Technology of Heat Seal Coatings

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Topics to cover

1. **Types of packaging** with heat sealing
2. Significance of sealing process in **packaging design**
3. **Dynamics** of heat sealing
4. Types of **adhesion** in heat sealing
5. Factors affecting **heat seal quality**
6. Conventional **materials** used for heat sealing
7. Shift from **plastics to coatings** for heat sealing
8. **Formulating water-based heat seal coatings**

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Types of Packaging with Heat Sealing

Flat bottom bag

Pillow bag

Flat Sachets & Pouches

Spouted Pouch

Doy Pack

Lidding Pack

Blister Pack

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Significance of Sealing process in Packaging Design

1. Determine packaging material consumption

- Sealing width
- Film thickness

2. Optimizing seal strength for easy or tight release

- Modifying process parameters
- Optimizing formulation

3. Determine dwell time in packaging process

- Set production speed
- Influence energy consumption

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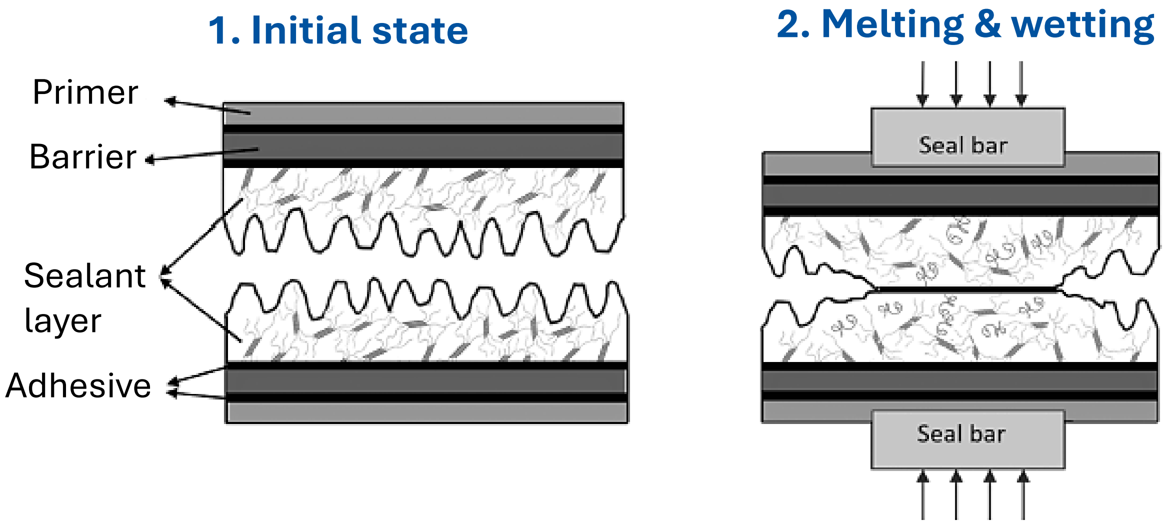
Understanding Dynamics of Heat Sealing



- Heat sealing with contact equipment such as seal bars and seal bands is achieved by the **combination of temperature, pressure and time.**

- **Wetting contributes to filling all the small gaps** between two surfaces in first milliseconds of the sealing process.

- A certain amount of **pressure** is important during heat sealing to ensure complete wetting.

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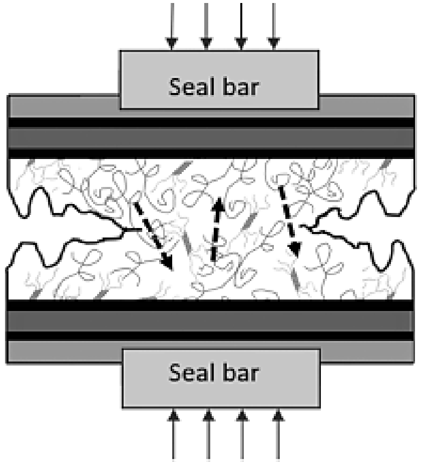
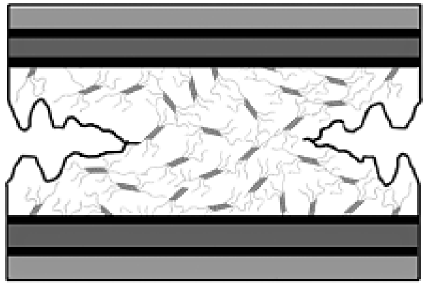
Understanding Dynamics of Heat Sealing

3. Adhesion & Diffusion



4. Entanglement & recrystallization



$$D_{rate} = pRTr^2/6\mu M_w$$

μ = viscosity of sealant
D_{rate} = Diffusion rate
p = density of sealant
R = gas constant
T = temperature
r = radius of sealant molecule
M_w= molecular weight of sealant

- **Molecular weight** of the sealant layer significantly influences the diffusion rate.
- After sealing, there is **recrystallization of segments** that holds the surfaces together and enhances the seal strength.

