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"Sustainable Hydrophobic Coating on Paper Based on Natural Rubber Latex and Butyl Stearate"

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Introduction

Corrugated Boxes

Paperboard Cartons

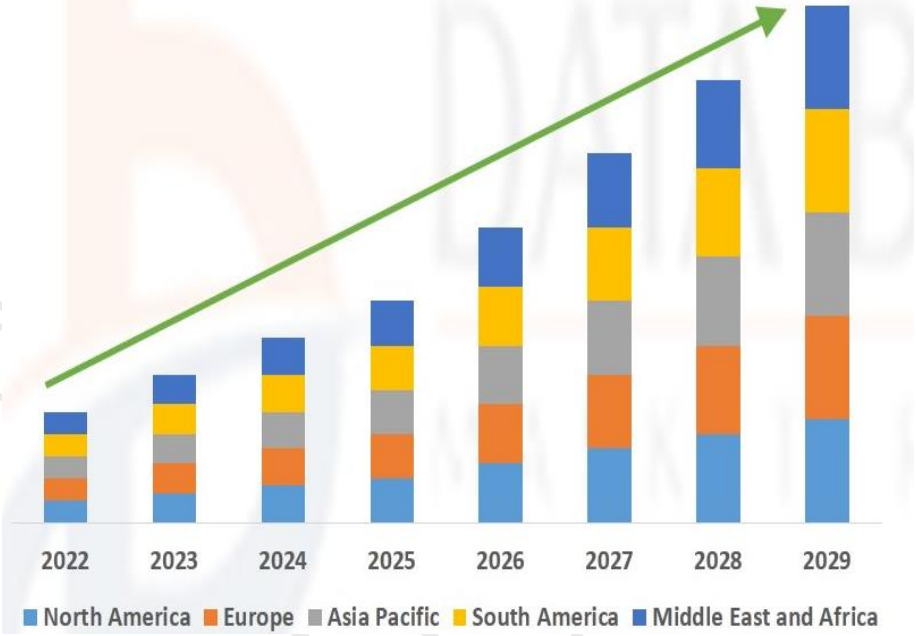
Paper Bags

Paper Sacks

Different types of paper based packaging materials

Introduction

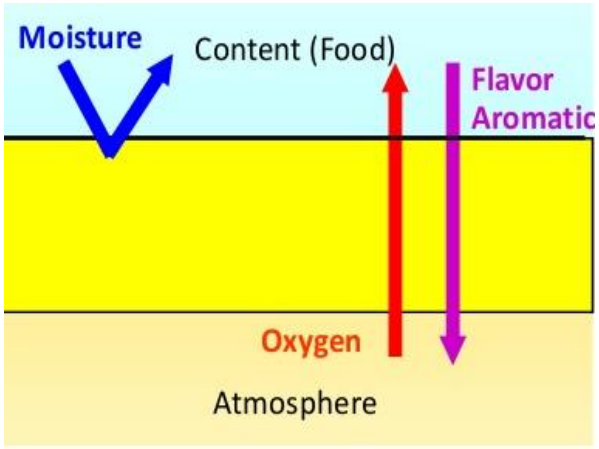
- The global Paper & paperboard packaging market is estimated grow from USD 200 billion in 2022 and is projected to reach USD 254.5 billion by 2026, at a CAGR of 5.0% during the forecast period



- Although paper based packaging has huge market potential, the main drawback is its poor barrier properties.

https://www.marketsandmarkets.com/Market-Reports/paper-paperboard-packaging-market-23392290.html

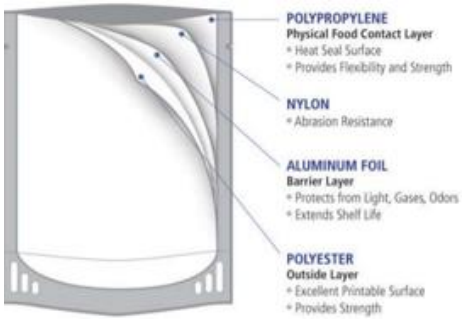
Importance of Barrier in Food Packaging



Barrier properties (oxygen & moisture)

Extended shelf life and to limit food deterioration

The food deterioration is mainly governed by oxidation process or caused by aerobic bacteria and mold growth in presence of Oxygen and moisture. (Sugiyama, 2006).



