer degradation under light, highlighting the ability to tailor degradation rates.
- How to prepare the compositions, what concentrations are used
- Also information about other properties too, e.g. elasticity and flexibility, embrittlement

Padlet Drive

Reading 5 discussion_group 8

Group 8

Group 8: Johannes Peace, Nissa solihat, Tiinamari Seppänen

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Reading 5 discussion_group 8

Group 9

CHEM-E2155 - Biopolymers

Reading assignment 5

Group 9

Oona Hanska, Eveliina Palo, Joona Pystynen, Eetu Varttila, Luka Louhi

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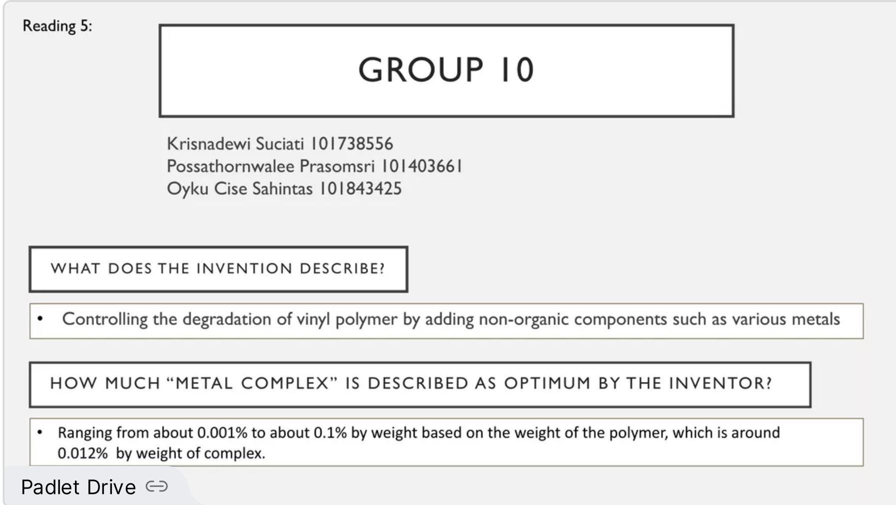
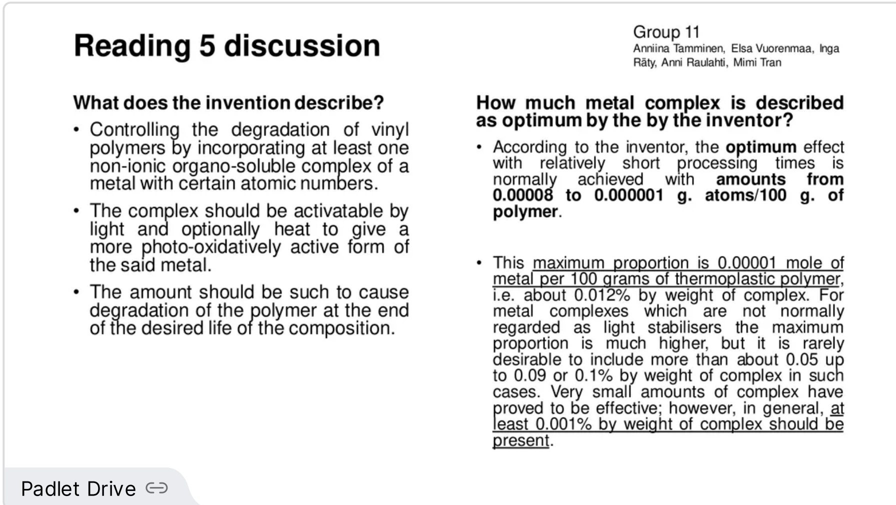


Reading 5

Group 11

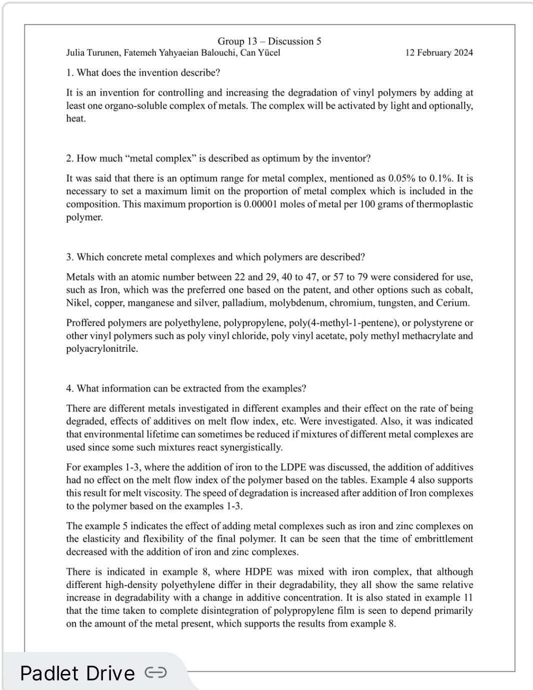


Group 11 Reading 5

Group 12

Discussion 5

Group 13



Group 13 – Discussion 5

Julia Turunen, Fatemeh Yahyaeian Balouchi, Can Yücel 12 February 2024

1. What does the invention describe?

It is an invention for controlling and increasing the degradation of vinyl polymers by adding at least one organo-soluble complex of metals. The complex will be activated by light and optionally, heat.

2. How much "metal complex" is described as optimum by the inventor?

It was said that there is an optimum range for metal complex, mentioned as 0.05% to 0.1%. It is necessary to set a maximum limit on the proportion of metal complex which is included in the composition. This maximum proportion is 0.00001 moles of metal per 100 grams of thermoplastic polymer.

3. Which concrete metal complexes and which polymers are described?

Metals with an atomic number between 22 and 29, 40 to 47, or 57 to 79 were considered for use, such as Iron, which was the preferred one based on the patent, and other options such as cobalt, Nikel, copper, manganese and silver, palladium, molybdenum, chromium, tungsten, and Cerium.

Proffered polymers are polyethylene, polypropylene, poly(4-methyl-1-pentene), or polystyrene or other vinyl polymers such as poly vinyl chloride, poly vinyl acetate, poly methyl methacrylate and polyacrylonitrile.

4. What information can be extracted from the examples?

There are different metals investigated in different examples and their effect on the rate of being degraded, effects of additives on melt flow index, etc. Were investigated. Also, it was indicated that environmental lifetime can sometimes be reduced if mixtures of different metal complexes are used since some such mixtures react synergistically.

For examples 1-3, where the addition of iron to the LDPE was discussed, the addition of additives had no effect on the melt flow index of the polymer based on the tables. Example 4 also supports this result for melt viscosity. The speed of degradation is increased after addition of Iron complexes to the polymer based on the examples 1-3.

The example 5 indicates the effect of adding metal complexes such as iron and zinc complexes on the elasticity and flexibility of the final polymer. It can be seen that the time of embrittlement decreased with the addition of iron and zinc complexes.

There is indicated in example 8, where HDPE was mixed with iron complex, that although different high-density polyethylene differ in their degradability, they all show the same relative increase in degradability with a change in additive concentration. It is also stated in example 11 that the time taken to complete disintegration of polypropylene film is seen to depend primarily on the amount of the metal present, which supports the results from example 8.

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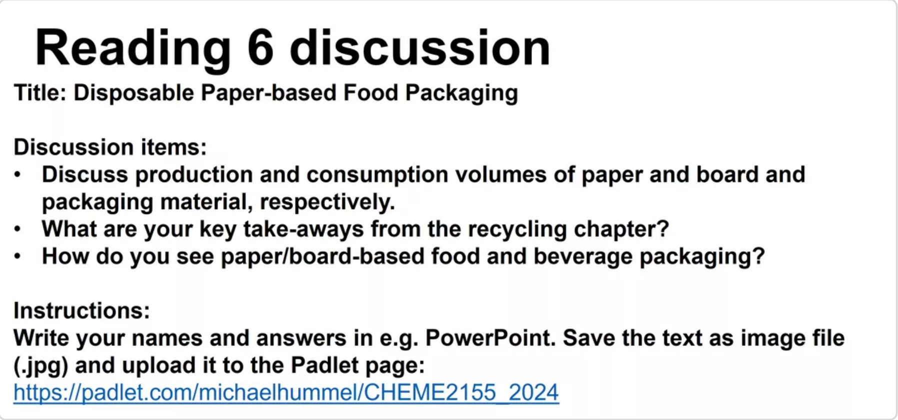
Discussion 5 Group 13

Reading Assignment 6



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Reading 6 - Group 1

GROUP 2 - READING 6 DISCUSSION

READING 6 DISCUSSION – GROUP 2

Discuss production and consumption volumes of paper and board and packaging material, respectively

1. **Pulp**
   - EU production 37.3 million tonnes in 2021.
   - World 178.7 million tonnes .
   - 3.6% increase in production from 2021.
   - 77% of EU production is chemical pulp.
2. **Paper and paperboard (Europe)**
   - Production 90.6 million tonnes.
   - Consumption: 75,2 million tonnes.
3. **Paper-based packaging (Euope)**
   - Total paper consumption 75, 2 million tonnes
   - Packaging consumption: 44.9 million tonnes
   - The EU paper-based packaging market is expected to continue its steady growth in the coming years.

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Group 2: Bonvini Andrea, Donatoni Giorgia, Kantelinen Jan, Zimmermann Christian

READING 6 DISCUSSION - GROUP 2

Group 3

26.2.2023 Eva González Carmona , Sara Hautojärvi, Laura Ahvenjärvi, Nikita Jamkin

Discuss production and consumption volumes of paper and board and packaging material, respectively.

- The consumption of traditional paper products, such as newspaper or printing paper, experienced a decline of almost 8% since 2010, summing up to 75.2 million tonnes of paper and board (70.4 million tonnes of local european producers + 4.8 million tonnes imported, mainly from Brazil).
- The capacity production, in the other hand, increased 13% from 2010, up to 137000 tonnes in 2021, even though the overall production of paper and board decreased among those years.
- However, lately this has been greatly compensated by the increase of online shopping and food and beverages paper-based packaging, which consumption is expected to double by 2050.
- In the EU, 40% of plastics and 50% of paper used are destined for packaging
- The European paper industry has set a target to achieve a 76% paper recycling rate

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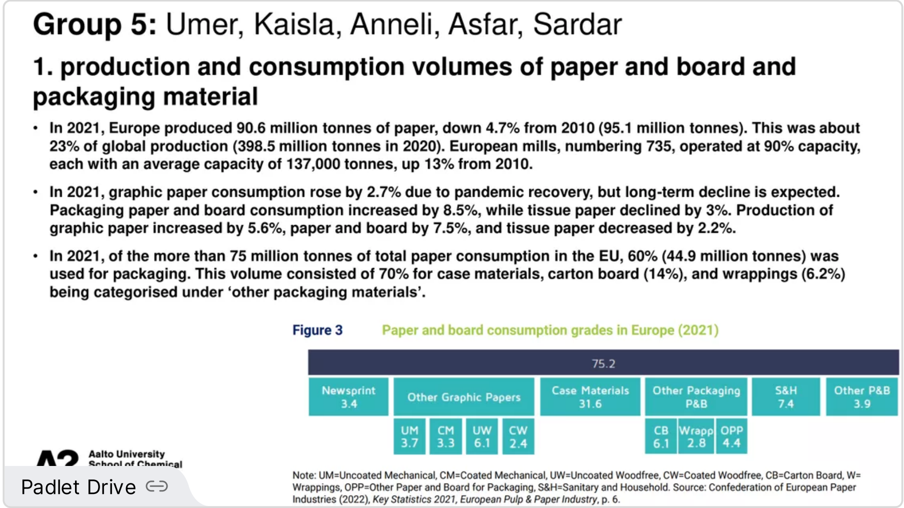
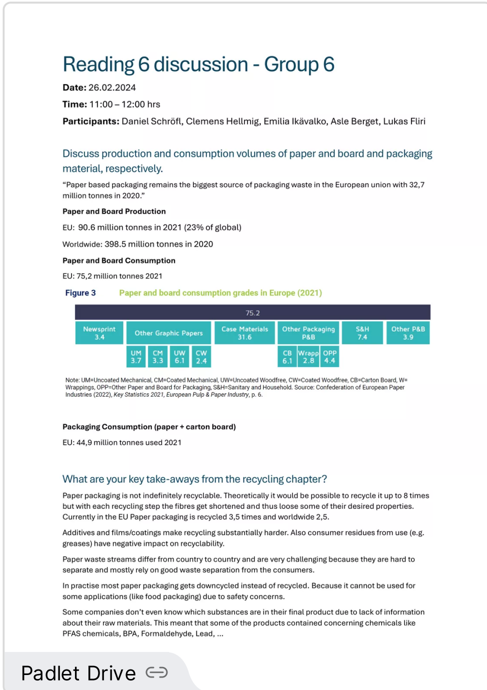
Group 3



Group 5 - reading 6 summary

Discussion Reading 6 Group 6



Reading 6 discussion - Group 6

Date: 26.02.2024

Time: 11:00 – 12:00 hrs

Participants: Daniel Schröfl, Clemens Hellmig, Emilia Ikävalko, Asle Berget, Lukas Fliri

Discuss production and consumption volumes of paper and board and packaging material, respectively.

"Paper based packaging remains the biggest source of packaging waste in the European union with 32,7 million tonnes in 2020."

Paper and Board Production

EU: 90.6 million tonnes in 2021 (23% of global)

Worldwide: 398.5 million tonnes in 2020

Paper and Board Consumption

EU: 75,2 million tonnes 2021

Note: UM=Uncoated Mechanical, CM=Coated Mechanical, UW=Uncoated Woodfree, CW=Coated Woodfree, CB=Carton Board, W= Wrappings, OPP=Other Paper and Board for Packaging, S&H=Sanitary and Household. Source: Confederation of European Paper Industries (2022), *Key Statistics 2021, European Pulp & Paper Industry*, p. 6.

Packaging Consumption (paper + carton board)

EU: 44,9 million tonnes used 2021

What are your key take-aways from the recycling chapter?

Paper packaging is not indefinitely recyclable. Theoretically it would be possible to recycle it up to 8 times but with each recycling step the fibres get shortened and thus loose some of their desired properties. Currently in the EU Paper packaging is recycled 3,5 times and worldwide 2,5.

Additives and films/coatings make recycling substantially harder. Also consumer residues from use (e.g. greases) have negative impact on recyclability.

Paper waste streams differ from country to country and are very challenging because they are hard to separate and mostly rely on good waste separation from the consumers.

In practise most paper packaging gets downcycled instead of recycled. Because it cannot be used for some applications (like food packaging) due to safety concerns.

Some companies don't even know which substances are in their final product due to lack of information about their raw materials. This meant that some of the products contained concerning chemicals like PFAS chemicals, BPA, Formaldehyde, Lead, ...

Padlet Drive

Discussion Reading 6 Group 6

Group 7: Veera Ollikainen, Sampsa Mäenpää, Tiina Pasanen, Mikael Nortes

Reading 6

1. Production and consumption volumes of
   1. Paper and board: production 90.6 million tonnes, consumption 75.2 million tonnes
   2. Packaging material: consumption 44.9 mllion tonnes
2. Chapter on Recycling
   1. In theory can be recycled 8 times, in practice 3.5 times
   2. For food and beverage packaging, recycled fibers are not so applicable
   3. Coatings, inks e.g. multimaterial packages are difficult to separate, thus recycling is challenging -> microplastics, chemical contamination
   4. If recycling relies on fossil energy, climate impact is ineffective
3. Our take on paper/board-based food and beverage packaging
   1. Expected to grow
   2. Our daily-life experience is that paper-based packages can in fact be more difficult to recycle since they contain many layers that must be separated before recycling: plastic yogurt cup can be more easily thrown into plastic recycling without separation of layers.
   3. Contaminated board packages (e.g. pizza boxes) may disrupt the process: are people informed enough about this?

