Biopolymers Discussion day

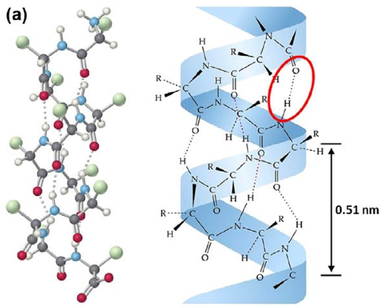
Biopolymers
CHEM-E2155

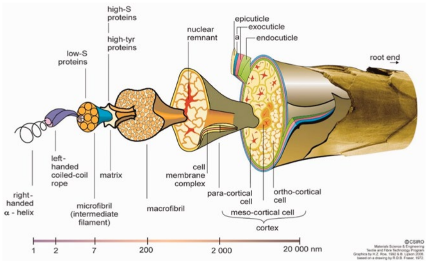
Inge Schlapp-Hackl

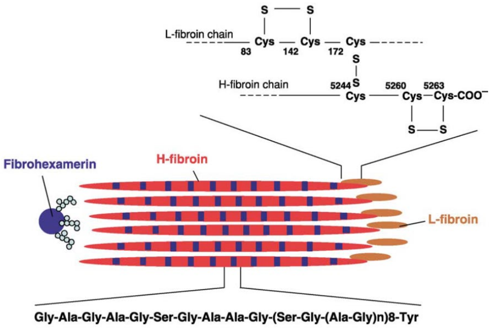
Aalto University
School of Chemical
Engineering

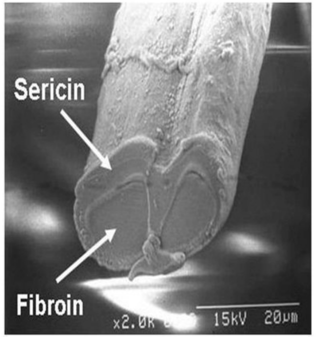
Previous lecture

Keratin and fibroin

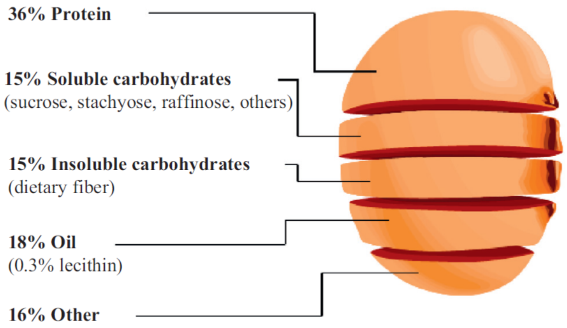




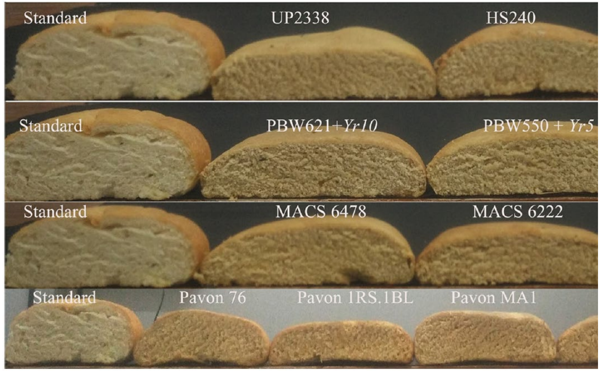




Soy protein



Glutens



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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
11 March	Proteins	Reading 8
18 March	Discussion day	Reading 9 & Assignment 3
25 March	TBD	Reading 10

Schedule

- **Analysis and discussion of Assignment 3**
- **Discussion of reading assignment 9**

Assignment 3
Kitchen chemistry

Learning Outcomes

For the third assignment you

- developed an understanding for the reactivity and/or property changes of selected biopolymer(s) through simple chemical modification
- have developed diplomatic skills to explain the mess in your kitchen

Demonstrated kitchen chemistry

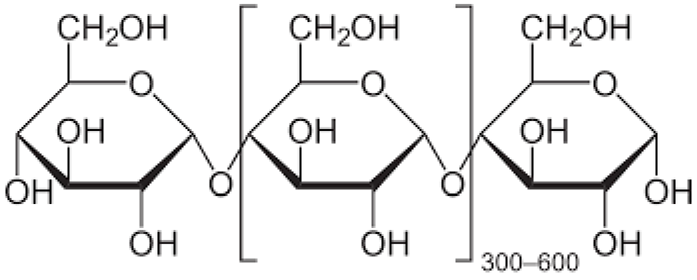
- plastic starch
  - corn: 18
  - potato: 9
  - oat: 1
  - rice: 1
  - tapioca: 1
  - Banana: 1