Traditional High barrier packages

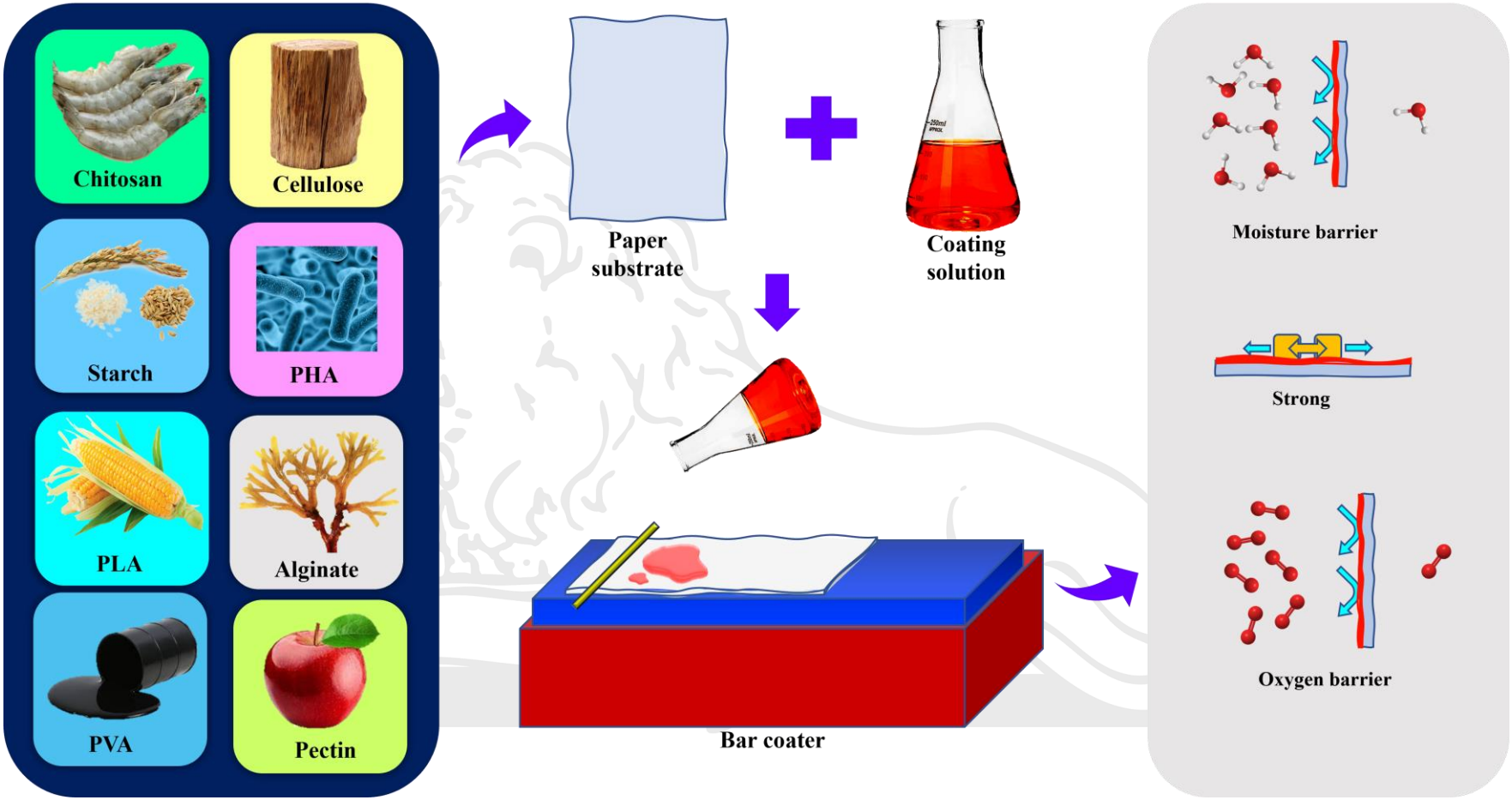
Issues

- ✓ Susceptible to lose its barrier because of flexural cracking.
- ✓ Costs associated with this solution (to make high barrier)
- ✓ Processing
- ✓ limits their recyclability
- ✓ Limits their biodegradability (or compostability)

Paper Packaging material

→ Generally, poor barrier → Limits their application in food packaging

Sustainable coatings on paper for enhancing properties

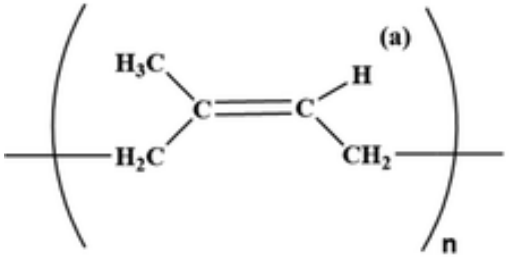


Hydrophobic coatings

- Hydrophobicity comes from the Greek word
  - Hydro(water)
  - Phobicity(fear)
- It refers to the physical property of a material that repels water.
- The process of coating the surface of a material with hydrophobic material in order to avoid sticking of liquids on that surface is called **Hydrophobic Coating.**
- Paper is a hydrophilic material. In order to make paper hydrophobic we need to use hydrophobic coating.