Group 8

Group 8: Johannes Peace, Nissa Solihat, Tiinamari Seppänen

Production and Consumption Volumes of Paper and Board and Packaging Material

- Paper and board: The production and consumption of paper and board are substantial, with significant volumes attributed to packaging materials. In 2021, a total of 90.6 million tonnes of paper and paperboard was produced in Europe. Meanwhile, of over 75 million tonnes of total paper consumption in the EU, 60% (44.9 million tonnes) was used for packaging. This is indicative of the widespread use of these materials in various sectors, especially in packaging. Between 2010 and 2050, the amount of paper and paperboard consumed worldwide is predicted to almost double.
- In 2021, the leading paper- and board-producing countries in Europe were Germany, Italy, Sweden, Finland, Spain, and France
- Packaging material: Specifically, paper and board constitute a major part of packaging materials, underlining their critical role in the packaging industry. Their dominance in the market is attributed to their perceived sustainability and versatility in applications. The growth of the paper-based packaging market is expected to continue steadily in the coming years.

Key Takeaways from the Recycling Chapter

Paper-based packaging accounts for the majority of packaging waste.The recycling of paper and board packaging faces several challenges as the recycling industry has to cope with new, more complex packaging products:

- Contamination and quality: The presence of food residues, plastics, chemicals, and other contaminants can significantly lower the quality of recycled paper and board, making it difficult to use in new products.
- Recycling rates: Paper and board have relatively high recycling rates compared to other materials. However, paper cannot be recycled endlessly, as the process gradually shortens and weakens the fibres. The effectiveness of recycling processes can be hindered by contamination, chemicals used, and the mixing of materials. Although the fibres could be recycled up to 8 times, they are recycled only around 3.5. times in Europe.
- Environmental impact: The recycling process itself consumes resources and less energy compared to producing paper from virgin fibres, and the efficiency of recycling efforts is crucial in mitigating the environmental impact of paper and board packaging waste.

Perspective on Paper/Board-Based Food and Beverage Packaging

Even though the use of paper and board-based packaging for food and beverage products is growing rapidly, due to e.g. consumer demand and regulatory pressure on single-used plastics, it is viewed with mixed feelings:

- Sustainability concerns: While often marketed as an eco-friendly option, the sustainability of paper and board packaging is complex. Issues with recycling, the use of mixed materials, and the environmental impact of production raise questions about their overall sustainability.
- Consumer preferences and market trends: Consumer demand for sustainable packaging options continues to grow, driving the market towards materials like paper and board.

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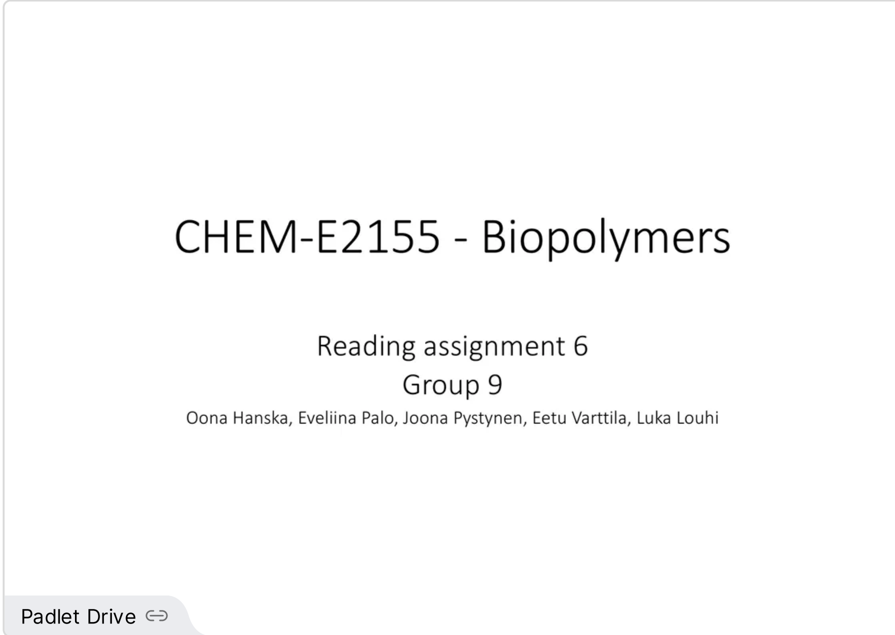
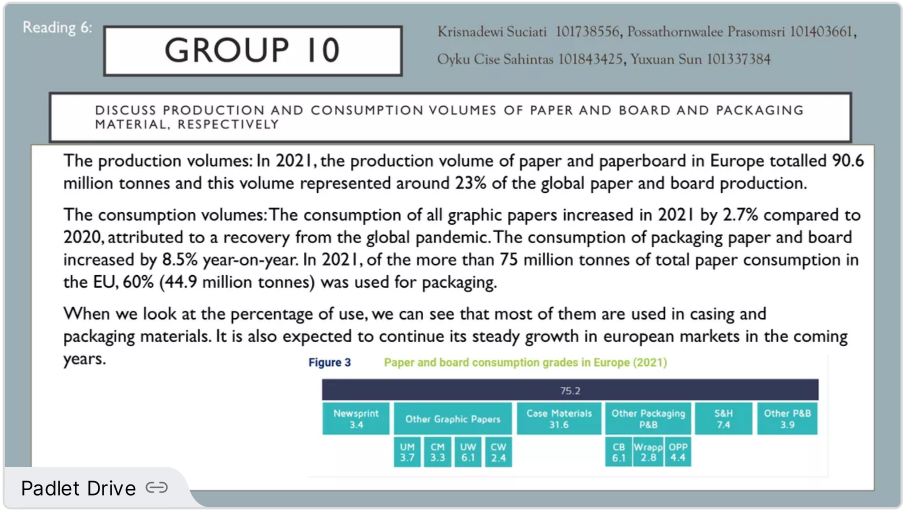
Reading 6, group 8

Group 9



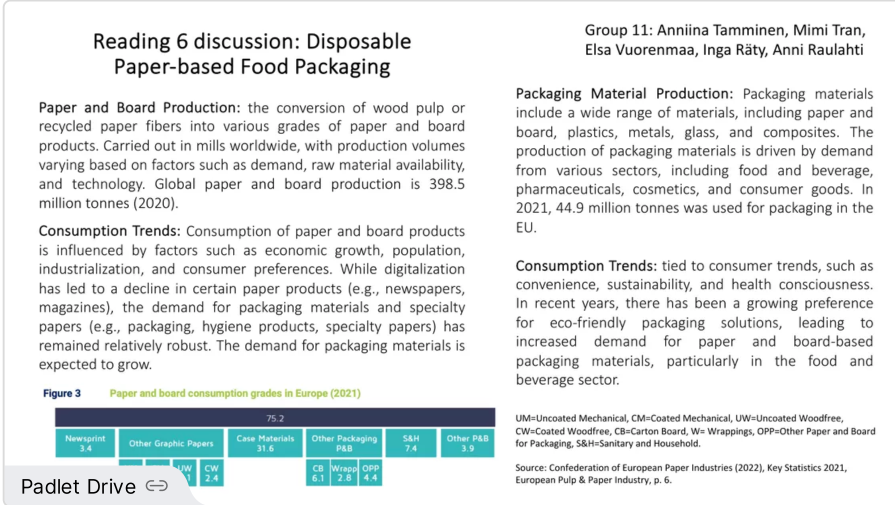
Reading 6, Biopolymers group 9

Reading 6 Group 10



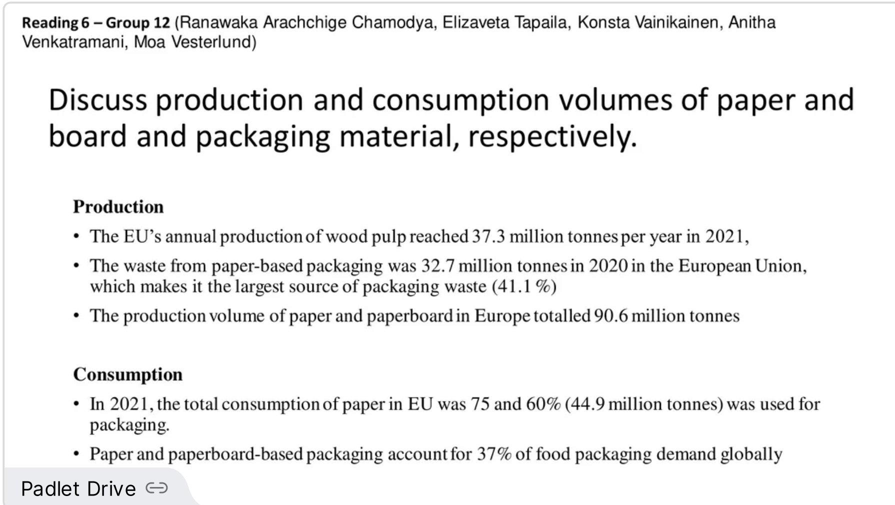
Reading 6 Group 10

Group 11

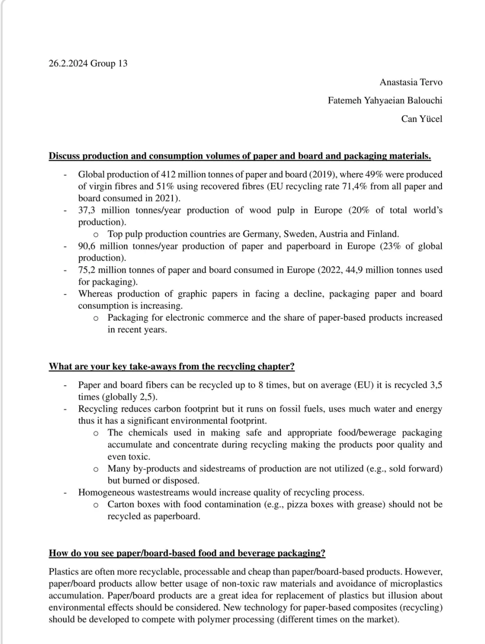


Reading 6

Reading 6 Discussion - Group 12



Reading 6_Group 12



26.2.2024 Group 13

Anastasia Tervo

Fatemeh Yahyaeian Balouchi

Can Yücel

Discuss production and consumption volumes of paper and board and packaging materials.

- Global production of 412 million tonnes of paper and board (2019), where 49% were produced of virgin fibres and 51% using recovered fibres (EU recycling rate 71,4% from all paper and board consumed in 2021).
- 37,3 million tonnes/year production of wood pulp in Europe (20% of total world's production).
  - Top pulp production countries are Germany, Sweden, Austria and Finland.
- 90,6 million tonnes/year production of paper and paperboard in Europe (23% of global production).
- 75,2 million tonnes of paper and board consumed in Europe (2022, 44,9 million tonnes used for packaging).
- Whereas production of graphic papers in facing a decline, packaging paper and board consumption is increasing.
  - Packaging for electronic commerce and the share of paper-based products increased in recent years.

What are your key take-aways from the recycling chapter?

- Paper and board fibers can be recycled up to 8 times, but on average (EU) it is recycled 3,5 times (globally 2,5).
- Recycling reduces carbon footprint but it runs on fossil fuels, uses much water and energy thus it has a significant environmental footprint.
  - The chemicals used in making safe and appropriate food/bewerage packaging accumulate and concentrate during recycling making the products poor quality and even toxic.
  - Many by-products and sidestreams of production are not utilized (e.g., sold forward) but burned or disposed.
- Homogeneous wastestreams would increase quality of recycling process.
  - Carton boxes with food contamination (e.g., pizza boxes with grease) should not be recycled as paperboard.

How do you see paper/board-based food and beverage packaging?

Plastics are often more recyclable, processable and cheap than paper/board-based products. However, paper/board products allow better usage of non-toxic raw materials and avoidance of microplastics accumulation. Paper/board products are a great idea for replacement of plastics but illusion about environmental effects should be considered. New technology for paper-based composites (recycling) should be developed to compete with polymer processing (different times on the market).

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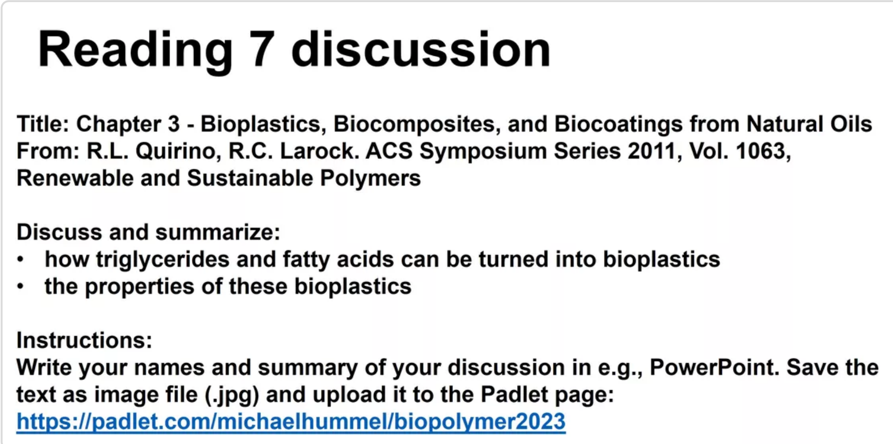
Polymeeri_G13_Discussion6

Reading Assignment 7



Reading 7 – Group 1

Abdi Babak, Carl-Alfons Antson, Juho Liekkinen, Jenny Leppänen and Gurung Sagar

- Triglycerides and fatty acids can be turned into bioplastics by:
  - Cationic polymerization
    - Requires a strong electrophile to promote polymerization
  - Free radical polymerization
    - Carbon-carbon double bonds reaction in triglycerides with vinyl comonomers
  - Thermal copolymerization
    - Autooxidation of drying oils in the presence of oxygen, forming peroxides that results in crosslinking through free radical recombination
  - Ring opening metathesis polymerization
    - Strained unsaturated cyclic molecules are opened at the carbon-carbon double bond
- Mechanical properties vary significantly depending on the number of double bonds in the biopolymer, but usually polymerized fatty acids and triglycerides results in a low tensile strength and a low Young's modulus
  - These properties can be improved with the addition of fillers such as glass fibers, functionalized organoclay and various natural fillers
- These bioplastics demonstrate a good thermal stability
  - Different polymerization methods and the nature of starting materials result in varying specific properties
- Thermophysical and mechanical properties of PUDs emulsive copolymerization with acrylates and vinyl comonomers improves significantly

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Reading 7

Group 2. Bonvini Andrea, Zimmermann Christan, Donatoni Giorgia, Jan Kantelinen

How triglycerides and fatty acids can be turned into bioplastics

The reactive sites in the triglyceride units are the carbon-carbon double bonds that once broken can react with adjacent broken bonds and create a cross-liked structure. In addition, the reactivity of these sites significantly increases if the double bonds are isomerized and brought to conjugation.

