Biopolymers Discussion day

Biopolymers
CHEM-E2155

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Schedule

Day	Subject of lecture	Discussion part
08 January	Introduction to the course	
15 January	Biopolymers overview	Reading 1
22 January	Biopolymers for packaging	Reading 2
29 January	Discussion day	Reading 3 & Assignment 1
05 February	Biodegradation 1	Reading 4
12 February	Biodegradation 2	Reading 5
26 February	Discussion day	Reading 6 & Assignment 2
04 March	Chitin, alginates and others	Reading 7
12 March	Proteins	Reading 8
19 March	Discussion day	Reading 9 & Assignment 3
25 March	TBD	Reading 10

Schedule

- **Short joint discussion** / ca. 5-10 min
- **Breakout rooms with each 4-5 students** / 25-30 min
- **Return to main session for rep-up**/ ca. 5 min

- **Break**

- **Discussion of reading assignment 3**

Learning Outcomes

For the first assignment

- You have used tools to identify current material properties
- Selected criteria to provide a solution for a defined problem

Assignment 1

1. Find out what kind of (bio-)polymers LEGO® uses currently (or used in the past) to make their LEGO® pieces.
2. Choose one of the polymers above (either biobased or not).
3. Discuss the properties of such polymer in terms of thermal properties (glass transition or melting temperatures) and its recyclability.
4. Propose one alternative to address one of the enhanced properties indicated above (a), (b) or (c), keeping in mind that such alternative should not disturb the process used, e.g., thermo-molding.

Polymer	What is made with it?
ABS (acrylonitrile butadiene styrene)	Classic LEGO bricks and DUPLO
HIPS (high impact polystyrene)	Baseplates
PA (polyamide)	Gearwheels and connectors
MABS (methyl methacrylate-acrylonitrile-butadiene-styrene)	Transparent elements e.g. windshields and transparent plates
MTPO (metallocene thermoplastic polyolefins)	Flexible rods and baskets
PC (polycarbonate)	Hinges as well as ball and cup connectors
PE (polyethylene)	HDPE: flags and limb elements, LDPE: plants
POM (polyoxymethylene)	Axles and connector pegs
PP (polypropylene)	Some more specific parts e.g. ninja sword
TPU (thermoplastic polyurethane)	Bendable elements e.g. LEGO dots bracelet
SEBS (styrene-ethylene-butylene-styrene)	e.g. tires
TP (thermoplastic polyester)	e.g. roof tiles and brick separator

Proposed substitutes

- (biobased) PE, r-(HD)PE
- ABL Acrylonitrile butadiene lignin
- ABS with biobased CAN
- ABS+flax
- PLA (PLA/ABS, PLA/PC)
- r-PET
- PHAs
- (r-)PP
- bio-PA
- polycarbonate
- poly(limonene carbonate)
- Polyimine-paper composites
- (bio-)thermoplasic polyurethane
- Polybutylene adipate-terephthalate
- Sulapac Luxe – IM1025
- CA+clay

Comments

Missing considerations:

- viscosity for injection molding
- dyeability
- price
- toxicity

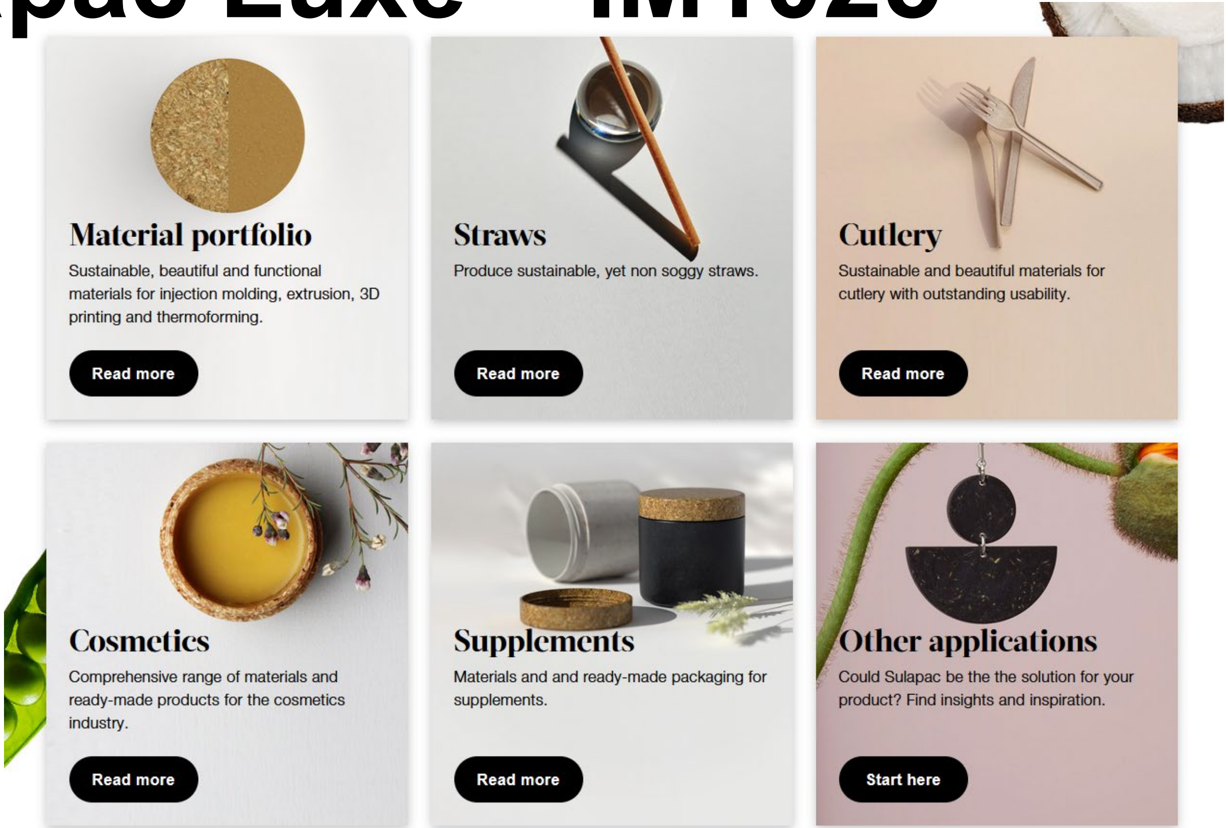
Notes:

- source of pictures has to be mentioned
- add access date to web-page

Grading

- Fulfilling all criteria mentioned in the assignment description led to grade 4
- Relevant additional information and coherent presentation: 5
- Reductions for missing information
- Used sources (webpages, scientific articles, etc.)

Sulapac Luxe – IM1025



https://www.sulapac.com/

Sulapac Luxe – IM1025

TDS – SULAPAC LUXE – IM1025
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SULAPAC

TECHNICAL DATA SHEET

6.3.2023

Version 1.1

SULAPAC LUXE – IM1025

MATERIAL FEATURES

Sulapac Luxe is a bio-based (~80%) material for injection molding made of sustainably sourced biodegradable biopolymers and wood flour. It is safe for people and the planet: it leaves no permanent microplastic or toxic load behind. The material is recyclable and can also be made with recycled content. Sulapac Luxe is resistant to temperature fluctuations, has a ceramic feel and sound, and enables a glossy, smooth surface for a product, making it ideal for caps and lids of premium cosmetics packaging, for example.

MECHANICAL PROPERTIES	
MATERIAL	SULAPAC LUXE (IM1025)
PHYSICAL PROPERTIES	
Material density (g/cm^3)	1.27
Shrinkage (%)	0.3
TENSILE PROPERTIES (ISO 527-1)	
Tensile strength (MPa)	50
Tensile modulus (GPa)	3.6
Tensile strain (%)	2
FLEXURAL PROPERTIES (ISO 178)	
Flexural strength (MPa)	75
Flexural modulus (GPa)	3.7
Flexural strain (%)	2.7
IMPACT PROPERTIES (Unnotched, ISO 179-1)	
Charpy impact strength (kJ/m^2)	15
RHEOLOGICAL PROPERTIES (ISO 1133)	
MFI (190 °C/2.16 kg)	14 – 16

https://www.sulapac.com/wp-content/uploads/2023/08/TDS-Sulapac-Luxe-IM1025-ID-14060.pdf

Sulapac Luxe – IM1025

Example 1: Preparation of the first biopolymer

PBHV (ENMAT Y1000P) is dried at 80 ˚C for 4 hours. PHBV and talc with median particle size of 1.7 µm are fed from separate gravimetric feeders into a twin-screw extruder. PHBV is fed from the zone 1 of the extruder and talc from side feeder in the middle of the extruder. Materials are melt-mixed in composition of 70 wt.-% of PHBV and 30 wt.-% of talc using processing temperatures of 120-160-170-160-150-150 ˚C, with a screw speed of 300 rounds per minute and total throughput of 40 kg/h. The resulting compound has a melt temperature of 174 ˚C, torque of 75 % and melt pressure of 57 to 61 bar. The produced strands are cooled down using a water-bath and granulated. Melt flow index of the resulting compound is 5.8 to 6.2 g/10 min (190 ˚C, 2.16 kg).

Example 2: Forming a container and a closure

2K-injection moulding was performed using a container mould with product diameters of container outer diameter 60 ± 0.15 mm and inner diameter 50.5 of mm. The container holding capacity was 50 ml. The used mould temperature was 60 ˚C for inner coating layer, i.e. the first biopolymer layer, including PHBV and talc according to example 1, and cold (between 20 to 40 ˚C) for outer, PLA-wood based second layer. The thickness of the coating layer was 0.8 mm, thread thickness in the collar part 0.9 to 1.7 mm, and thickness of the wood containing outer layer was 4.1 mm.

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Example 1. Preparation of the composite materials

10 wt.% PHBH Kaneka X331N, 35.5 wt.% bioPBS FZ71PM and 5 wt.% PLA L105, 1 wt.% of calcium stearate, and 0.5 wt.% of ethylene-bis-steramic wax were fed with gravimetric feeders into a mass-scale co-rotating twin-screw extruder from the first zone without prior drying. The temperature of the extruder with 11 heating zones was set to 170-170-170-170-170-165-160-160-160-160-160°C, from the hopper to the die, accordingly. Wood with 0.5 mm average particle size was applied from the 1. side feeder between 2 and 3 heating zones, and talc with D50 of 6 µm of was fed from the 2. side feeder between the 6. and 7. heating zones. Throughput of 155 kg/h and rpm of 85 was used. During the compounding, melt pressure and melt temperature was determined, resulting in 33 and 178°C, accordingly. The produced strands were cooled down using a water bath and granulated. From the output, melt flow index, melt volume rate, ash content, and moisture were analyzed. The resulting compound had MFI of 5.6 g/10 min (190°C, 2.16 kg), MVR of 4.2 cm^3/10min (190°C, 2.16 kg), ash content of 26.8 %, and moisture of 0.13%.

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Injection molding

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https://www.youtube.com/watch?v=RMjtmsr3CqA

Discussion of Assignment 1

1) Present your slides to each other
2) Discuss how and where you have found your information
3) Explain your solution

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