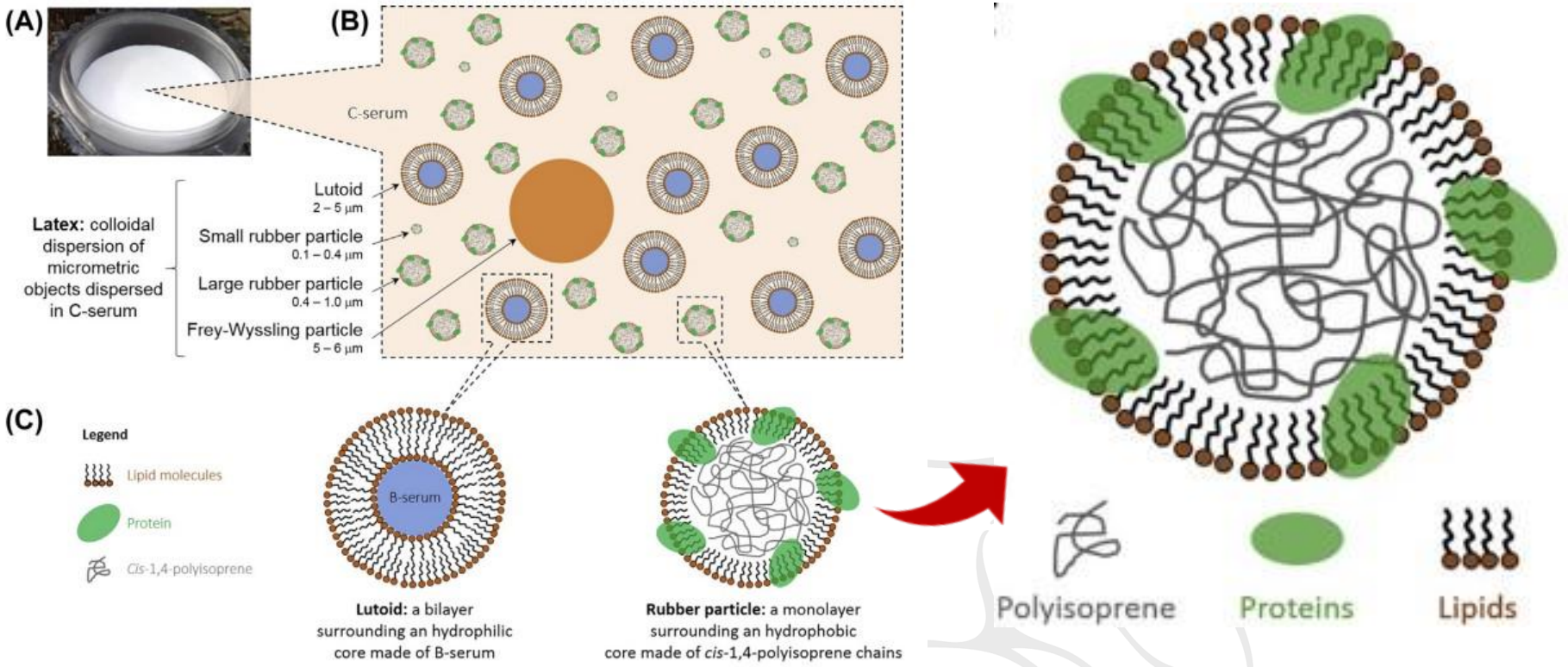
Natural Rubber Latex

Natural Rubber Latex



- Natural Latex is produced from the *Hevea Brasiliensis* rubber tree consists of **poly-*cis*-1,4-isoprene polymer**.
- These trees primarily found in Thailand, Indonesia, Malaysia, and Liberia.
- Natural Latex is a cloudy, white liquid that is collected by cutting thin strips of bark from the tree.
- The latex is placed into a centrifuge, stabilizers are added, and the latex is centrifuged to remove some of the water & increase the rubber content of the latex. latex concentrate, and contains roughly 60% rubber.