- plastic from casein: 17
- gelatine (Jell-O shot): 6
- agar: 2
- egg white protein: 1
- paper foam: 1

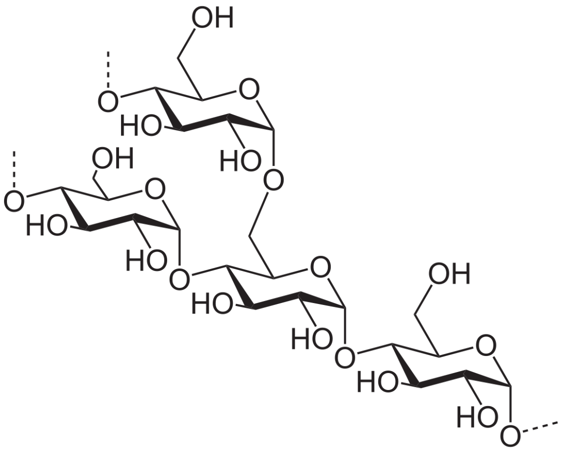
Message from Michael:

It was really fun to watch your videos. Most of you did an excellent job. I hope you shared the video with your friends and family. I am sure they will enjoy your own mini biopolymers lecture!

Plastic from starch



Amylose
20-30%



Amylopectine
up to 85%
branching via α(1→6) bonds every 24 to 30 AGU

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Plastic from starch

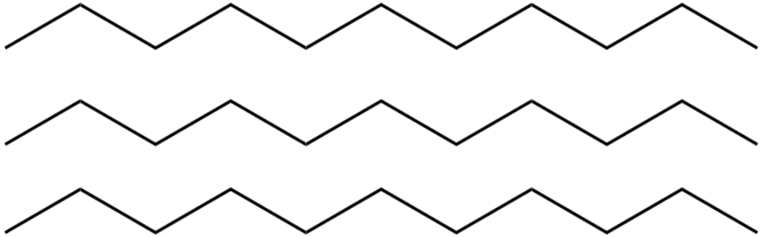

Figure 1 Polymer chains lined up – the product is very brittle

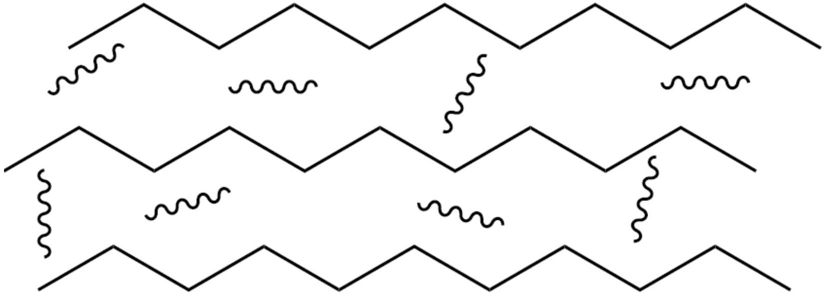

Figure 2 Polymer chains have small molecules between them, which prevents them from lining up

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For more info see:
https://edu.rsc.org/experiments/making-plastic-from-potato-starch/1741.article

Plastic from starch

TABLE 4. MECHANICAL PROPERTIES OF WHEAT STARCH FILMS WITH DIFFERENT GLYCEROL CONTENTS (% W/W) AT 25C AND DIFFERENT RELATIVE HUMIDITIES*