Oil-based polymers can be developed trough different methods:

- Free-radical
- Thermal: Free radical and thermal polymerizations follow the same mechanism: reactive initiation sites are generated and a chain reaction occurs. These sites can be induced by the presence of radical groups or thermal energy (high temperatures) that breaks double bonds.
- Cationic:
  - Electrophile is needed => Lewis acid is very suitable
  - Lewis acid is forming a radical at a double bonded carbon at the fatty acid
  - Another fatty acid is attaching to the radical forming a new radical => chain is growing
- ROMP (Ring Opening Metathesis Polymerization)
  - Cyclic molecules are opened at double bonded carbons
  - Ruthenium carbene catalyst is attaching to opened bonds
  - The results are unsaturated polymers that can be additionally crosslinked trough thermal reaction of the remaining double bonds
  - acid chains need to be modified to be processed with ROMP

Padlet Drive

Group2_4.3.2024

Group 3 4.3.2023 Eva González Carmona , Sara Hautojärvi, Laura Ahvenjärvi, Nikita Jamkin

How triglycerides and fatty acids can be turned into bioplastics

ROMP
Ring-opening metathesis polymerization (ROMP) is a method where alkenes are opened and polymerized with metal carbene catalysts
A metal (ruthenium) carbene complex reacts with a cyclic molecule
The carbon-carbon double bond is opened (Figure 1.)
This results in an unsaturated polymer
Additional crosslinking can be done through thermal reactions
Vegetable oils need to me modificated in order to use them in ROMP
Another possibility is to use fatty alcohols derived from vegetable oils

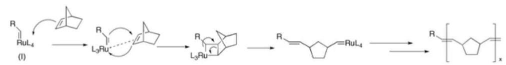

Figure 1. Mechanism of ROMP

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Group 3

Bioplastics, Biocomposites, and Biocoatings from Natural Oils

Polymerization methods for turning triglycerides and fatty acids (present in natural oils) into bioplastics:

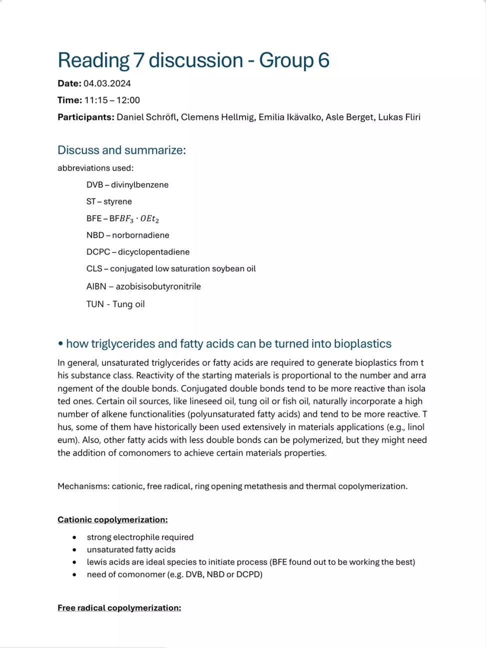
1. Ring opening polymerization
   - Fatty acid chains are modified before polymerization
2. Cationic copolymerization
   - Strong electrophile initiates
   - Lewis acids are ideal to initiate the process
3. Free radical copolymerization
   - Conjugated vegetable oils are ideal starting materials
   - Initiators required
4. Thermal copolymerization
   1. Same mechanism as in free radical copolymerization, but heat initiates
5. Acyclic diene metathesis (ADMET)

The carbon-carbon double bond is the reactive site

Padlet Drive

Group 5: Umer, Kaisla, Anneli, Asfar, Sardar

Reading 7 - group 5



Reading 7 discussion - Group 6

Date: 04.03.2024

Time: 11:15 – 12:00

Participants: Daniel Schröfl, Clemens Hellmig, Emilia Ikävalko, Asle Berget, Lukas Fliri

Discuss and summarize:

abbreviations used:

DVB – divinylbenzene

ST – styrene

BFE – BF$BF_3 \cdot OEt_2$

NBD – norbornadiene

DCPC – dicyclopentadiene

CLS – conjugated low saturation soybean oil

AIBN – azobisisobutyronitrile

TUN - Tung oil

• how triglycerides and fatty acids can be turned into bioplastics

In general, unsaturated triglycerides or fatty acids are required to generate bioplastics from t his substance class. Reactivity of the starting materials is proportional to the number and arra ngement of the double bonds. Conjugated double bonds tend to be more reactive than isola ted ones. Certain oil sources, like lineseed oil, tung oil or fish oil, naturally incorporate a high number of alkene functionalities (polyunsaturated fatty acids) and tend to be more reactive. T hus, some of them have historically been used extensively in materials applications (e.g., linol eum). Also, other fatty acids with less double bonds can be polymerized, but they might need the addition of comonomers to achieve certain materials properties.

Mechanisms: cationic, free radical, ring opening metathesis and thermal copolymerization.

Cationic copolymerization:

- strong electrophile required
- unsaturated fatty acids
- lewis acids are ideal species to initiate process (BFE found out to be working the best)
- need of comonomer (e.g. DVB, NBD or DCPD)

Free radical copolymerization:

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Reading 7 discussion - Group 6

Group 7

Padlet Drive

Reading 7 Group 7

Group 8: Nissa Solihat, Johannes Peace, Tiinamari Seppänen

1. **How triglycerides and fatty acids can be turned into bioplastics**

The carbon-carbon double bonds in triglycerides can be reacted in many ways to form biobased polymers. The main types of polymerizations such as Ring Opening Metathesis Polymerization (ROMP), cationic, free radical, and thermal polymerizations.

- **Cationic copolymerizatio**n: a strong electrophile is required to promote the cationic polymerization of triglycerides and fatty acids such as $AlCl_3$, $TiCl_4$, $SnCl_4$, $ZnCl_2$, $FeCl_3$, $SnCl_4 \cdot 5H2O$, H_2SO_4 and $BF_3 \cdot OEt_2$ (BFE). The addition of reactive petroleum-based comonomers is crucial to obtain viable thermosets.
- **Free Radical Copolymerization**: vegetable oil thermosets can be obtained by free radical copolymerisation of reactive unsaturated triglycerides and vinyl monomers. Requires that carbon-carbon double bonds in the oil are reactive to form a homogenous material. Conjugated double bonds form more stable intermediates during free radical polymerization, suggesting that conjugated vegetable oils are better starting materials for the preparation of free radical biobased thermosets.
- **Thermal Copolymerization**: Drying oils undergo auto-oxidation in the presence of oxygen, and form peroxides, which then undergo crosslinking through free radical recombination to form highly branched polymeric materials.
- **Ring Opening Metathesis Polymerization (ROMP**): strained, unsaturated cyclic molecules are opened at the carbon-carbon double bond by catalyst and modification of the fatty acid chains is necessary.
- **Epoxidized Vegetable Oils**: Utilize epoxidized vegetable oils as intermediates to produce polyols through a ring-opening reaction, which are then converted into polyurethanes by reacting with di-isocyanates.

2. **The properties of these bioplastics**

- **Cationic copolymerization**: Depending on the comonomers and crosslinker agents. For instance, 30-60 wt % of a fish oil triglyceride + styrene (ST) and DVB affords materials ranging from soft rubbers to rigid plastics. While fish oil ethyl esters + styrene (ST) and DVB affords lower mechanical properties.
- **Free Radical Copolymerization**: depending on the free radical reaction and copolymerization mixture. 1 wt % of azobisisobutyronitrile as a free radical initiator created a range of materials from flexible to rigid thermosets while benzoyl peroxide obtained rigid thermosets. When the vegetable oil content is increased, the properties of thermosets tend to decrease.
- **Thermal Copolymerization**: depending on the catalyst and copolymer concentration simply varying the stoichiometry of the comonomers to create rigid plastics. Increasing amounts of cobalt drying catalyst in TUN-based thermosets increases the crosslinking densities.
- **ROMP**: depending on the modification of vegetable oil and its amount but in general resulted in rubbery to rigid transparent thermosets with increased crosslink densities, good thermophysical and mechanical properties, and thermal stabilities. The increase in thermal stability increases with increasing oil content.
- When a part of DVB is substituted with polystyrene, the overall properties of the plastics are improved.
- Biodegradability: Bioplastics derived from natural sources like vegetable oils often exhibit enhanced biodegradability compared to conventional plastics, contributing to reduced environmental pollution.

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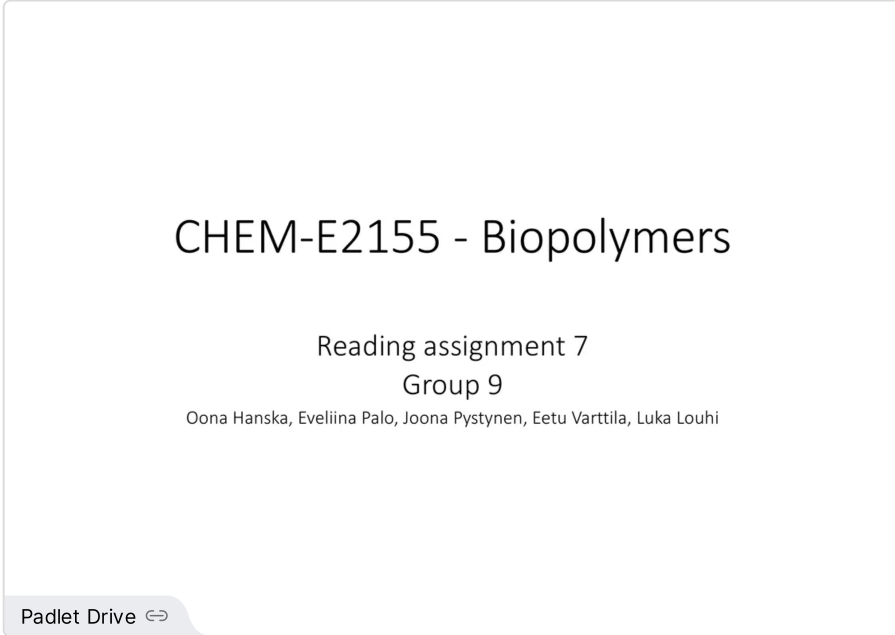
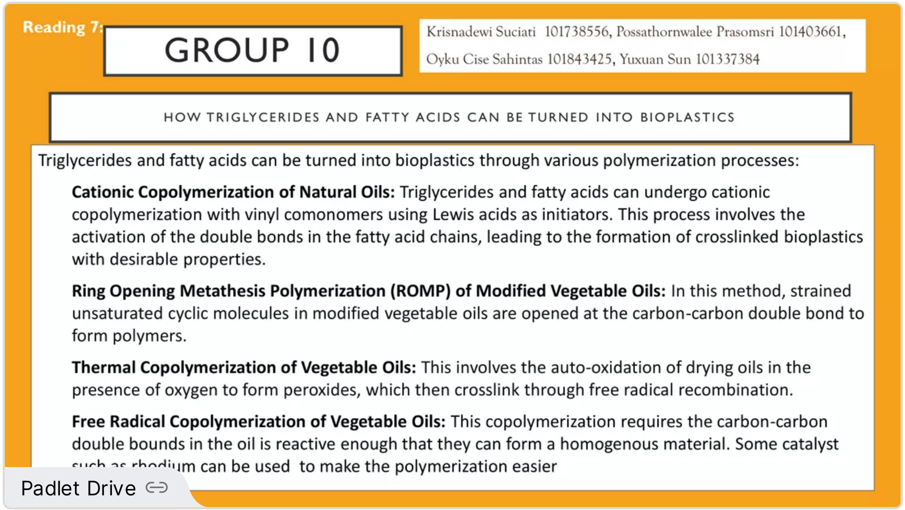
Discussion 7 group 8

Group 9



Biopolymers group 9 reading 7

Reading 7 group 10



Reading 7 group 10

Reading 7: Chapter 3 - Bioplastics, Biocomposites, and Biocoatings from Natural Oils
From: R.L. Quirino, R.C. Larock. ACS Symposium Series 2011, Vol. 1063, Renewable and Sustainable Polymers

Group 11: Anniina Tamminen, Elsa Vuorenmaa, Inga Räty, Mimi Tran, Anni Raulahti

How triglycerides and fatty acids can be turned into bioplastics:

- Biopolymers can be derived from:
    - The cationic copolymerization of natural oils
        - The cationic polymerization of triglycerides follows a different mechanism, initiated by a strong electrophile. Lewis acids are the ideal species to initiate this process.
    - The free radical copolymerization of vegetable oils
        - Requires that the carbon-carbon double bonds in the oil be sufficiently reactive in order to form a homogeneous material
    - The thermal copolymerization of vegetable oils
        - Drying oils undergo auto-oxidation in the presence of oxygen, and form peroxides, which then undergo crosslinking through free radical recombination to form highly branched polymeric materials.
        - The free radical and thermal polymerizations of triglycerides follow essentially the same mechanism, differing only with respect to the initiation process.
    - The ring opening metathesis polymerization (ROMP) of modified vegetable oils
        - Strained, unsaturated cyclic molecules are opened at the carbon-carbon double bond, by interaction with a ruthenium carbene catalyst.

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Group 11 Reading 7

Group 12

Reading 7 – Group 12 (Ranawaka Arachchige Chamodya, Elizaveta Tapaila, Konsta Vainikainen, Anitha Venkatramani, Moa Vesterlund)

1. How triglycerides and fatty acids can be turned into bioplastics

There are four main polymerization copolymerization methods described in the chapter as summarized below;

1. Free radical copolymerization

- Translucent vegetable oil-based thermosets are obtained via free radical copolymerization
- the presence of conjugated double bonds in the oils leads to the formation of stable intermediates during the process
- Highly branched polymer materials

2. Thermal copolymerization

- Used for vegetable oils (to produce coatings)
- Drying of oils in the presence of oxygen forms peroxides. These undergo crosslinking through free radical recombination
- This forms a highly branched polymer.

3. Cationic copolymerization

- Initiators such as $AlCl_3$, $TiCl_4$, $SnCl_4$, $ZnCl_2$, $FeCl_3$, $SnCl_4 \cdot 5H_2O$, H_2SO_4, and $BF_3 \cdot OEt_2$ have been used for this purpose.
- Reactive petroleum-based comonomers are added to triglycerides to produce viable solid thermosets.
- Different vegetable oils, including olive, peanut, sesame, canola, grapeseed, sunflower, safflower, walnut, and linseed oils, have been copolymerized to form thermosets tailored for specific applications.

4. Ring Opening Metathesis Polymerization (ROMP)

- Modified oils and fatty alcohols
- Bioplastics have been developed via ROMP by strained cyclic alkanes, resulting in rubbery and hard materials
- Cyclic molecules with unsaturated double carbon-carbon bonds are opened with a catalyst, leading to the coordination of new molecules and an unsaturated polymer

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Reading 7

Anastasia Tervo, Fatemeh Yahyaeian Balouchi, Julia Turunen, Can Yücel 04.03.2024

CHEM-E2155 Discussion 7 Group 13

Q1) How triglycerides and fatty acids can be turned into bioplastics?

- Cationic copolymerization:
  - The carbon-carbon double bonds in triglycerides can be reacted in many different ways to form biobased polymers (See others in the other bullet points).
  - A strong electrophile is required to promote the cationic polymerization of triglycerides and fatty acids.
  - Lewis acids are ideal but AlCl3, TiCl4, SnCl4, ZnCl2, FeCl3, SnCl4·5H2O, H2SO4 and BF3·OEt2 (BFE) have been used to initiate copolymerization.
  - Each unsaturated fatty acid chain in the triglyceride can participate in the cationic reaction, thus a crosslinked, three-dimensional polymer network can be formed.
  - The intermediate free radicals and carbocations can be stabilized by the electrons on the adjacent double bonds.
  - The conjugated triglycerides are more readily polymerized than natural, non-modified oils.
- Free radical copolymerization:
  - We need a free radical initiator that intermediates are stabilized by adjacent electrons of the double bonds. The natural oil must be reactive as partly conjugated. We need an oil initiator and vinyl monomers.
  - If vegetable oil is not conjugated enough, it will form soft and rubbery plastics.
- Thermal copolymerization:
  - Drying oils undergo auto oxidation in the presence of oxygen, and form peroxides which then undergo crosslinking through free radical recombination to form highly branched polymeric materials.
- Ring-opening metathesis polymerization (ROMP):
  - In the ROMP process, strained, unsaturated cyclic molecules are opened at the carbon-carbon double bond, by interaction with a ruthenium carbene catalyst.
  - The modification of fatty acid chains is necessary in order to use vegetable oils.

Q2) The properties of these bioplastics.