Natural Rubber Latex



- The fatty acid composition of Hevea lipid extracts shows 9 different species including myristic acid (C14:0), palmitic acid (C16:0), palmitoleic acid (C16:1), **stearic acid (C18:0),** oleic acid (C18:1), linoleic acid (C18:2), linolenic acid (C18:3), arachidic acid (C20:0) and furanoid fatty acid

Properties of NRL

Properties

- High molecular weight
- High elasticity
- Recyclability
- Ease of film-forming

Disadvantages

- Poor grease barrier resistance
- Generally unable to bear high loads
- Poor weather resistance

Applications

- Coatings
- Adhesives
- Eraser
- Mattresses
- Gloves
- Power transmission belts
- Chewing gum

Bio-degradable

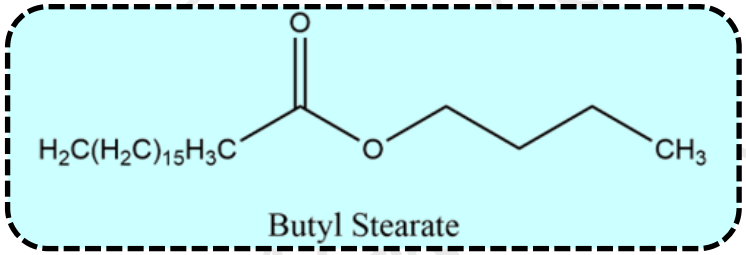
Butyl Stearate

Butyl Stearate

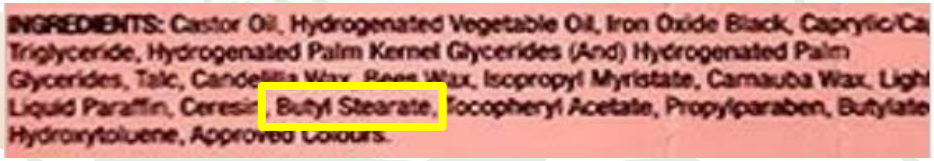
- Butyl stearate, also called octadecanoic acid, is an organic chemical compound which belongs to the family of alkyl esters of fatty acids.
- Butyl stearate is a long-chain fatty acid ester composed of butanol and stearic acid.

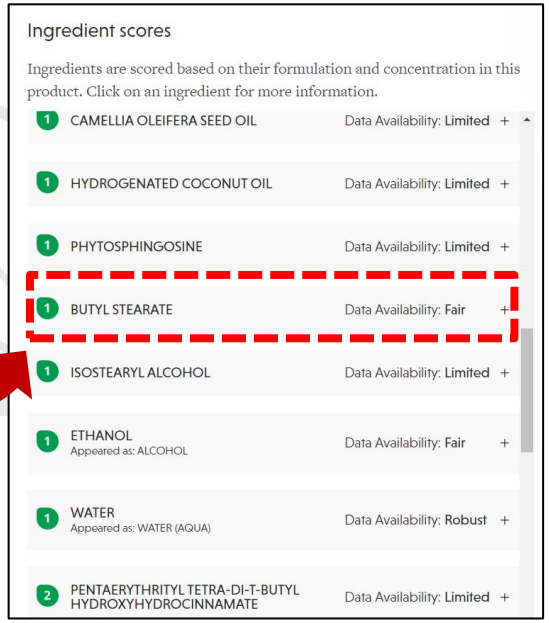
Properties

- tendency to form **hydrophobic**, non-greasy film
- low viscosity
- ideal lubricant in metalworking
- additive for paints& printing inks



Butyl Stearate





Butyl Stearate

Applications

- Plasticizer in the production of plastic and polymers
- Oiling agent for textile
- Emollient in cosmetics & personal care products
- Emulsifying and flavoring agent in food & beverage industry

Hi Food! I am Butyl Stearate. Can I be in contact with you?

Why not Butyl. It's my pleasure to be in contact with you.

Food and Drugs Administration Approved Material

Problem Statement

Problem with using synthetic based hydrophobic coatings

Non-Biodegradable

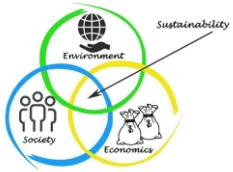
Due to the presence of synthetic plastics, commercial hydrophobic coatings are not bio-degradable

