Biopolymer Films for Product Packaging

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Meet The Team

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Overview

Paper-based Packaging

Properties
✓ Structural integrity
✓ Low cost
✓ Recyclability, biodegradability
✗ Poor moisture barrier

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Barrier properties compensated by polyolefins

Proposed Strategies

1: Biopolymer Films

- Polymers derived from natural sources
  - Chitosan
  - Pectin
  - Gelatin

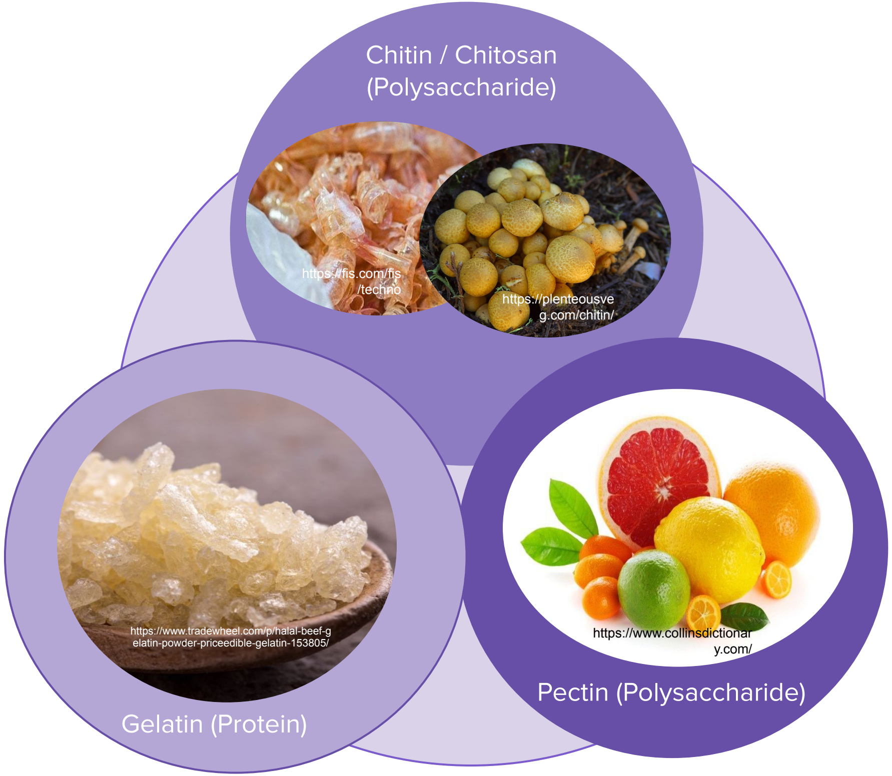
2: Chemical Additives: "Cross-linkers"

- Crosslinking film to improve barrier & mechanical properties with:
  - Genipin
  - Ferulic Acid

3: Physical Additives: "Nanofillers"

- Reinforcing film's barrier & mechanical properties with:
  - Nanoclays
    - Montmorillonite (MMT)
  - Fibers
    - Cellulose Nanocrystals

Selected biopolymers for film formulation



Performance criteria for Bad Actors & Biopolymers

		PFAS*	Polyethylene	Polypropylene	Chitin/Chitosan	Pectin	Gelatin
Barrier Properties	Water Vapor Permeability (WVP) (g/m*day*atm)	H	H	H	L	L	M
	Water Contact Angle	H	H	H	H	M	
Mechanical Properties	Tensile Strength (MPa)	H	H	H	M	M	H
	Total Elongation at Break	H	H	H	M	L	L

*Teflon (Polytetrafluoroethylene-PTFE) was used as a baseline for PFAS performance criteria comparisons.