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Discussion7_Group13

Reading Assignment 8

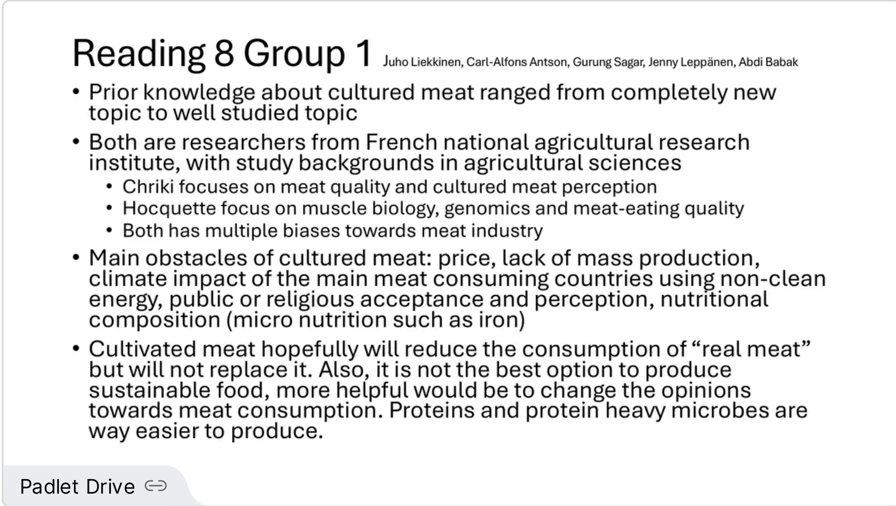
Reading 8 discussion

Title: The Myth of Cultured Meat: A Review
From: Chriki, S. and Hocquette, J.-F. *Frontiers in Nutrition* 2020

Discussion and summarize briefly:

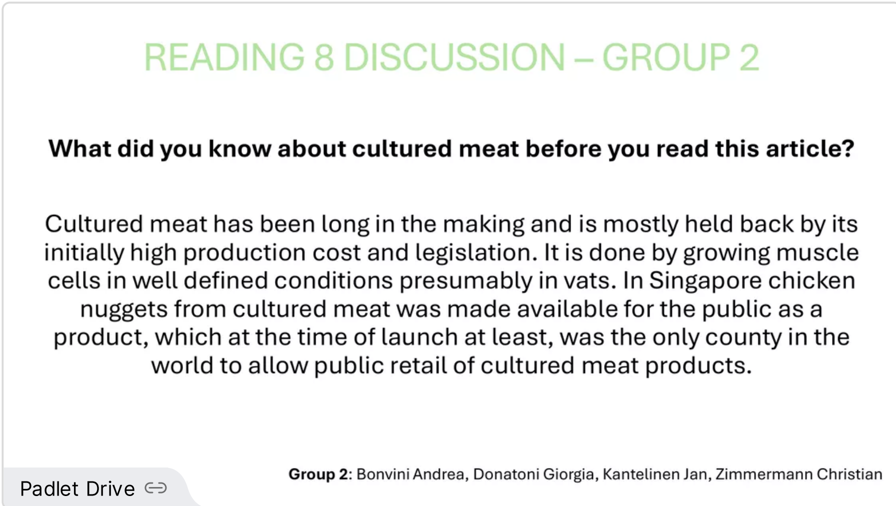
- What did you know about cultured meat before you read this article?
- Who are Prof. Sghaier Chriki and Dr. Jean-François Hocquette?
- What are the main obstacles of cultured meat towards mass consumption?
- What is your opinion on cultured meat?

Instructions:
Write your names and summary of discussion in e.g. PowerPoint. Save the text as image file (.jpg) and upload it to the Padlet page:
https://padlet.com/michaelhummel/CHEME2155_2024

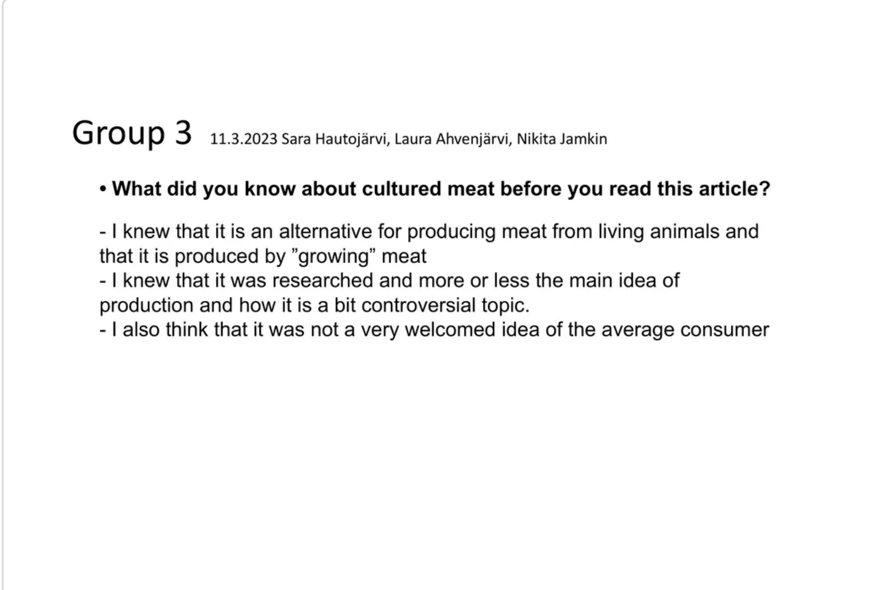


Reading 8 Group 1 Juho Liekkinen, Carl-Alfons

Reading 8 Discussion - Group 2



READING 8 DISCUSSION – GROUP 2



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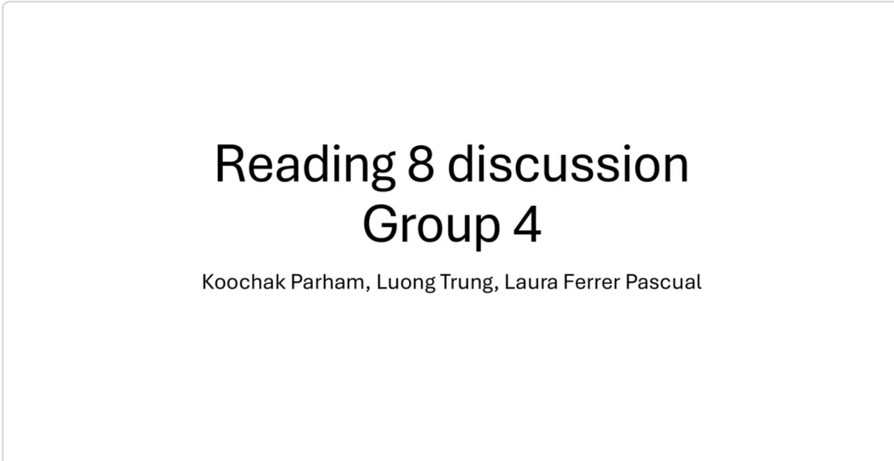
Group 3



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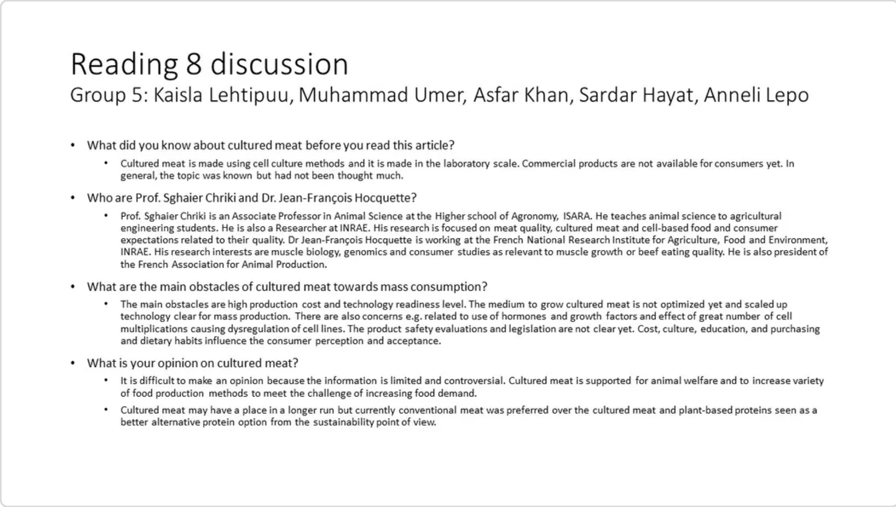
Reading 8 discussion group 4

Group 5

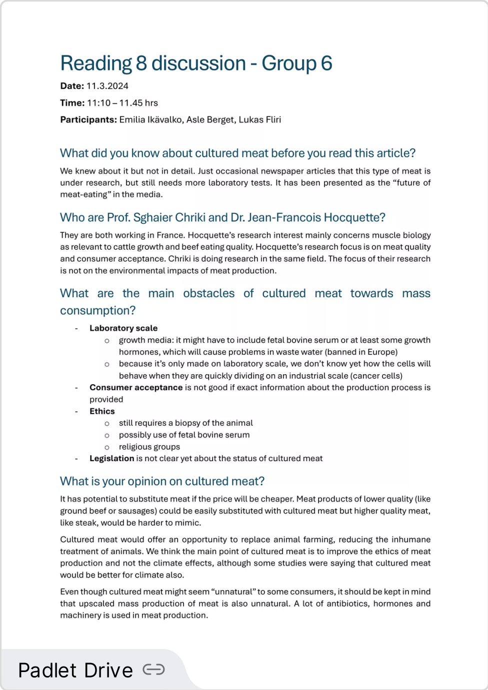


Reading 8 discussion

Group 5: Kaisla Lehtipuu, Muhammad Umer, Asfar Khan, Sardar Hayat, Anneli Lepo

- What did you know about cultured meat before you read this article?
  - Cultured meat is made using cell culture methods and it is made in the laboratory scale. Commercial products are not available for consumers yet. In general, the topic was known but had not been thought much.
- Who are Prof. Sghaier Chriki and Dr. Jean-François Hocquette?
  - Prof. Sghaier Chriki is an Associate Professor in Animal Science at the Higher school of Agronomy, ISARA. He teaches animal science to agricultural engineering students. He is also a Researcher at INRAE. His research is focused on meat quality, cultured meat and cell-based food and consumer expectations related to their quality. Dr Jean-François Hocquette is working at the French National Research Institute for Agriculture, Food and Environment, INRAE. His research interests are muscle biology, genomics and consumer studies as relevant to muscle growth or beef eating quality. He is also president of the French Association for Animal Production.
- What are the main obstacles of cultured meat towards mass consumption?
  - The main obstacles are high production cost and technology readiness level. The medium to grow cultured meat is not optimized yet and scaled up technology clear for mass production. There are also concerns e.g. related to use of hormones and growth factors and effect of great number of cell multiplications causing dysregulation of cell lines. The product safety evaluations and legislation are not clear yet. Cost, culture, education, and purchasing and dietary habits influence the consumer perception and acceptance.
- What is your opinion on cultured meat?
  - It is difficult to make an opinion because the information is limited and controversial. Cultured meat is supported for animal welfare and to increase variety of food production methods to meet the challenge of increasing food demand.
  - Cultured meat may have a place in a longer run but currently conventional meat was preferred over the cultured meat and plant-based proteins seen as a better alternative protein option from the sustainability point of view.

Group 6



Reading 8 discussion - Group 6

Date: 11.3.2024

Time: 11:10 – 11.45 hrs

Participants: Emilia Ikävalko, Asle Berget, Lukas Fliri

What did you know about cultured meat before you read this article?

We knew about it but not in detail. Just occasional newspaper articles that this type of meat is under research, but still needs more laboratory tests. It has been presented as the "future of meat-eating" in the media.

Who are Prof. Sghaier Chriki and Dr. Jean-Francois Hocquette?

They are both working in France. Hocquette's research interest mainly concerns muscle biology as relevant to cattle growth and beef eating quality. Hocquette's research focus is on meat quality and consumer acceptance. Chriki is doing research in the same field. The focus of their research is not on the environmental impacts of meat production.

What are the main obstacles of cultured meat towards mass consumption?

- **Laboratory scale**
  - growth media: it might have to include fetal bovine serum or at least some growth hormones, which will cause problems in waste water (banned in Europe)
  - because it's only made on laboratory scale, we don't know yet how the cells will behave when they are quickly dividing on an industrial scale (cancer cells)
- **Consumer acceptance** is not good if exact information about the production process is provided
- **Ethics**
  - still requires a biopsy of the animal
  - possibly use of fetal bovine serum
  - religious groups
- **Legislation** is not clear yet about the status of cultured meat

What is your opinion on cultured meat?

It has potential to substitute meat if the price will be cheaper. Meat products of lower quality (like ground beef or sausages) could be easily substituted with cultured meat but higher quality meat, like steak, would be harder to mimic.

Cultured meat would offer an opportunity to replace animal farming, reducing the inhumane treatment of animals. We think the main point of cultured meat is to improve the ethics of meat production and not the climate effects, although some studies were saying that cultured meat would be better for climate also.

Even though cultured meat might seem "unnatural" to some consumers, it should be kept in mind that upscaled mass production of meat is also unnatural. A lot of antibiotics, hormones and machinery is used in meat production.

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Group 6 Reading discussion 8

Reading 8 discussion

Group 7: Tiina Pasanen, Veera Ollikainen, Sampsa Mäenpää, Mikael Nortes

- What did you know about cultured meat before you read this article?

Production is expensive nowadays, can not make for example steak, only like minced meat. Production has expected to grow but many technical issues, for example scale-up. Are there all the nutrients needed, for example B12?

- Who are Prof. Sghaier Chriki and Dr. Jean-François Hocquette?

Both authors have a background in the French national research institute for agriculture, food and the environment, which operates under the French state.

Hocquette has interest towards the animal industry as he has been organizing French Meat R&D congress as is involved with the activities of European Association for Animal Production.

“Prof. Sghaier Chriki is an associate professor at ISARA, a French high school for agronomic studies, and a Researcher at INRAE (National Research Institute for Agriculture, Food and Environment). Research is focused on cultured meat. Dr. Jean-François Hocquette is PhD, DSc, Sr Scientist, INRA, is an international expert and speaker on research (muscle biology, genomics) and social interest (e.g. in vitro meat) topics.” (Loop Sghaier Chriki and Jean-François Hocquette, links below)

https://loop.frontiersin.org/people/543797/overview

https://loop.frontiersin.org/people/891509/overview

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Reading 8 discussion, group 7

Reading 8 discussion

Discussion and summarize briefly:

• What did you know about cultured meat before you read this article? But

Two of us had heard it before but did not know what it is. One team member knew most of the details discussed in the article due to working in the alternative protein industry.

• Who are Prof. Sghaier Chriki and Dr. Jean-François Hocquette?

Scientists at French National Institute for Agriculture, Food, and Environment (INRAE) are working on meat quality, and "cultured meat" (cell-based food) perception.

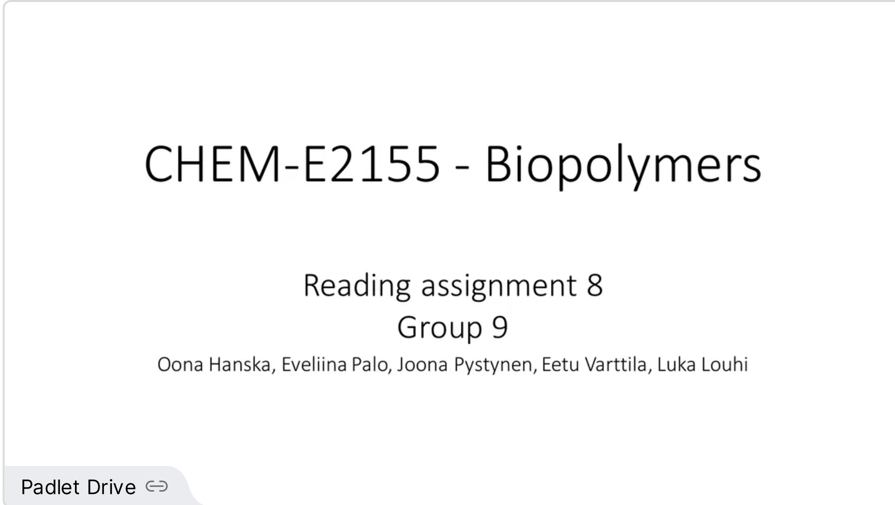
• What are the main obstacles of cultured meat towards mass consumption?

- Cultured meat will have to compete with other meat substitutes, especially plant-based alternatives.
- Consumer acceptance will be strongly influenced by many factors and consumers seem to dislike unnatural food. The customers may feel disgust due to it being “unnatural” food.
- Lack of long term studies on effect for human health.
- Controlling the micronutrient composition is still under a research.
- High price
- Fear of diseases and unneccesary use of antibiotics
- Fear of unknown

• What is your opinion on cultured meat?