Non-Recyclable

As synthetic polymer coatings will be done on papers, recycling is not possible

Harmful to health and environment

Synthetic polymers are harmful to both humans health and environment



Sustainability

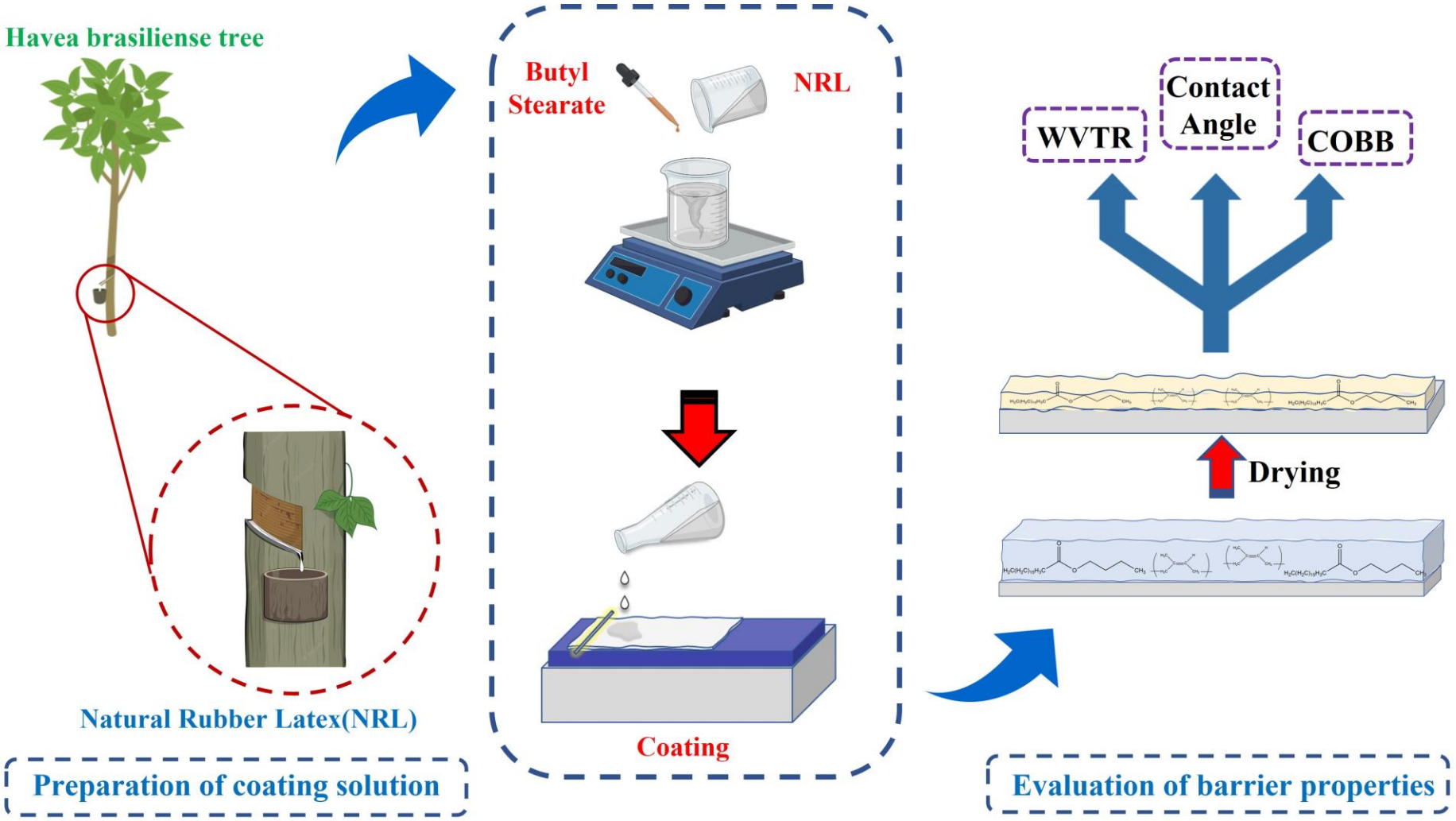
Commercial hydrophobic coatings are not sustainable because they are produced from synthetic plastics

Cost

Hydrophobic coatings available in the market are highly costly

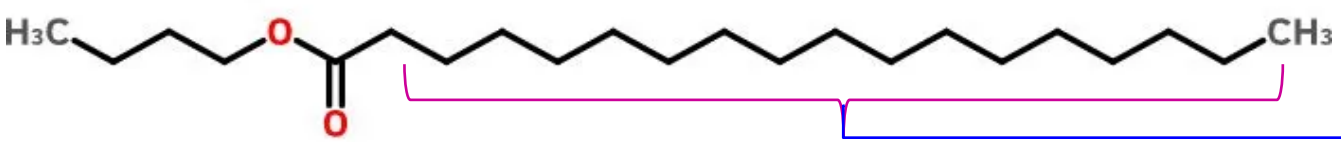
Coating Development

Methodology



Mechanism

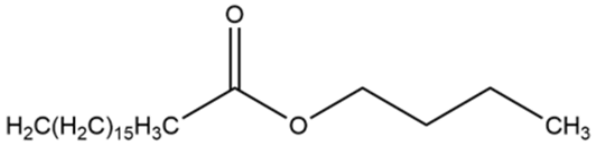
Chemistry behind Hydrophobicity of Coating solution