High Efficiency | Medium Efficiency | Low Efficiency | Data Gap

Hazard Assessment for Bad Actors & Biopolymers

Bad Actors & Biopolymers	**PFAS**	**Polyethylene**	**Polypropylene**	**Chitin/Chitosan**	**Pectin**	**Gelatin**
Persistence	H	H	H	L	L	L
Bioaccumulation	H	L	L	L	L	L
Sensitivity / Irritation *(Eye, Skin, Respiratory)*	M	M	M	L	M	M
Toxicity (Dev & Repro, Systemic, Neuro.)	H	D	D	L	L	D
Aquatic Toxicity	H	L	L	M	D	L
Carcinogenicity / Mutagenicity	H	L	L	L	L	L
Endocrine	H	D	D	D	D	D

Low Hazard | Medium Hazard | High Hazard | Data Gap

Cross-linking

- **Cross-linking** is a "stabilization process in polymer chemistry which leads to multidimensional extension of polymeric chain resulting in network structure."

- Not only does technical performance depend on the **biopolymer combination**, it also depends on the **crosslinker** and the nature of its **crosslinking mechanism**.

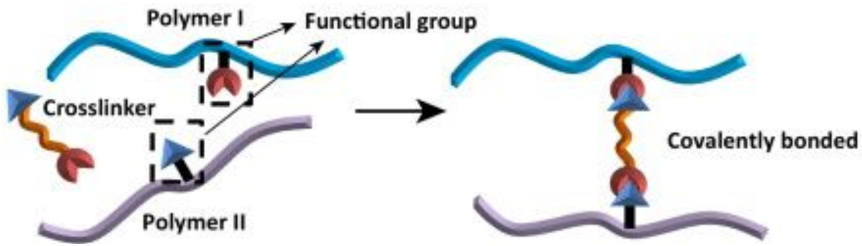


Image from https://www.sciencedirect.com/science/article/pii/S0167779915000700#tbl0005

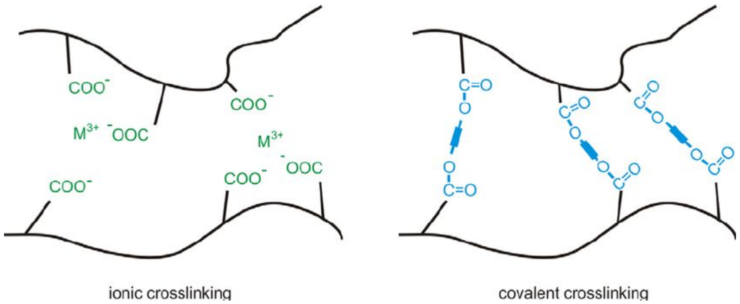


Image from
https://www.researchgate.net/publication/263355077_Investigation_of_Cross-Linked_and_Additive_Containing_Polymer_Materials_for_Membranes_with_Improved_Performance_in_Pervaporation_and_Gas_Separation

Performance criteria for Crosslinking Reagents

		Glutaraldehyde			Genipin			Ferulic Acid		
Biopolymer		**Pectin**	**Gelatin**	**Chitosan**	**Pectin**	**Gelatin**	**Chitosan**	**Pectin**	**Gelatin**	**Chitosan**
Barrier Properties	**Water Vapor Permeability (g*mm/kPa *m2* h)**	D	H	M	H		M	D	M	L
	Water contact Angle	D	D	H	D	D	H	D	D	D
Mechanical Properties	**Tensile Strength (MPa)**	H	H	H	D	H	H	D	M	M
	Total Elongation at Break	H	H	D	D	L	M	D	L	L

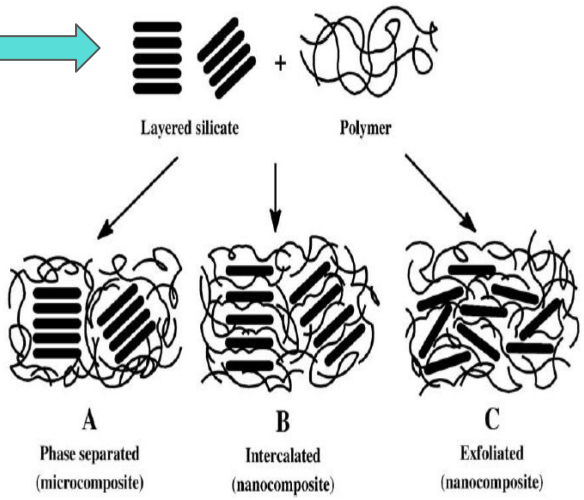
High Efficiency | Medium Efficiency | Low Efficiency | Data Gap