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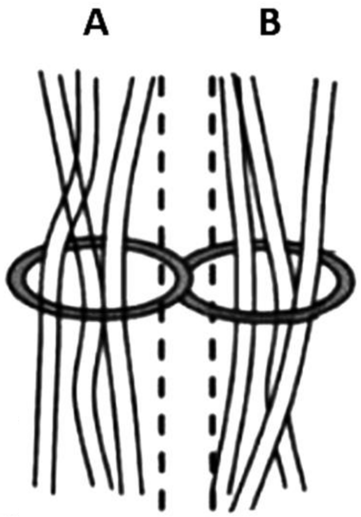
Types of Adhesion and Bonding in Heat Sealing

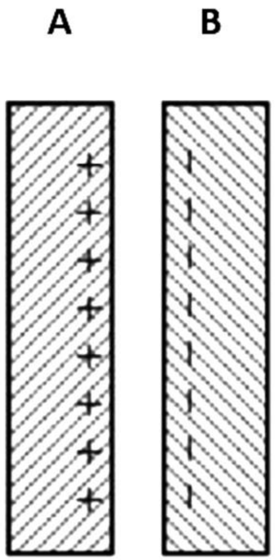
Chain Bonding



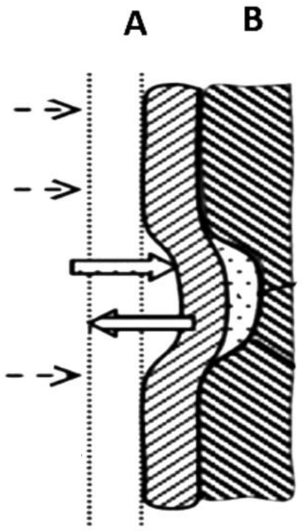
Intermolecular Bonding

Wedge Bonding

Electrostatic Bonding



Vacuum Bonding



For amorphous polymers, the adequate seal strength development depends solely on the self-adhesion and diffusion dynamics rather than the crystallization due to cooling.