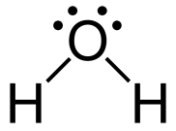
Butyl Stearate

Long Hydrocarbon Chain

Repels Water



Non-Polar Molecule

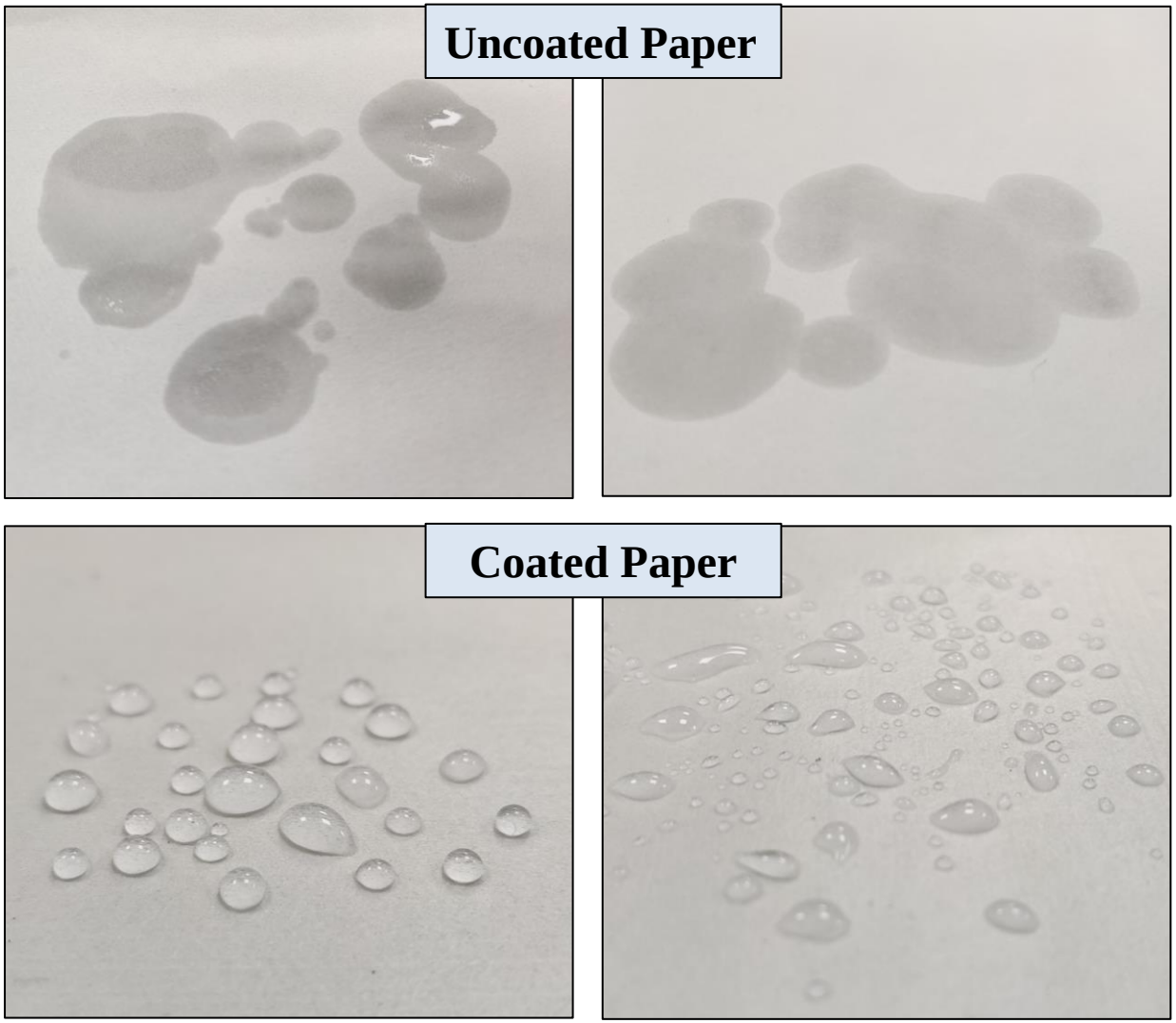


Polar Molecule

- Butyl stearate has a non-polar molecular structure, which means it is not attracted to water molecules.
- The hydrophobic nature of butyl stearate prevents it from forming a strong bond with water molecules.
- The hydrocarbon chains of butyl stearate are too long and are not able to interact with water molecules.
- Butyl stearate is a wax-like substance and therefore forms a protective barrier on the surface