	RH (%)	Glycerol (%) 0	20	30	40	50
A						
Tensile strength (MPa)	11	23.42 ± 0.12^{Aa}	21.77 ± 0.01^{Ab}	19.25 ± 0.48^{Ac}	17.48 ± 0.49^{Ad}	12.27 ± 0.13^{Ae}
	22	21.43 ± 0.25^{Ba}	18.70 ± 0.84^{Bb}	17.41 ± 0.50^{Bc}	16.75 ± 0.52^{Bc}	4.77 ± 0.09^{Bd}
	38	19.52 ± 0.23^{Ca}	17.47 ± 00.50^{Cb}	16.10 ± 0.31^{Cc}	4.53 ± 0.23^{Cd}	2.87 ± 0.16^{Ce}
	64	13.40 ± 0.17^{Da}	11.95 ± 2.61^{Db}	5.62 ± 0.39^{Dc}	$2.05 \pm 0.13^{ED,d}$	1.85 ± 0.08^{Dd}
	74	11.78 ± 0.17^{Ea}	9.36 ± 0.24^{Eb}	3.89 ± 0.21^{Ec}	2.20 ± 0.10^{Dd}	1.65 ± 0.06^{Ee}
	84	10.19 ± 0.20^{Fa}	7.26 ± 0.27^{Fb}	3.42 ± 0.35^{Ec}	1.63 ± 0.12^{Ed}	1.49 ± 0.14^{Ed}
Percent elongation at break (%)	11	0.53 ± 0.07^{Fe}	1.05 ± 0.57^{Ed}	1.89 ± 0.23^{Fc}	5.20 ± 0.05^{Fb}	5.95 ± 0.07^{Fa}
	22	1.81 ± 0.14^{Ee}	3.17 ± 0.10^{Dd}	3.82 ± 0.14^{Ec}	8.32 ± 0.16^{Eb}	14.24 ± 0.14^{Ea}
	38	2.15 ± 0.30^{De}	3.53 ± 0.23^{Dd}	4.61 ± 0.06^{Dc}	15.07 ± 0.44^{Db}	16.69 ± 0.23^{Da}
	64	4.62 ± 0.16^{Ce}	6.75 ± 0.13^{Cd}	10.76 ± 0.09^{Cc}	16.16 ± 0.06^{Cb}	19.18 ± 0.01^{Ca}
	74	5.66 ± 0.14^{Be}	7.98 ± 0.08^{Bd}	11.85 ± 0.05^{Bc}	16.91 ± 0.06^{Bb}	21.43 ± 0.10^{Ba}
	84	11.31 ± 0.15^{Ae}	12.45 ± 0.63^{Ad}	14.16 ± 0.07^{Ac}	19.10 ± 0.60^{Ab}	21.43 ± 0.06^{Aa}

Journal of Texture Studies 2013, 44, 176-186. doi:10.1111/jtxs.12007

Isolation of casein

- Three kinds of proteins in milk: caseins, lactalbumins, and lactoglobulins (globular proteins; complete proteins)
- Casein, the main protein in milk, is a phosphoprotein, and appears as calcium caseinate in milk
- Three similar proteins which differ primarily in molecular weight and the amount of phosphorus groups they contain:
  - α- and β-casein: 25 kDa ; 9 and 4-5 phosphate groups per molecule, respectively; both insoluble in water
  - κ-casein: 8 kDa, 1-2 phosphate groups per molecule; can solubilize α- and β-casein in water by promoting the formation of micelles.

For more info see:
- https://www.chemistry.mcmaster.ca/~chem2o6/labmanual/expt11/2o6exp11.html
- International Dairy Journal 2017, 73, 98-108. http://dx.doi.org/10.1016/j.idairyj.2017.05.012

Isolation of casein

- Isoelectric point of calcium caseinate: pH 4.6 (Milk pH 6.6)

- Natural separation process occurs when milk sours; microorganisms hydrolyse lactose to form glucose and galactose; lactobacilli (bacteria strain present in milk) converts galactose into lactic acid (sour-tasting); pH drops

- Cheese production
- In 1921, the company Sarvis Oy in Tampere started to produce plastic from casein; ceased production with the rise of oil-based plastics

For more info see:
- https://www.chemistry.mcmaster.ca/~chem2o6/labmanual/expt11/2o6exp11.html
- International Dairy Journal 2017, 73, 98-108. http://dx.doi.org/10.1016/j.idairyj.2017.05.012

Comments

Majority of the submissions of high quality

Chemistry behind it mostly explained very well

Reading 9

Title: Green Polymer Chemistry and Bio-based Plastics: Dreams and Reality
From: Rolf Mülhaupt. *Macromol. Chem. Phys*. 2013, 214, 159−174.

- bioplastics vs. bioenergy = biocrisis
- Plastic vs. paper bag
- …It is well known that degradation renders polymers brittle, thus accounting for their disintegration into much smaller micro- and nanoparticles … dust-like particles are still present,…Spongy biodegradable polymers represent an attractive food source and a cozy habitat for a variety of microbes
- …Knowing that plastics wastes are biodegradable may open the door to unrestrained littering of all kinds of nondegradable wastes.
- …Today, bio-based monomers are used to render conventional plastics like PET and polyolefins renewable and green…

Reading 9 discussion

Title: Green Polymer Chemistry and Bio-based Plastics: Dreams and Reality
From: Rolf Mülhaupt. *Macromol. Chem. Phys*. 2013, 214, 159−174.

Discussion items:

- 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.

Instructions:
Upload your names and summary of your discussion to the Padlet page:
https://padlet.com/michaelhummel/CHEME2155_2024