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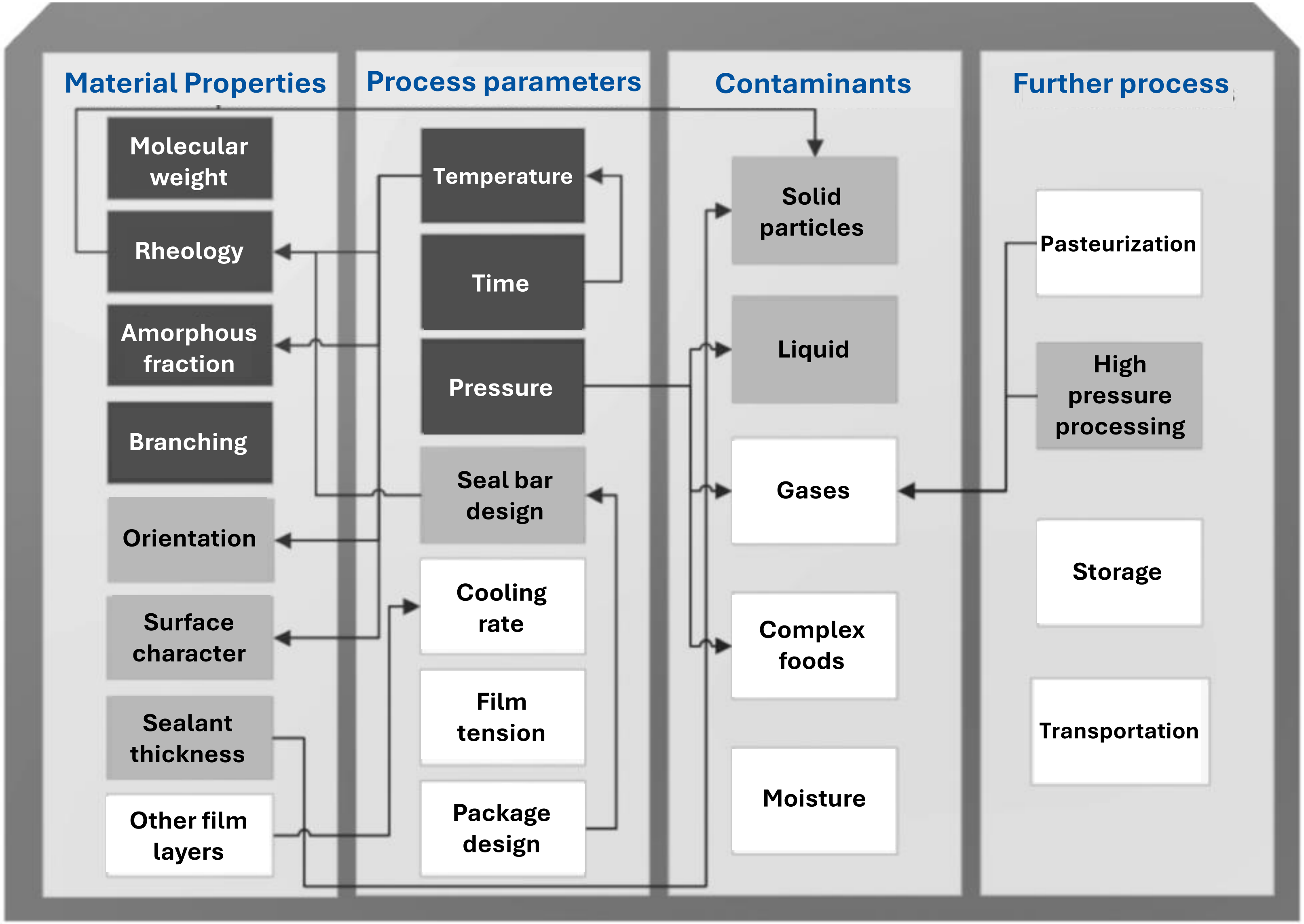
Factors affecting Heat Seal quality



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Factors affecting Heat Seal quality

Effect of Material Properties

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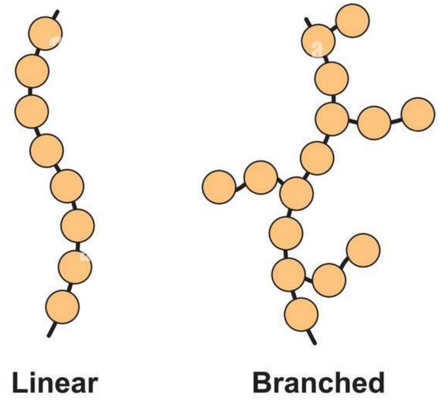
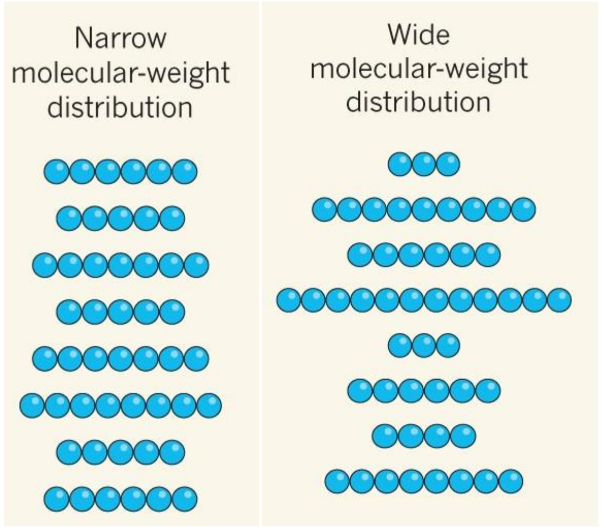
1. Molecular weight of polymer and Branching

- As Mw increases, seal strength increases, but diffusion rate decreases.
- Wide molecular weight distribution gives a lower seal initiation temperature. However, optimizing sealing parameters for such polymers is a challenge.
- Polymers with high branching result in weak sealing because of weaker diffusion