Technology Development

Paper substrates with hydrophobic coating

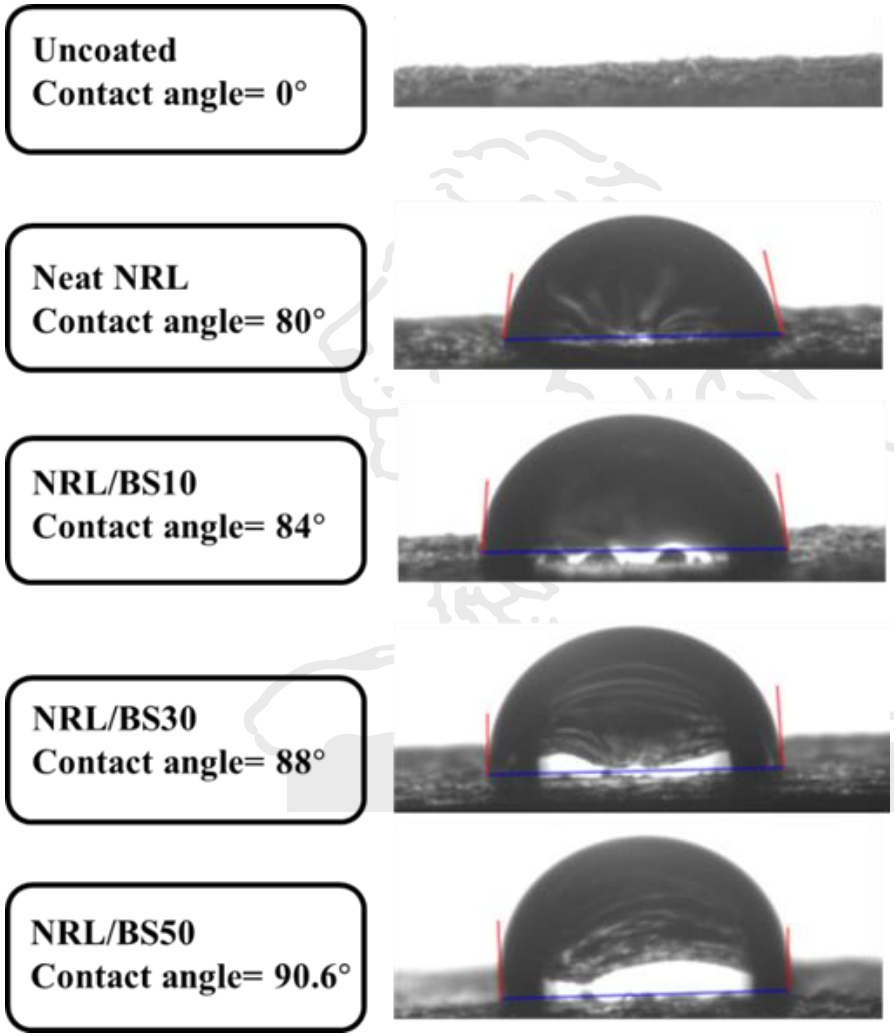


Coated on 90 GSM white paper

Technology Development

Demonstration of Water resistance of coated paper

Wettability



- The uncoated paper showed the lowest contact angle which is equivalent to 0° confirming its hydrophilicity.
- After coating with NRL, the contact angle suddenly raised to 80° showing intermediate wetting behaviour
- At 50% butyl stearate concentration contact angle exceeded 90° showing hydrophobic behaviour.