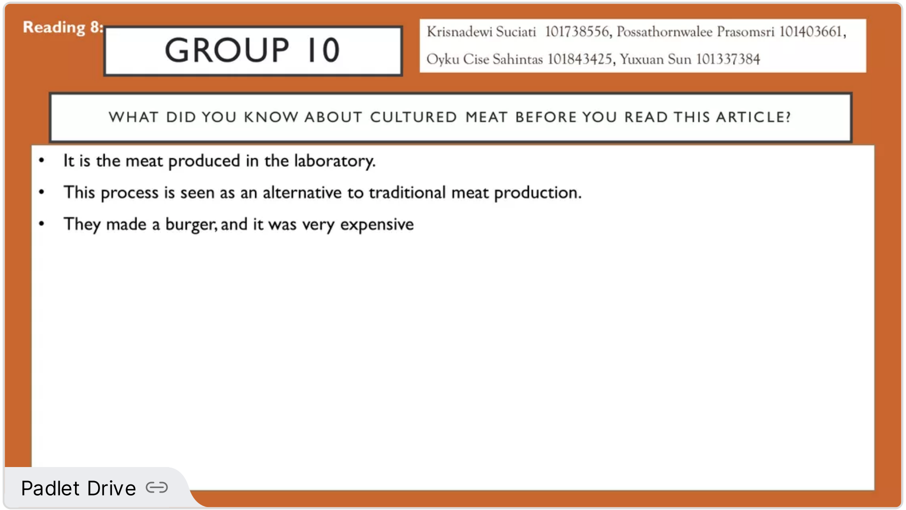
It is a better solution to conventional production, but some aspects should be considered such as scalability of production, regulatory approvals, public acceptance, and the long-term health and safety aspects. Some people express concerns about the artificial nature of the process or worry about the potential unintended consequences of widespread adoption. Biodiversity loss is one of the greatest risks for our planet and meat production one of the biggest contributors, however nutritionally speaking humans do not need any meat to thrive, hence I see little value in this technology. Then again, if the tech could be used to more high-value applications like grow replacement organs for humans that would be a better use of the tech.

Group 8



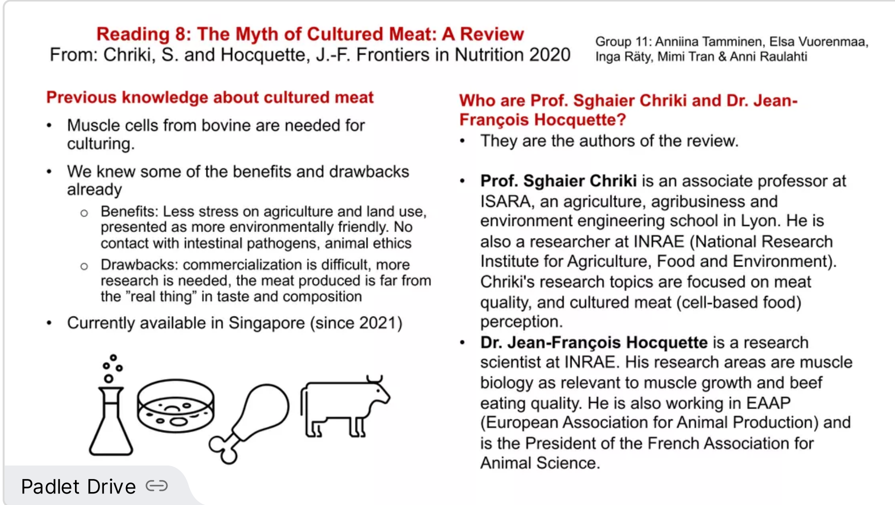
Biopolymers group 9_8

Reading 8 Group 10

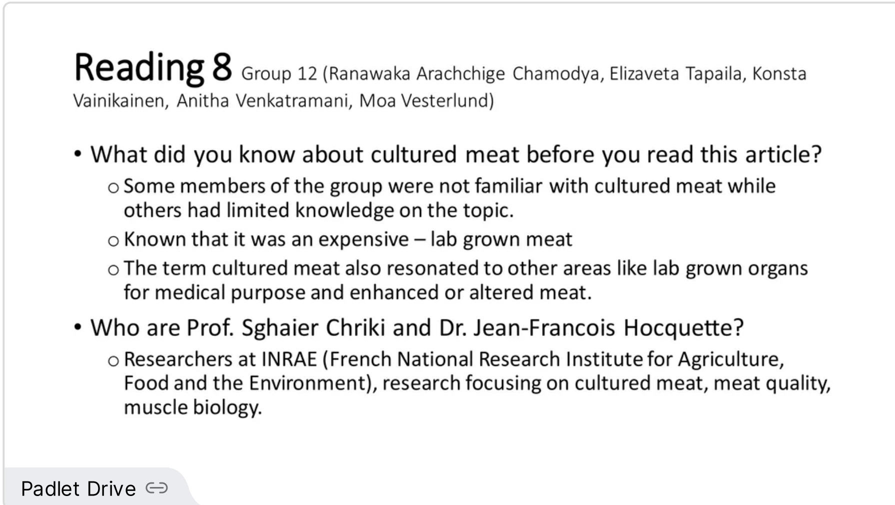


Reading 8 group 10

Group 11

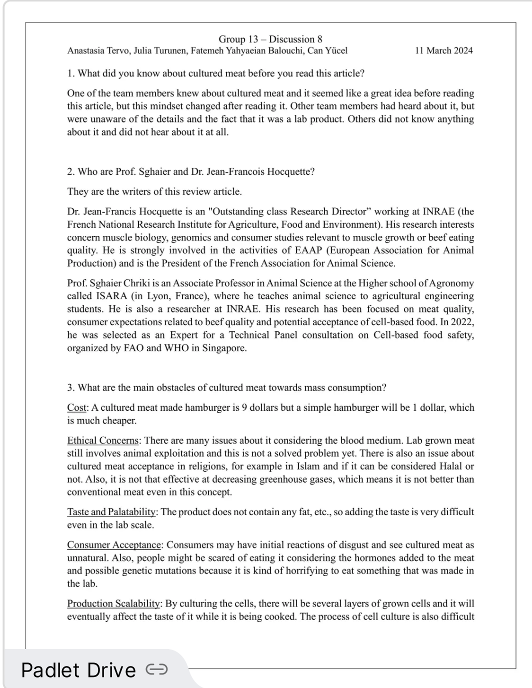


Reading 8 - Group 11



Group 12 reading 8

Group 13



Group 13 – Discussion 8

Anastasia Tervo, Julia Turunen, Fatemeh Yahyaeian Balouchi, Can Yücel 11 March 2024

1. What did you know about cultured meat before you read this article?

One of the team members knew about cultured meat and it seemed like a great idea before reading this article, but this mindset changed after reading it. Other team members had heard about it, but were unaware of the details and the fact that it was a lab product. Others did not know anything about it and did not hear about it at all.

2. Who are Prof. Sghaier and Dr. Jean-Francois Hocquette?

They are the writers of this review article.

Dr. Jean-Francis Hocquette is an "Outstanding class Research Director" working at INRAE (the French National Research Institute for Agriculture, Food and Environment). His research interests concern muscle biology, genomics and consumer studies relevant to muscle growth or beef eating quality. He is strongly involved in the activities of EAAP (European Association for Animal Production) and is the President of the French Association for Animal Science.

Prof. Sghaier Chriki is an Associate Professor in Animal Science at the Higher school of Agronomy called ISARA (in Lyon, France), where he teaches animal science to agricultural engineering students. He is also a researcher at INRAE. His research has been focused on meat quality, consumer expectations related to beef quality and potential acceptance of cell-based food. In 2022, he was selected as an Expert for a Technical Panel consultation on Cell-based food safety, organized by FAO and WHO in Singapore.

3. What are the main obstacles of cultured meat towards mass consumption?

Cost: A cultured meat made hamburger is 9 dollars but a simple hamburger will be 1 dollar, which is much cheaper.

Ethical Concerns: There are many issues about it considering the blood medium. Lab grown meat still involves animal exploitation and this is not a solved problem yet. There is also an issue about cultured meat acceptance in religions, for example in Islam and if it can be considered Halal or not. Also, it is not that effective at decreasing greenhouse gases, which means it is not better than conventional meat even in this concept.

Taste and Palatability: The product does not contain any fat, etc., so adding the taste is very difficult even in the lab scale.

Consumer Acceptance: Consumers may have initial reactions of disgust and see cultured meat as unnatural. Also, people might be scared of eating it considering the hormones added to the meat and possible genetic mutations because it is kind of horrifying to eat something that was made in the lab.

Production Scalability: By culturing the cells, there will be several layers of grown cells and it will eventually affect the taste of it while it is being cooked. The process of cell culture is also difficult

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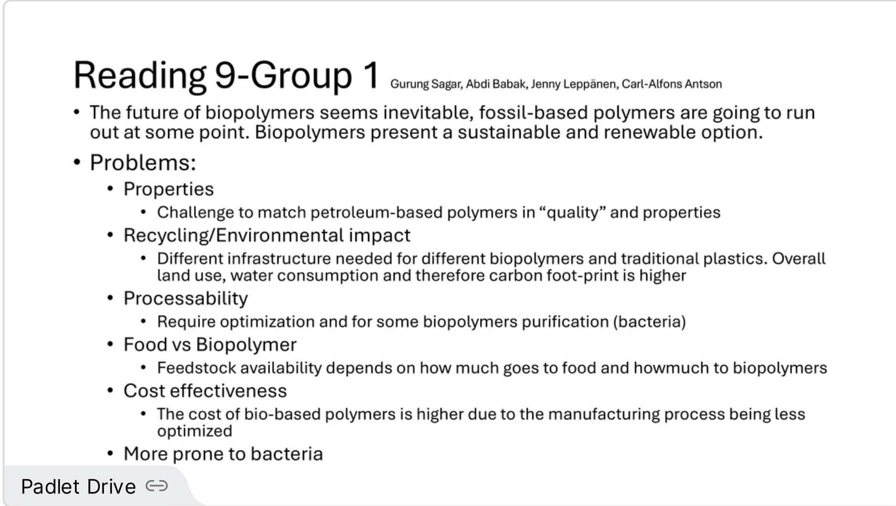
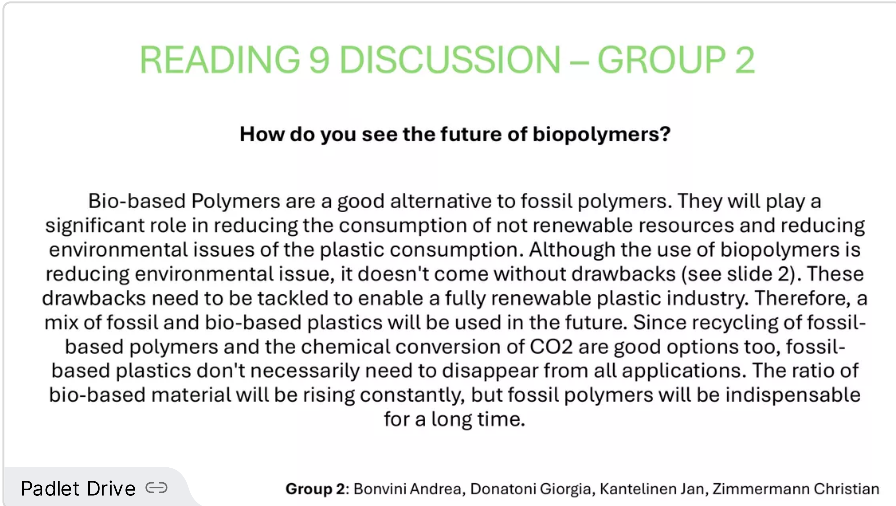
Discussion 8_group 13

Reading Assignment 9



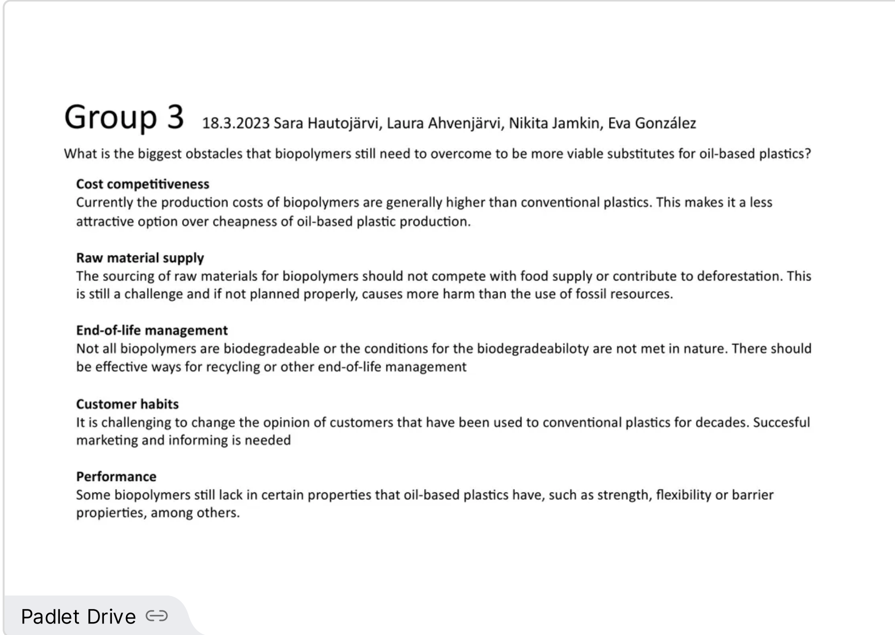
Reading 9-Group 1 Gurung Sagar, Abdi Babak

Reading 9 discussion - Group 2

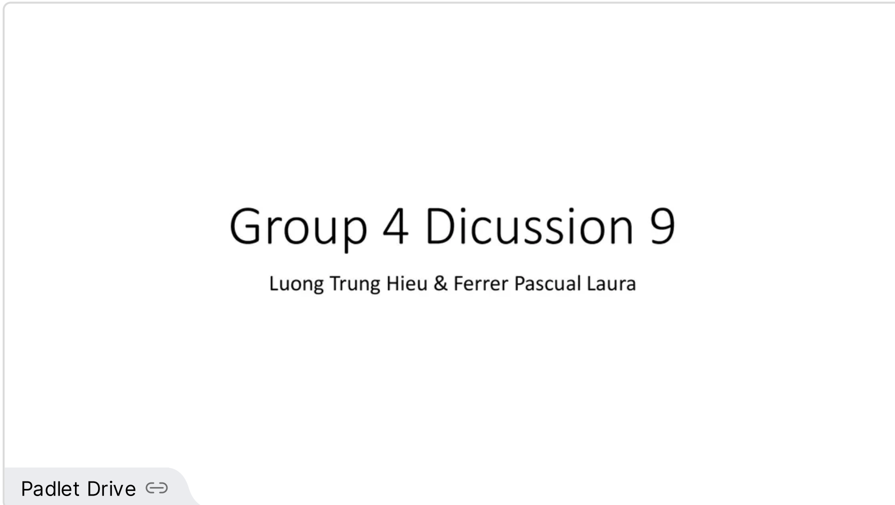


READING 9 DISCUSSION – GROUP 2

Reading 9 group 3



Group 3



Group 4 Dicussion 9

Reading 9
Group 5(Asfar Khan, Kaisla Lehtipuu, Muhammad Umer, Sardar Hayat, Anneli Lepo)

- How do you see the future of biopolymers?
  - Will take a lot of time to replace the current oil-based plastics.
  - Modification of biopolymers required to enhance its properties for use.
  - Will be utilized more, and as oil supplies decline, less oil-based polymers will be produced.
  - Wood cellulose uses less space for farming. Compared to annual plants, we see the use of wood cellulose for bioplastics more favorably.
  - More Biopolymers to combat climate change.
  - In terms of the sources of raw materials and carbon footprint, bio-based polymers may be a more environmentally friendly option than synthetic polymers. They still have a long way to go before their production method is as energy-efficient, low-cost, and high-performing as the one derived from fossil fuels.
  - There will be a rise in the study and development of biopolymers, providing further insight into their potential as an oil-based plastic substitute. But it will take a lot of time. Oil-based plastics won't likely be completely replaced by biopolymers, but their use will at least decline overall.