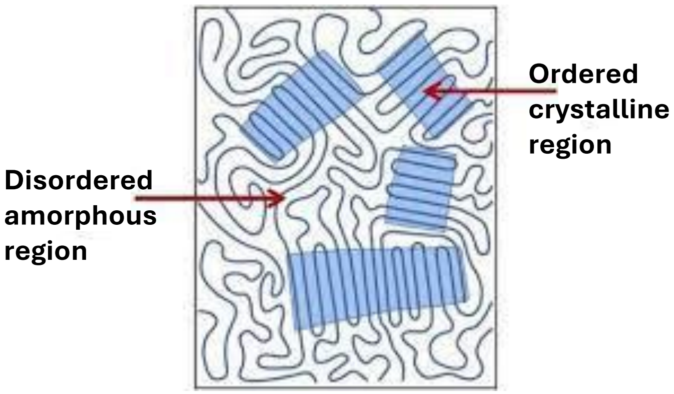


2. Rheology

- When the polymer becomes too fluid, squeeze-out occurs and the sealant will be pushed away from the seal area easily by the applied excessive pressure.

3. Amorphous fraction

- Seal strength is strongly correlated with the amorphous molecule ratio of melt polymer at a certain sealing temperature because the unmelted crystal macromolecules create obstacles against the chain diffusion



Factors affecting Heat Seal quality

Effect of Process Parameters

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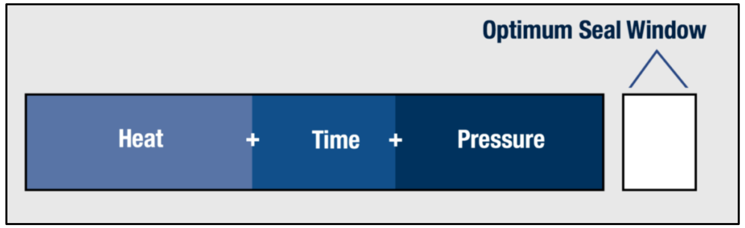
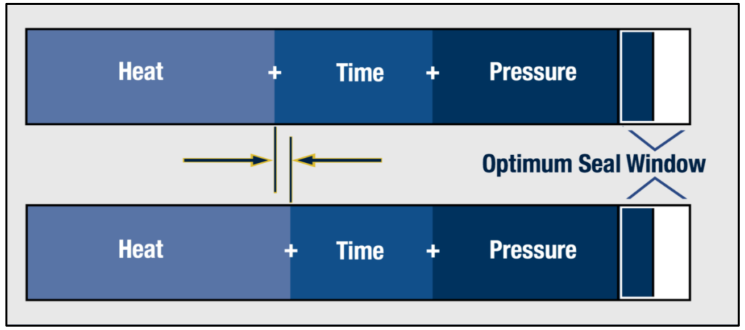


Inadequate Heat + Time + Pressure

If total heat, time, and pressure falls short of the optimal seal window, a quality seal can't be achieved, and significant leaks will be present.