Mechanical properties

Mechanical Properties coated paper

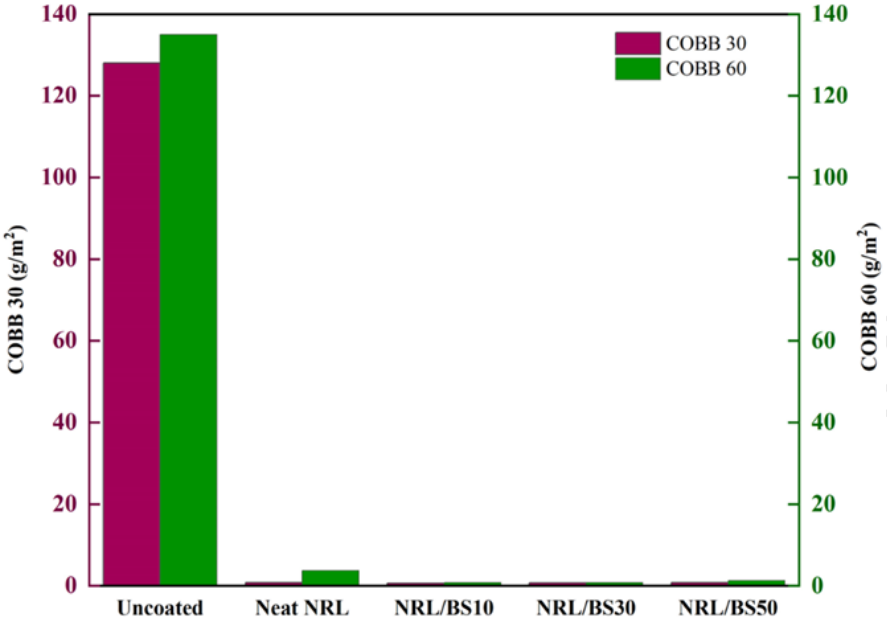
Sample	Tensile Strength(N)	TS Index(Nm/g)	Elongation at break(%)	Burst Strength(kg/cm^2)	Contact Angle(°)
Uncoated	21.04±0.24^{a}	15.41±0.17^{a}	2.68±0.05^{b,c}	9.7±0.18^{a}	0±0^{a}
Neat NRL	38.55±0.99^{c}	28.23±0.73^{c}	3.33±0.01^{c}	10.±0.05^{a}	80.44±0.56^{b}
NRL/BS10	31.16±1.24^{d}	22.83±0.91^{d}	2.58±0.11^{b}	10.±0.13^{a}	84.16±0.36^{c}
NRL/BS30	27.66±0.35^{b}	20.26±0.25^{b}	1.92±0.10^{a}	9.3±0.79^{a}	88.20±0.24^{d}
NRL/BS50	25.68±0.67^{b}	18.82±0.49^{b}	1.53±0.11^{a}	9.1±0.39^{a}	91.12±0.32^{e}

Values are represented as Mean± Standard deviation obtained from triplicate analysis.

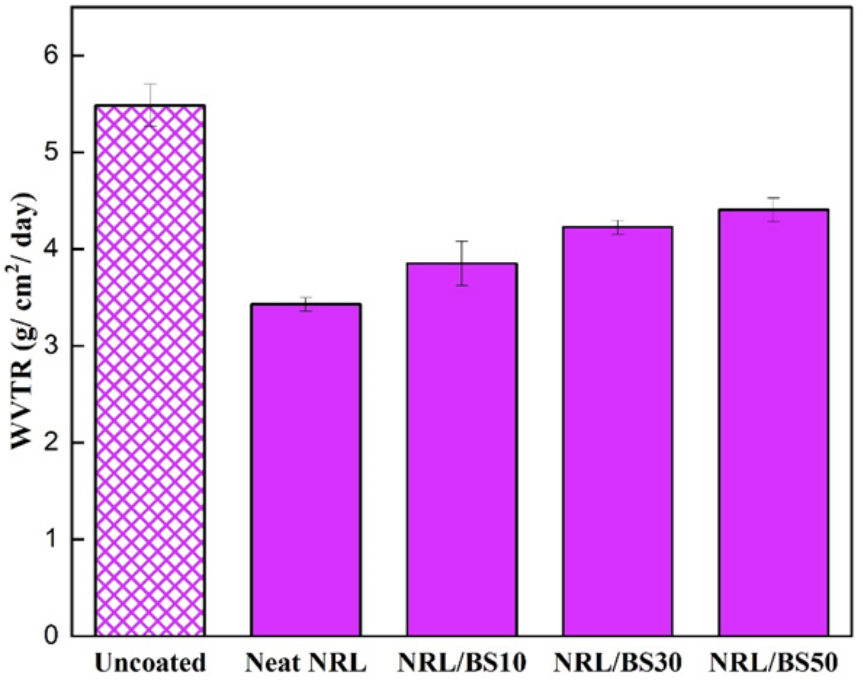
Values within the same column having different superscripts a,b,c are significant different at $p<0.05$.

Moisture barrier propeties

COBB



WVTR



Comparative study

Reference	Coating Material	WVTR(g/ cm^2/ day)	Contact Angle(°)	COBB Value(g/m^2)
(Adibi et al., 2022)	Natural rubber latex	300	96.9	2
(Hamdani et al., 2020)	Zein	500	90	20
(Koppolu et al., 2019)(N et al., 2020a)	Polylactic acid	57	-	3.17
(Willberg-Keyriläinen et al., 2018)	Cellulose ester	308±17	66.4 ± 1.8	-
(Ni et al., 2018)	Corn starch	234.12	117.93	
(Azin et al., 2022)	Natural rubber latex	140	106	8
Present Study	Natural rubber latex and Butyl stearate	348±21	90.6	0.8

Conclusion

- Novel coating formulation comprising Natural rubber latex and Butyl stearate there of.

- Coating formulation preparation method including proportions and method used to mix components have been developed.

- Coating solution application method on the paper substrate.


Thank you!