Hazard Assessment for Crosslinking Reagents

Crosslinking Reagents	**Glutaraldehyde**	**Genipin**	**Ferulic Acid**
Persistence	M	L	L
Bioaccumulation	L	D	D
Sensitivity / Irritation *(Eye, Skin, Respiratory)*	M	D	M
Toxicity (Dev & Repro, Systemic, Neuro.)	H	L	L
Aquatic Toxicity	H	D	L
Carcinogenicity / Mutagenicity	D	D	L
Endocrine	H	D	L

Low Hazard
Medium Hazard
High Hazard
Data Gap

Nanofillers: Clays and Fibers



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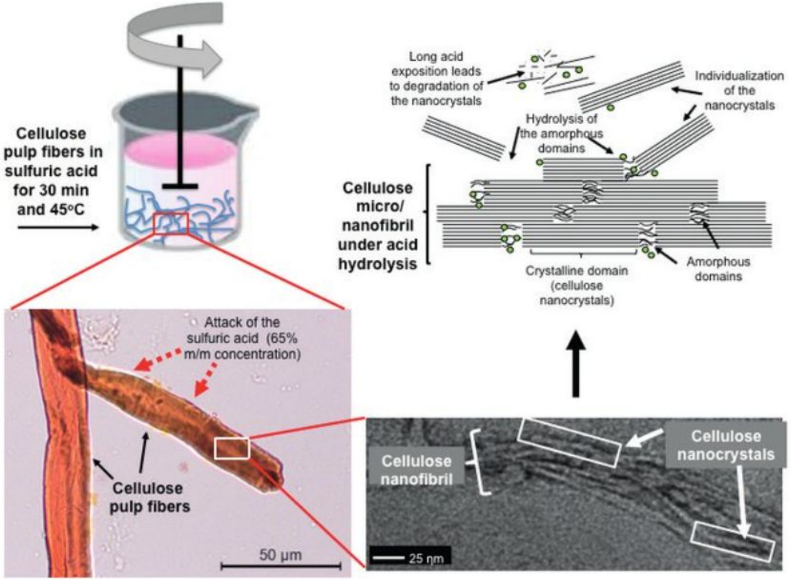
Natural Fibers



Performance criteria for Nanofillers

		Montmorillonite (MMT)			Cellulose Nanocrystals (CNC)		
Biopolymer		**Pectin**	**Gelatin**	**Chitosan**	**Pectin**	**Gelatin**	**Chitosan**
Barrier Properties	**Water Vapor Permeability**	H	H	H	H	H	H
	Water contact Angle	D	D	D	D	D	M
Mechanical Properties	**Tensile Strength (MPa)**	H	H	H	H	H	H
	Total Elongation at Break	L	L	L	H	L	D

High Efficiency | Medium Efficiency | Low Efficiency | Data Gap

Hazard Assessment for Nanofillers

Physical Additives	Montmorillonite	Cellulose Nanocrystal
Persistence	H	L
Bioaccumulation	L	D
Sensitivity / Irritation *(Eye, Skin, Respiratory)*	M	H
Toxicity (Dev & Repro, Systemic, Neuro.)	D	L
Aquatic Toxicity	L	L
Carcinogenicity / Mutagenicity	L	L
Endocrine	D	D

Low Hazard

Medium Hazard

High Hazard

Data Gap

Final Assessment

Laundry Powders

Detergents

Soaps

Increasing dilution and moisture barrier requirements

Questions?

And Discussions