Excess Heat + Time + Pressure

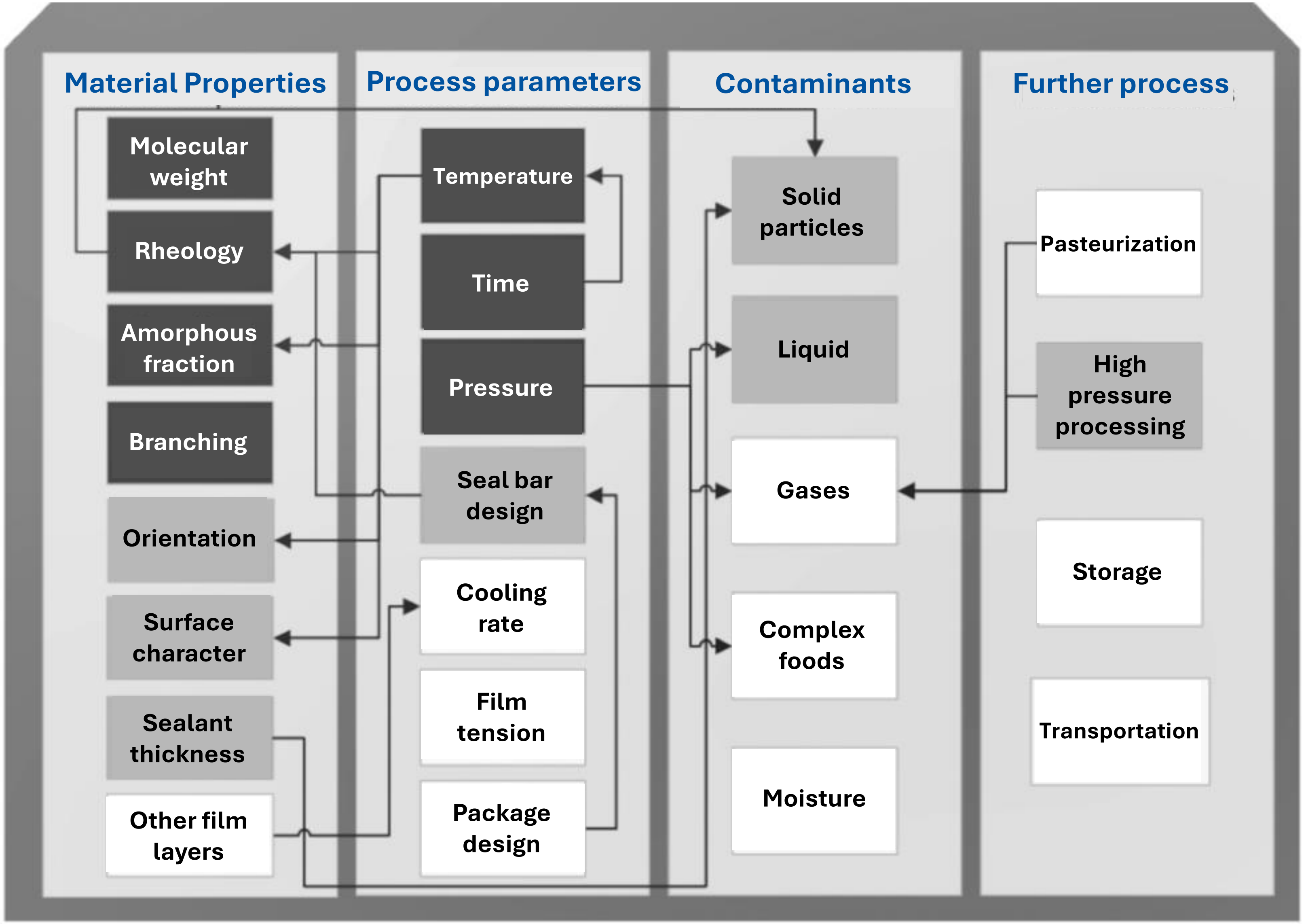
But more is not always better—totals that exceed the optimal seal window also reduce seal quality.



Adjustments

Adjustments that cause small changes in one sealing element can often be compensated for with small adjustments to another. The reduction in dwell time shown by these graphs, for example, has been offset by additional heat to maintain seal quality.