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Reading 9 (Group-5)

Reading Discussion Group 6:

Daniel Schröfl, Clemens, Hellmig, Emilia Ikävalko, Asle Berget, Lukas Fliri

How do you see the future of Biopolymers? What are the biggest obstacles that Biopolymers still need to overcome to be more viable substitutes for oil-based plastics?

- In the long run bio-based polymers will have a bigger market share. At a certain point (when oil resources dwindle down – "peak oil" reached) they will be cost competitive and when there is no more oil left, we will need bio-based alternatives. At which point this will happen is debatable (50 years, 100 years, 200 years…)
- There are different ways to approach this problem. Do we talk about changing current plastics with bio-based and bio-degradable solutions (i.e., packaging change plastic bag to bio-degradable starch / paper bag) or substitute the monomers used in plastics production to bio-based alternatives (i.e., bio-PE / bio-PET). Coming up with bio-based and biodegradable solutions would be best, but complicated to achieve.

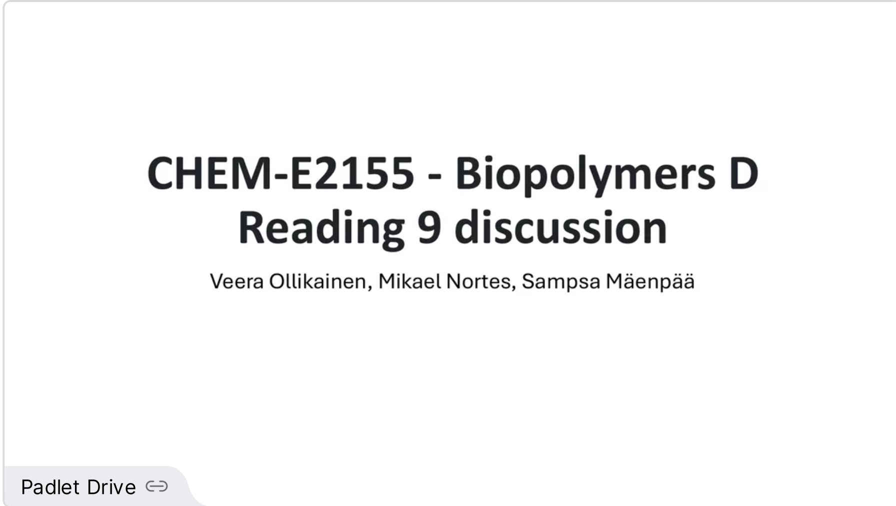
Obstacles:

- Oil-based plastics are right now much cheaper than bio-based alternatives.
- Existing production lines for oil-based materials in huge scales. Very difficult to become cost-competitive with smaller scale alternatives.
- Recycling of materials proposed as a way to solve the associated waste problems of oil-based plastics. Make them more sustainable and no need to switch to bioplastics. But imperfect solution in our opinion. Right now, not really recycling, but downcycling or burning.
- Big problem for bioplastic is the source of the materials. Needs to be grown somewhere (needs fertilizer, deforestation, competes with food production, etc.), transported and extracted somewhere (needs energy – mostly oil). Using big plantations will make it more cost-competitive but has associated issues with non-sustainable farming and reduced biodiversity.
- Production of bio-based alternatives can lead to a bigger CO_2 footprint than petrol-based materials (*i.e.*, paper-bag needs more resources to produce than plastic bag).

Padlet Drive

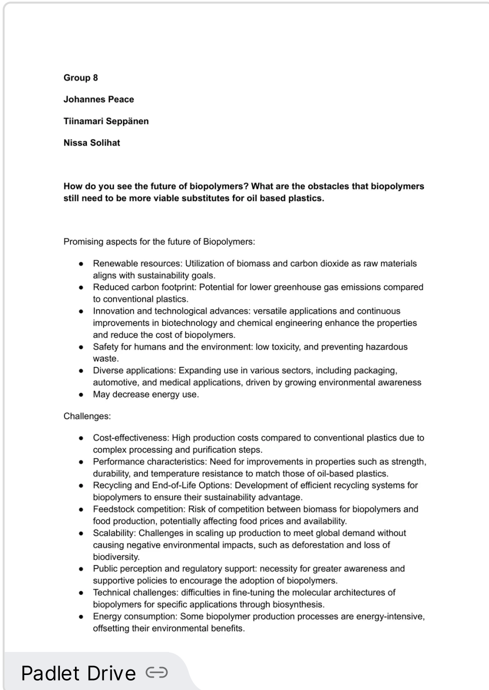
Reading 9

Group 7 reading 9



CHEM-E2155 - Biopolymers D reading 9

Reading 9 - Group 8



Group 8

Johannes Peace

Tiinamari Seppänen

Nissa Solihat

How do you see the future of biopolymers? What are the obstacles that biopolymers still need to be more viable substitutes for oil based plastics.

Promising aspects for the future of Biopolymers:

- Renewable resources: Utilization of biomass and carbon dioxide as raw materials aligns with sustainability goals.
- Reduced carbon footprint: Potential for lower greenhouse gas emissions compared to conventional plastics.
- Innovation and technological advances: versatile applications and continuous improvements in biotechnology and chemical engineering enhance the properties and reduce the cost of biopolymers.
- Safety for humans and the environment: low toxicity, and preventing hazardous waste.
- Diverse applications: Expanding use in various sectors, including packaging, automotive, and medical applications, driven by growing environmental awareness
- May decrease energy use.

Challenges:

- Cost-effectiveness: High production costs compared to conventional plastics due to complex processing and purification steps.
- Performance characteristics: Need for improvements in properties such as strength, durability, and temperature resistance to match those of oil-based plastics.
- Recycling and End-of-Life Options: Development of efficient recycling systems for biopolymers to ensure their sustainability advantage.
- Feedstock competition: Risk of competition between biomass for biopolymers and food production, potentially affecting food prices and availability.
- Scalability: Challenges in scaling up production to meet global demand without causing negative environmental impacts, such as deforestation and loss of biodiversity.
- Public perception and regulatory support: necessity for greater awareness and supportive policies to encourage the adoption of biopolymers.
- Technical challenges: difficulties in fine-tuning the molecular architectures of biopolymers for specific applications through biosynthesis.
- Energy consumption: Some biopolymer production processes are energy-intensive, offsetting their environmental benefits.

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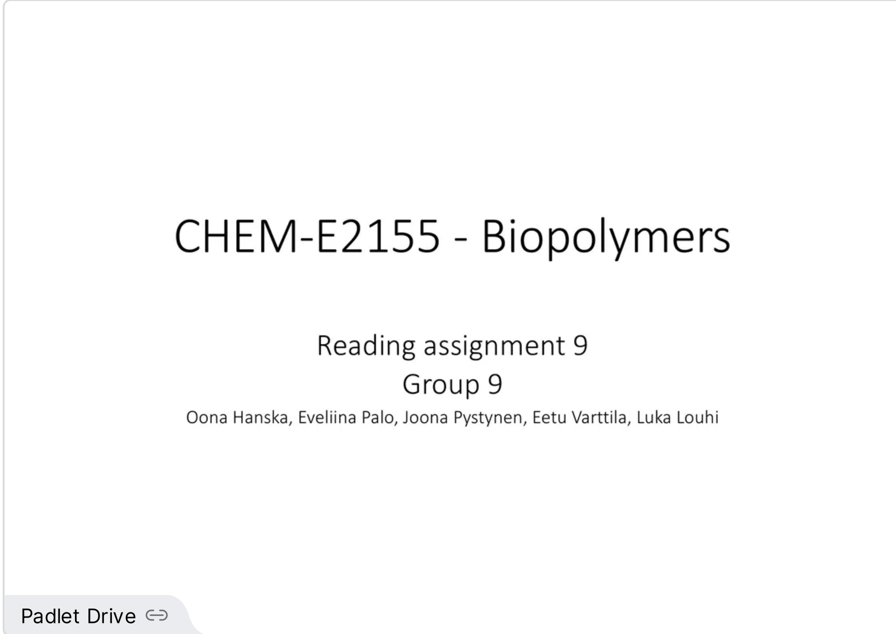
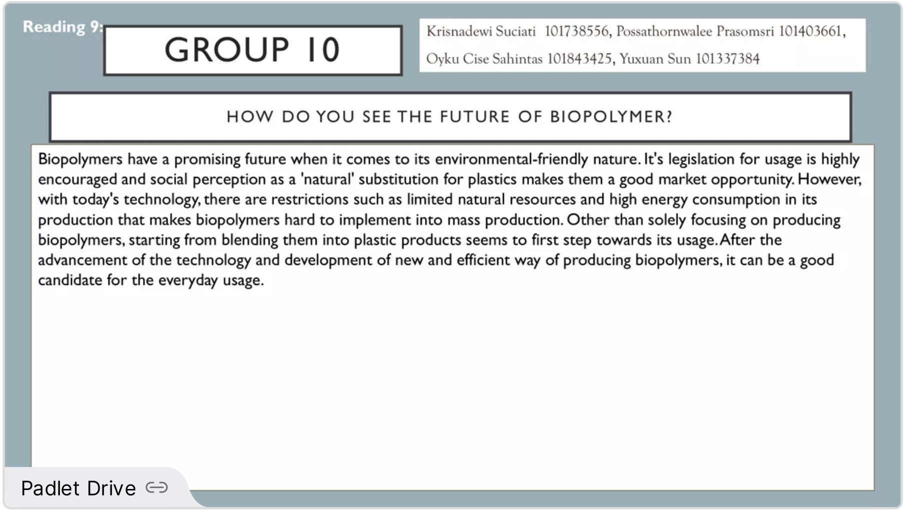
Group 8-Reading 9 Biopolymers

Group 9



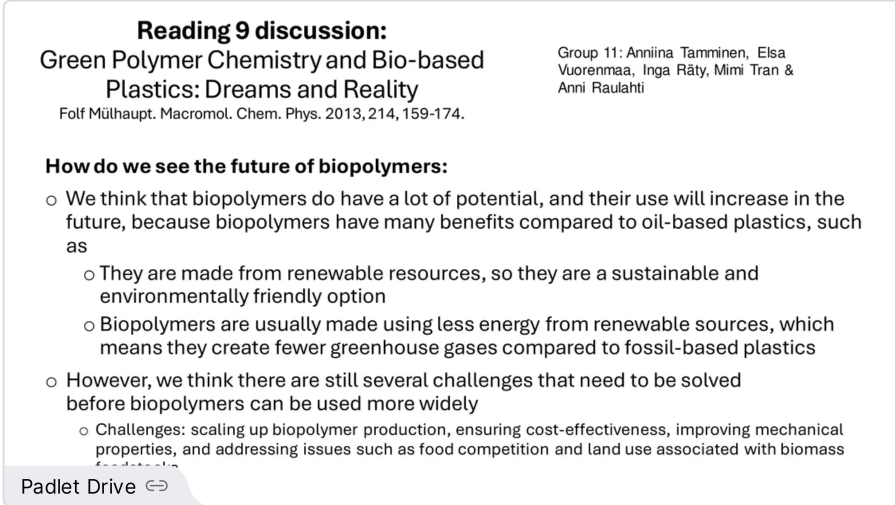
Reading 9, Biopolymers group 9

Reading 9 Group 10



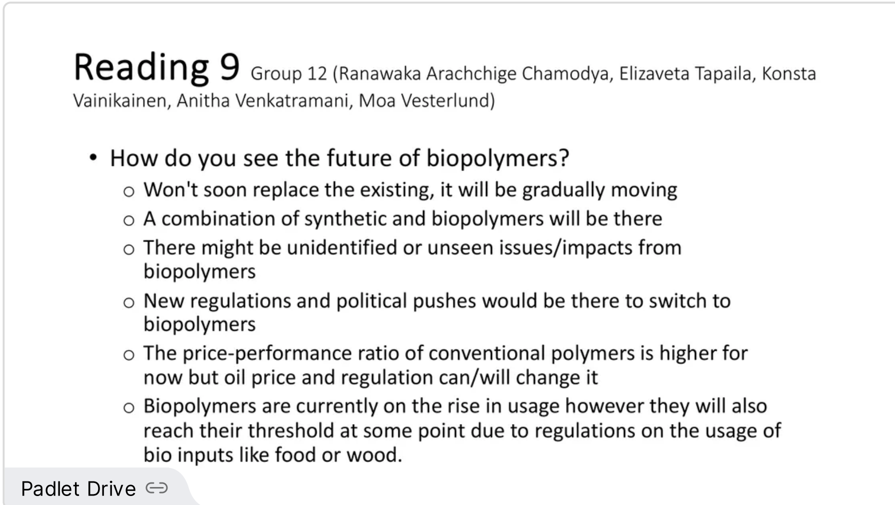
Reading 9 group 10

Reading 9 Group 11



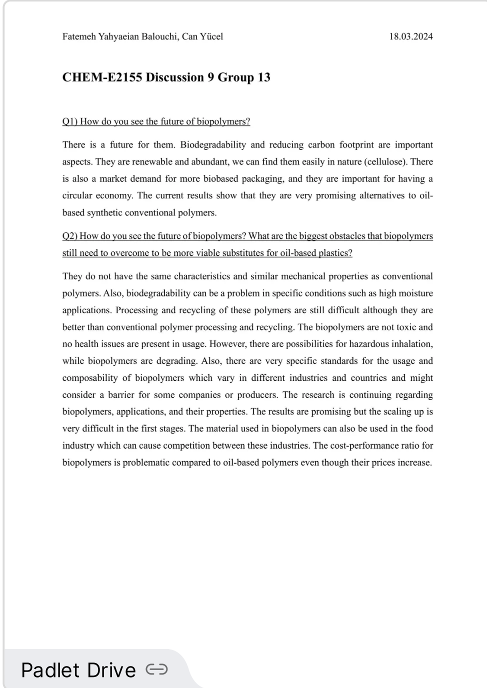
Reading 9

Group 12 - Reading 9



Reading 9 - Group 12

Group 13 Reading 9



Fatemeh Yahyaeian Balouchi, Can Yücel 18.03.2024

CHEM-E2155 Discussion 9 Group 13

Q1) How do you see the future of biopolymers?

There is a future for them. Biodegradability and reducing carbon footprint are important aspects. They are renewable and abundant, we can find them easily in nature (cellulose). There is also a market demand for more biobased packaging, and they are important for having a circular economy. The current results show that they are very promising alternatives to oil-based synthetic conventional polymers.

Q2) How do you see the future of biopolymers? What are the biggest obstacles that biopolymers still need to overcome to be more viable substitutes for oil-based plastics?

They do not have the same characteristics and similar mechanical properties as conventional polymers. Also, biodegradability can be a problem in specific conditions such as high moisture applications. Processing and recycling of these polymers are still difficult although they are better than conventional polymer processing and recycling. The biopolymers are not toxic and no health issues are present in usage. However, there are possibilities for hazardous inhalation, while biopolymers are degrading. Also, there are very specific standards for the usage and composability of biopolymers which vary in different industries and countries and might consider a barrier for some companies or producers. The research is continuing regarding biopolymers, applications, and their properties. The results are promising but the scaling up is very difficult in the first stages. The material used in biopolymers can also be used in the food industry which can cause competition between these industries. The cost-performance ratio for biopolymers is problematic compared to oil-based polymers even though their prices increase.

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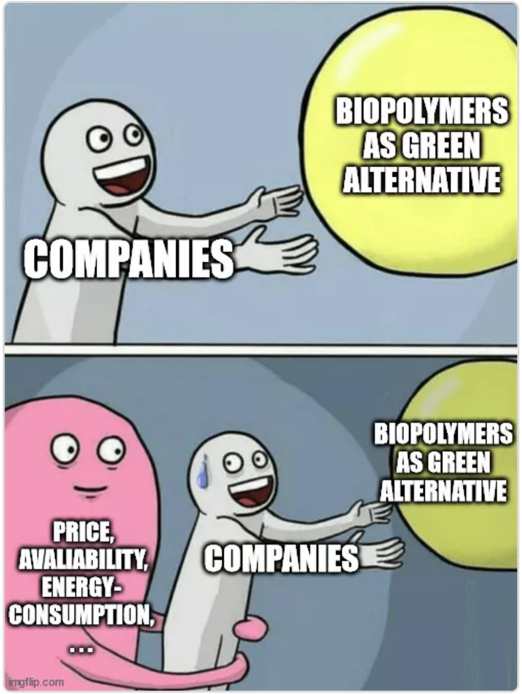
Discussion9_Group13

"Reading" Assignment 10: meme

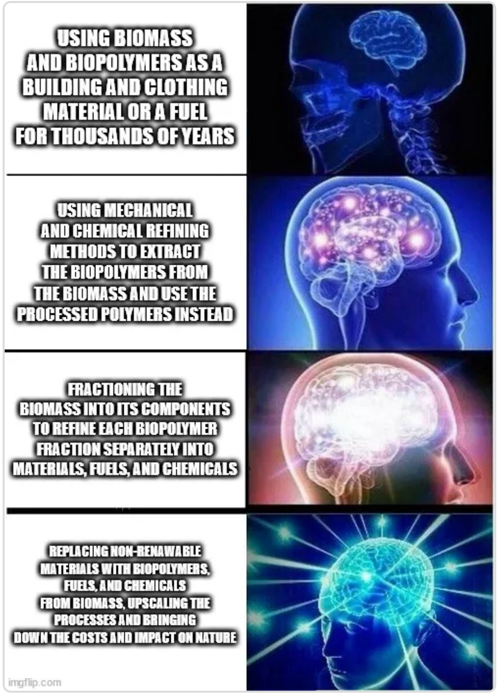
Meme Daniel Schröfl



Meme Elizaveta Tapaila

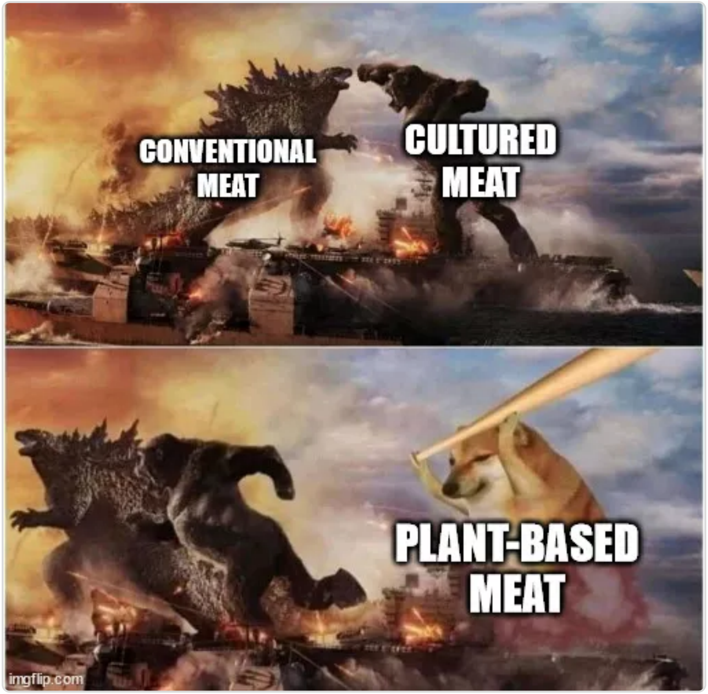
Meme Joona Pystynen

Meme Juho Liekkinen



Meme Konsta Vainikainen

Meme_Luong Trung Hieu

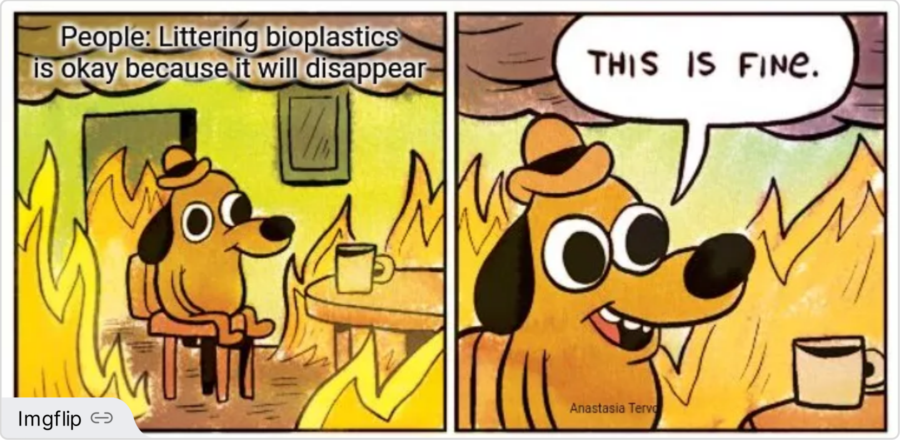


Bioplastic, it's fantastic

Laura Ferrer Pascual

Can Yucel

This is fine, Anastasia Tervo



This Is Fine

Meme Eveliina Palo

Meme_Jan Kantelinen

Important biopolymer research, Carl-Alfons Antson

THE SCIENCE EXPLORER

TECHNOLOGY | BRAIN AND BODY | NATURE | HUMANITY | UNIVERSE

Technology

New study shows: "Stepping on legos made from biolymers still hurts"

March 8, 2016 | Elizabeth Knowles

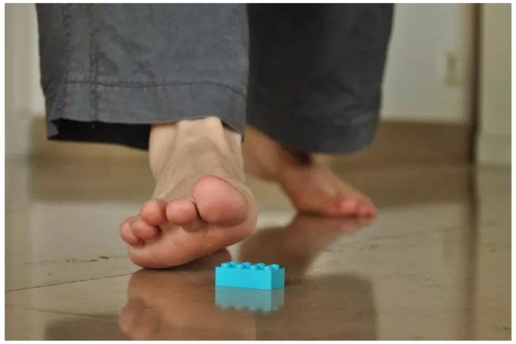


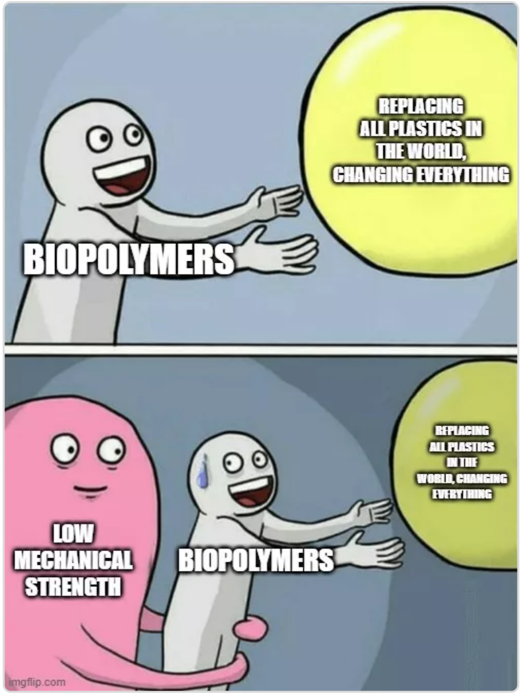
Photo credit: Frédérique Voisin-Demery/Flickr (CC BY 2.0)

Pain you wouldn't even wish on your worst enemy!

If you've ever had children in your house, you've probably experienced the extreme pain that comes with stepping on a piece of Lego. But does the biodegradability of the lego make it hurt less? According to scientist, biopolymers can have the exact same properties as regular plastics.