Factors affecting Heat Seal quality



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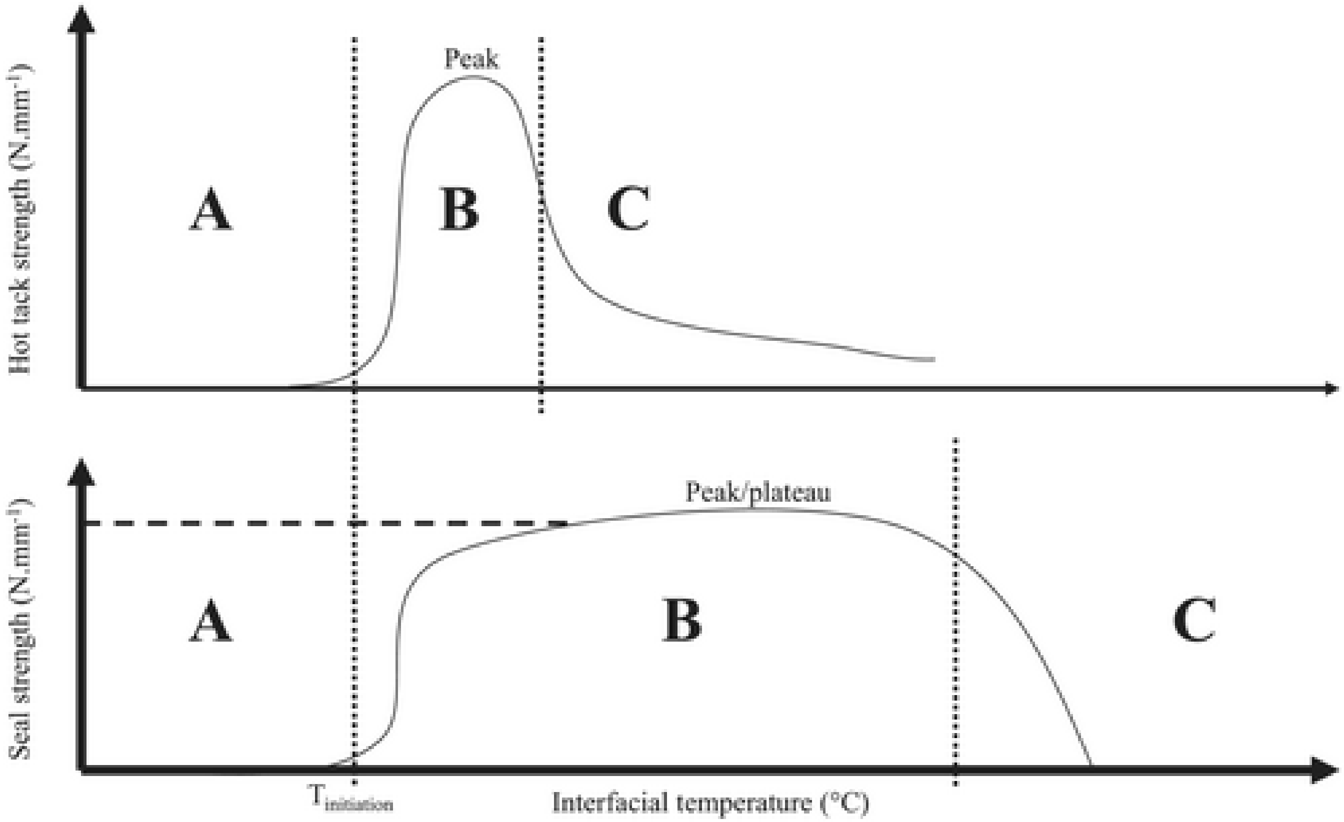
Conventional materials used for Heat Sealing

- Polyethylene - LDPE, LLDPE, VLDPE
- Polypropylene – CPP, OPP
- Polybutene
- Ethylene Vinyl Acetate
- Biopolymers – PLA, PBS



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Shift from Plastics to Sustainable alternatives