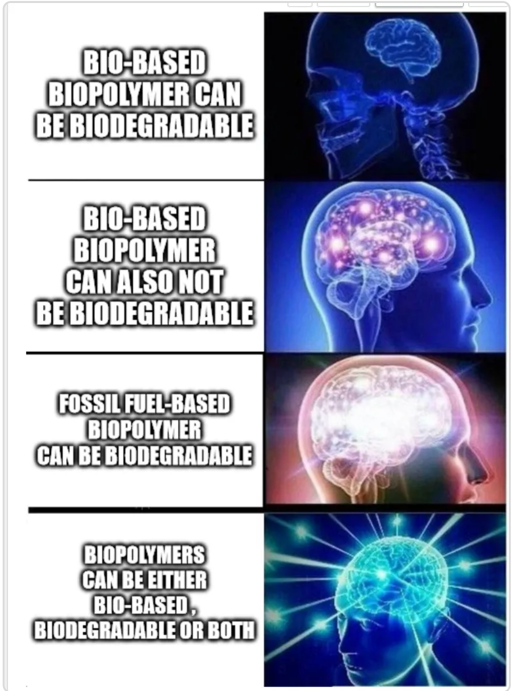
Meme Rasmus Huttunen

Meme Fatemeh Yahyaeian Balouchi

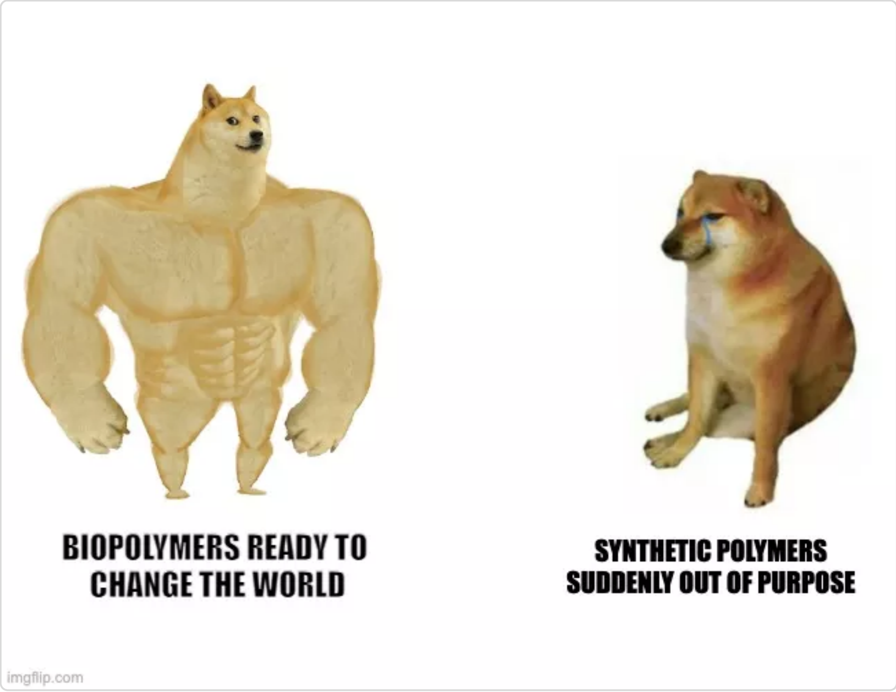


Meme Clemens Hellmig

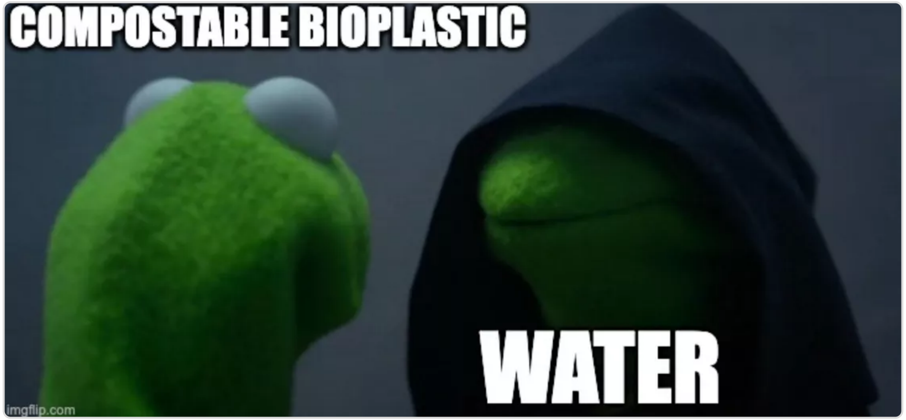
Meme Laura Ahvenjärvi



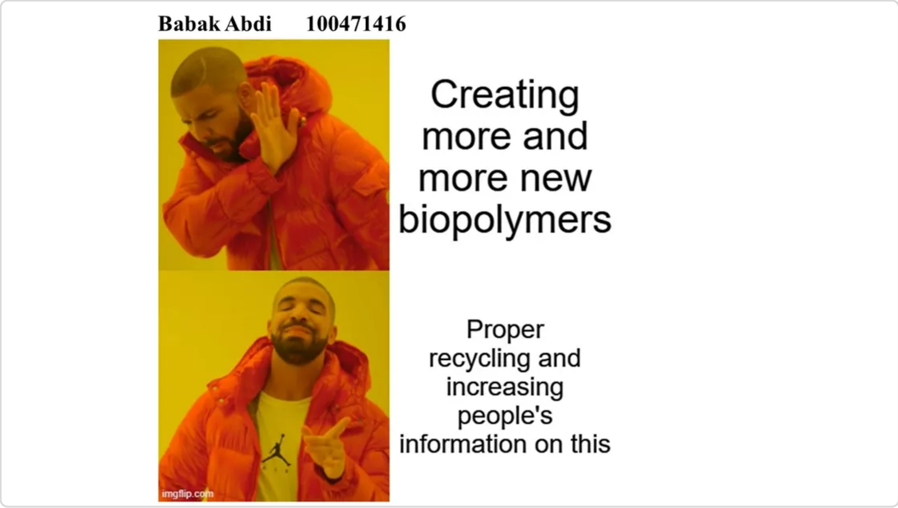
Meme Julia Turunen



Veera Ollikainen



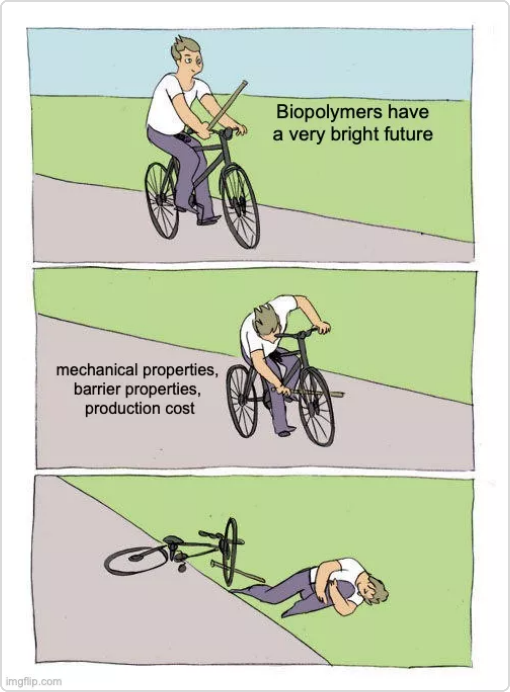
Babak Abdi



Krisnadewi Suciati

Tiina Pasanen

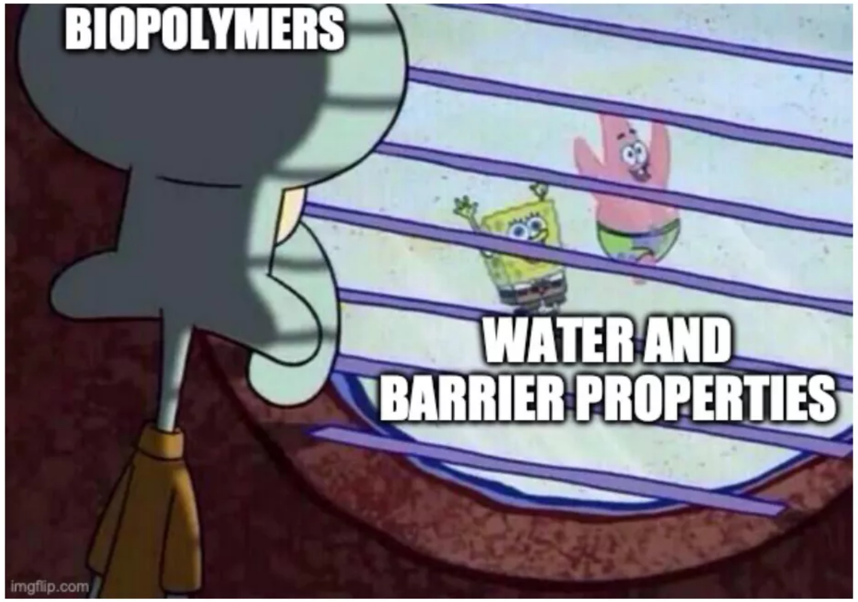
Possathornwalee Prasomsri



Meme Asle Hammer Berget

Meme Parham Koochak

Moa Vesterlund Meme

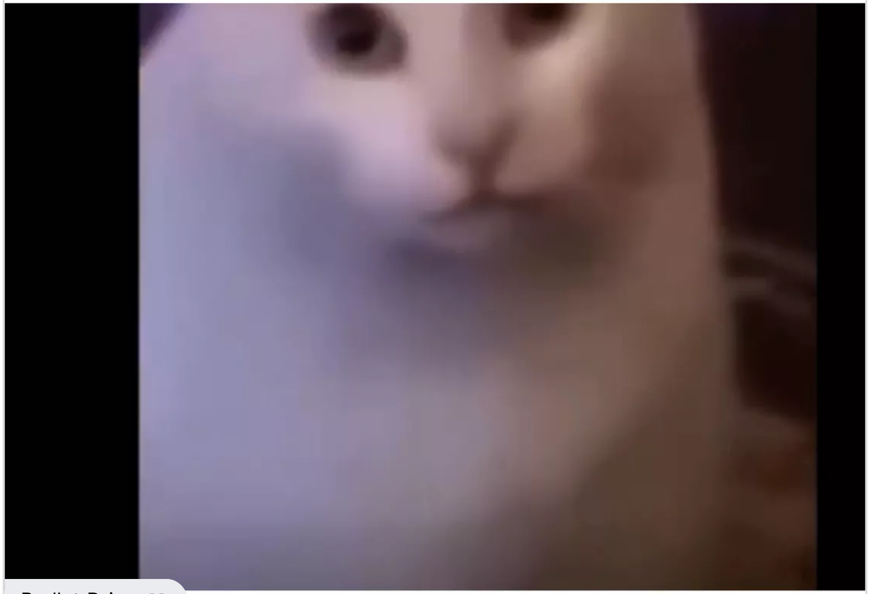


Meme Eetu Varttila

Meme Nissa Solihat

Meme Muhammad Umer

Me and my friends trying to replace oil-based polymers with biopolymers.
Meanwhile Le Biopolymers.



Padlet Drive

Cat Huh Meme

meme Kaisla Lehtipuu

Meme Sara Hautojärvi

Meme Emilia Ikävalko

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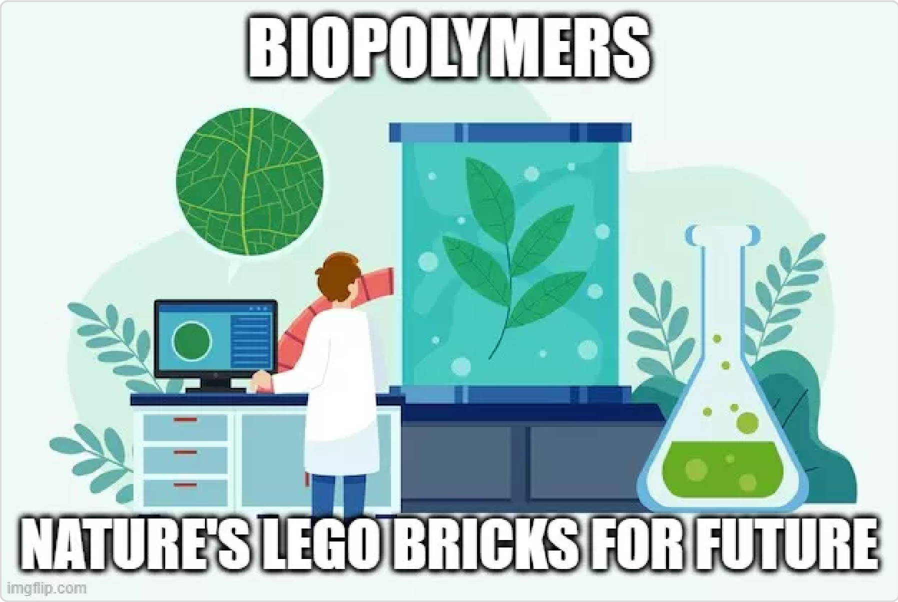
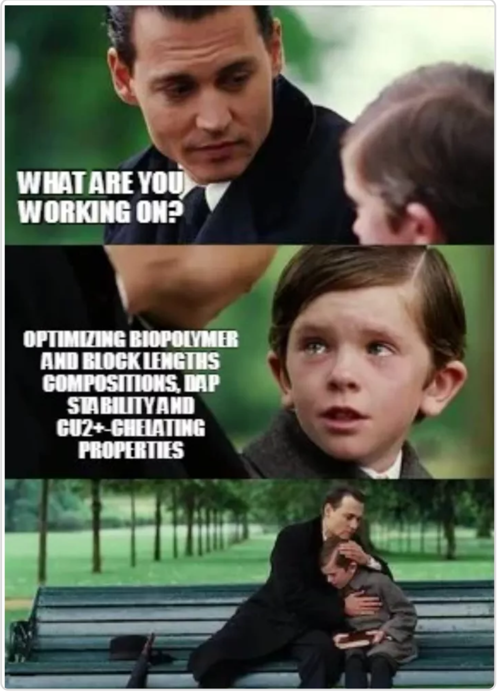
Anneli Lepo



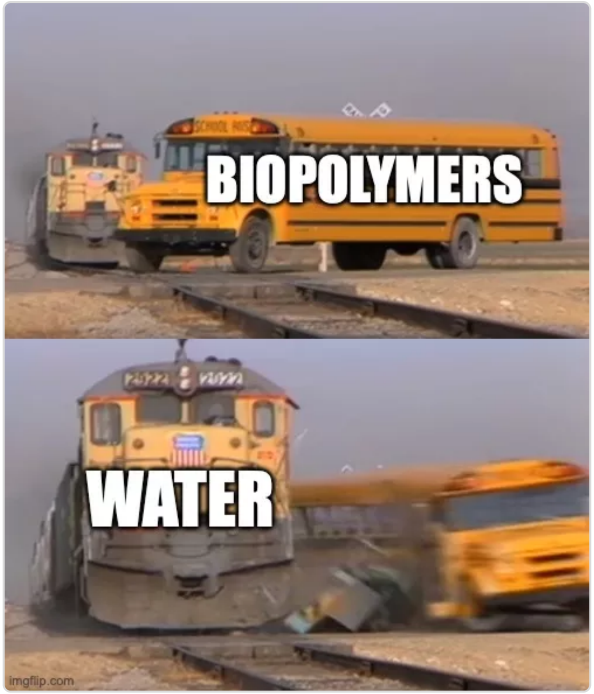
Meme by Sardar



Meme Oyku Cise

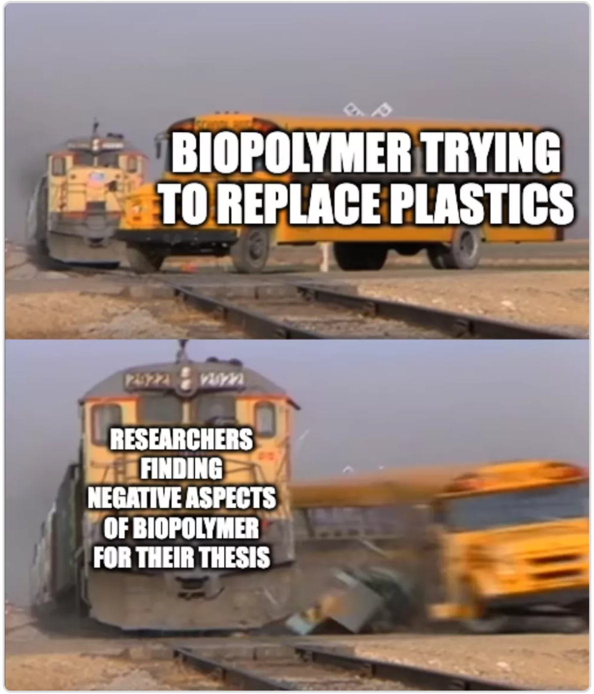
Meme Yuxuan Sun

Meme Elsa Vuorenmaa



Chamodya Ranawaka Arachchige

Meme Anitha Venkatramani

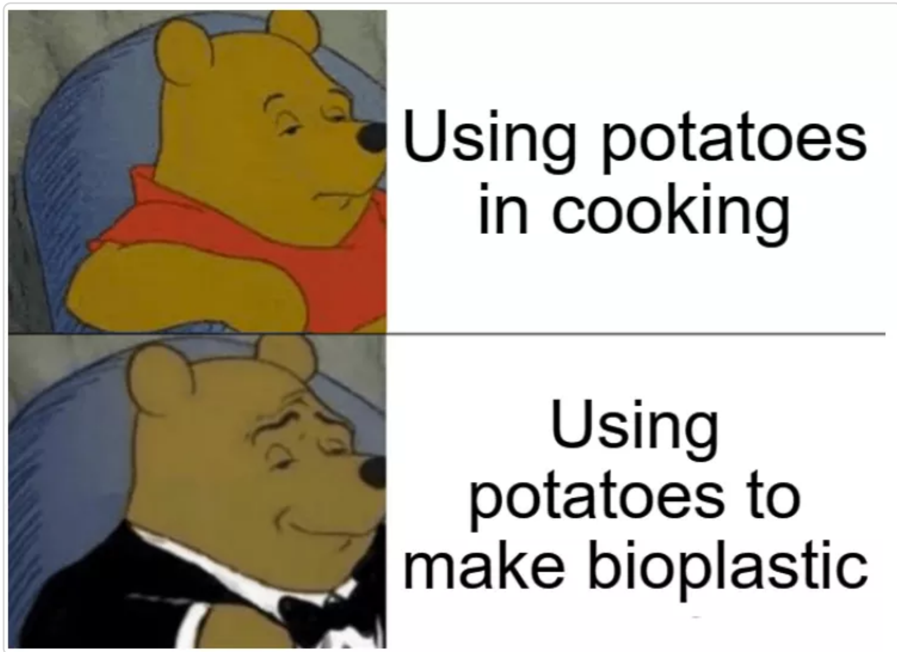


Meme Anni Raulahti

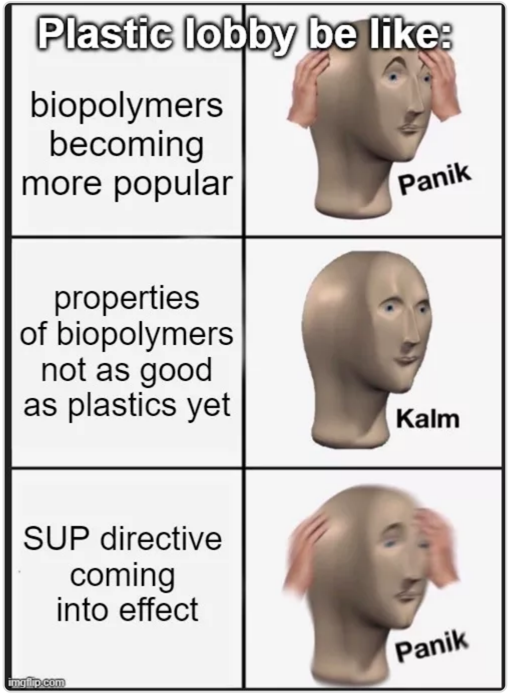
Anniina Tamminen

Meme Inga Räty

Meme Inga Räty

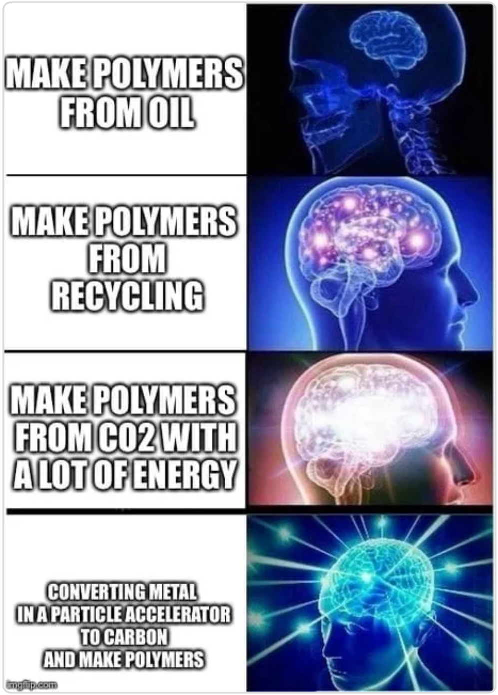


Meme Eva González

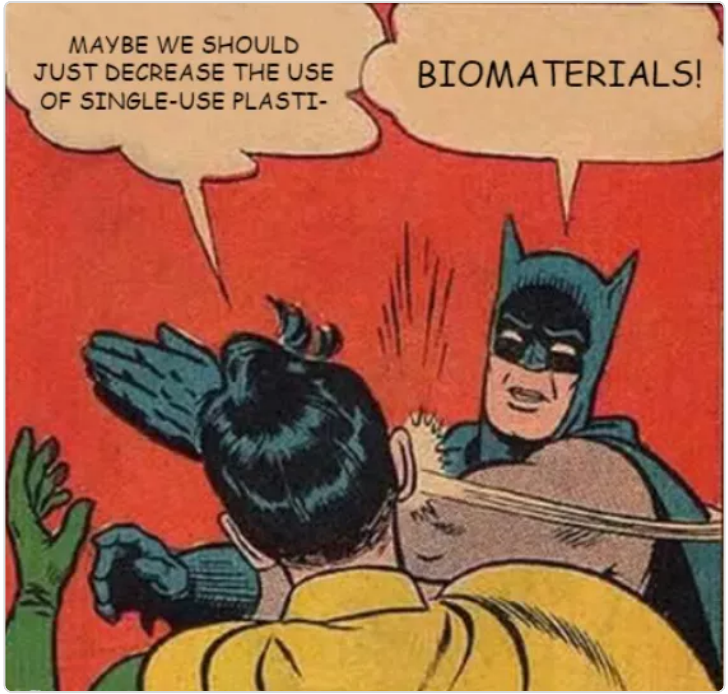


Sampsa Mäenpää

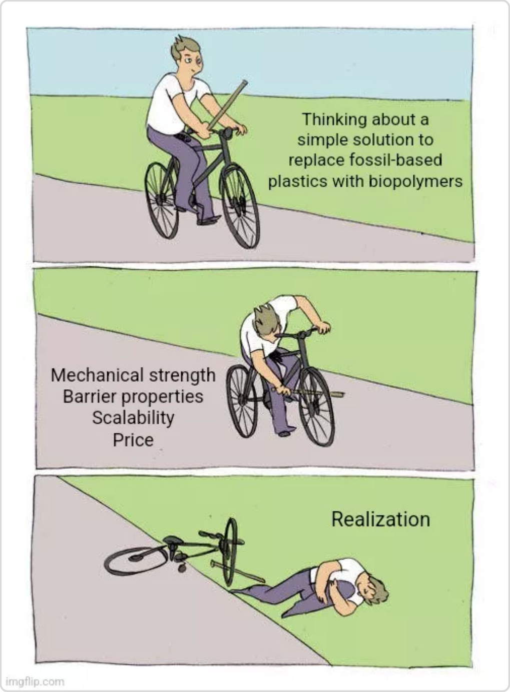
Asfar Hussain Khan



Meme Oona Hanska



Tiinamari Seppänen



Meme Yuxuan Sun

Krisnadewi Suciati

Meme Nikita Jamkin