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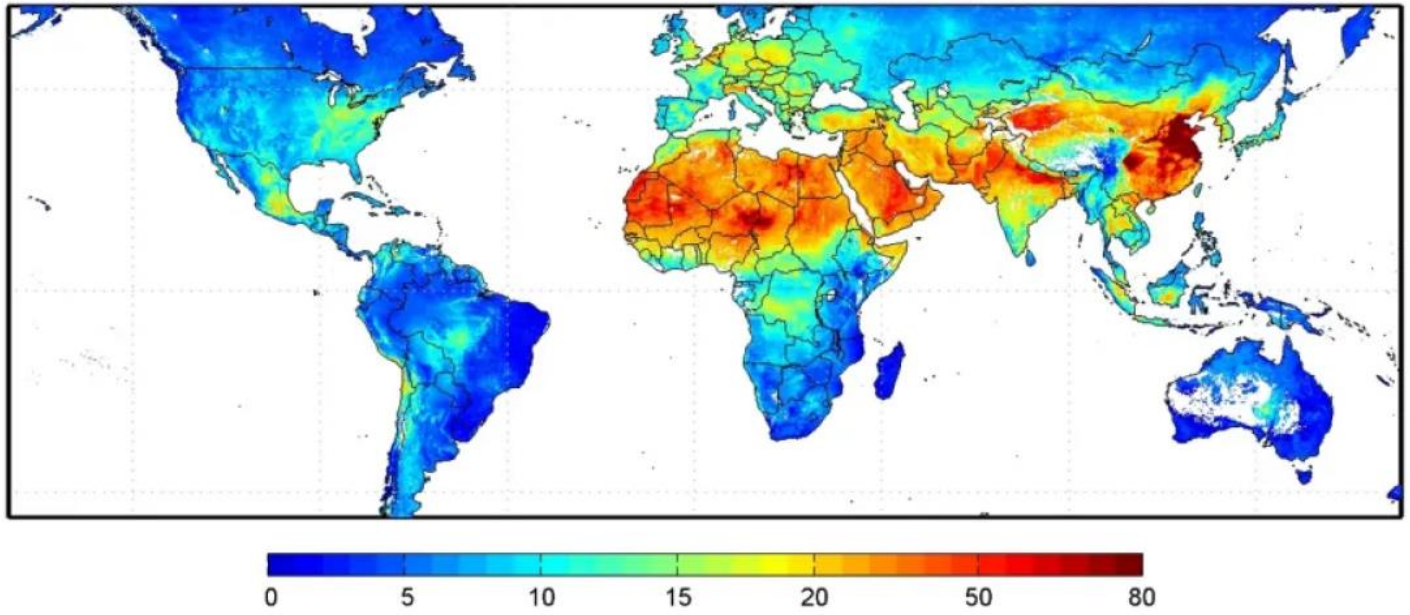
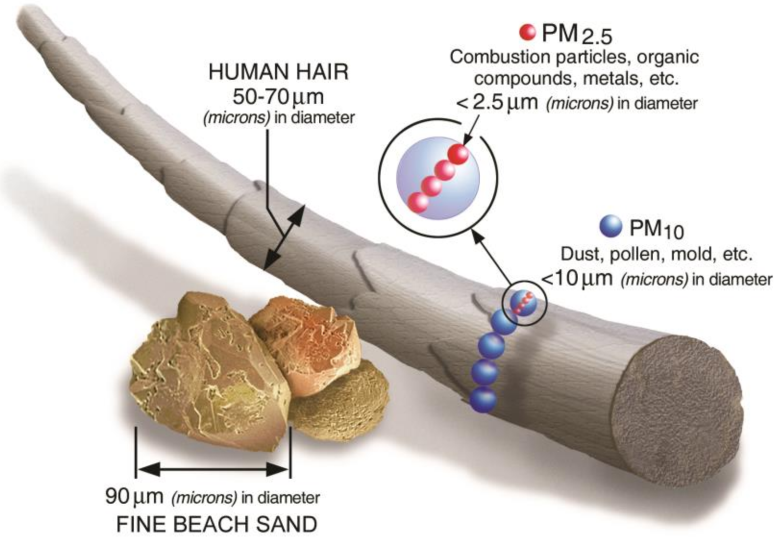
We must appreciate that plastics are unique, innovative, and versatile materials that can contribute to protecting the environment when used responsibly. The key is to recognize that there is no silver bullet to sustainability, only a **combination of well-designed strategies striving for a more sustainable future.**

Need for shifting from solvent based to water based heat seal coatings



concentration of Particulate Matter less than 2.5micron

- According to US-EPA, PM(2.5) pose **greatest health risks**, being inhalable particles
- Air Pollution is severe in India and China
- Organic solvents contribute about **25% of air pollution**



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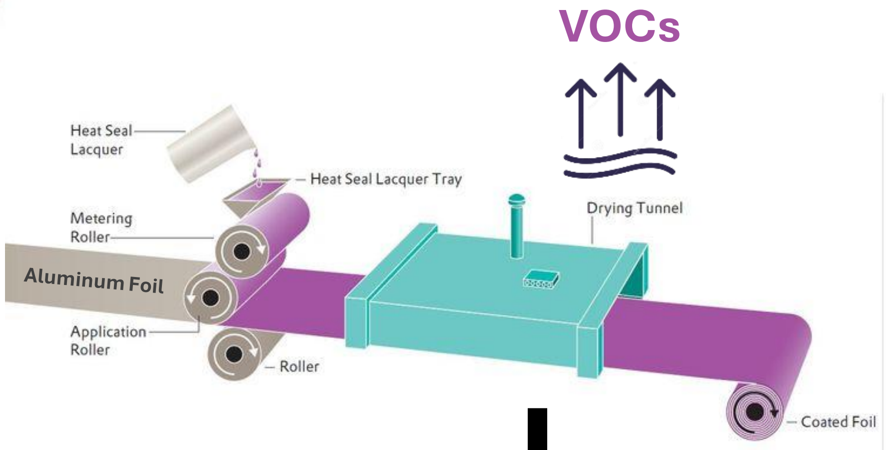
Need for shifting from solvent based to water based heat seal coatings



Al foil consumption	35,000 MT/yr
Coat weight	5 g/m2
Volume of solvent based HSL (NV: 25%)	11,000 MT/yr
Total VOC emission	**8,200 MT/yr**

Case Study for Aluminum foil Blister Packaging in India

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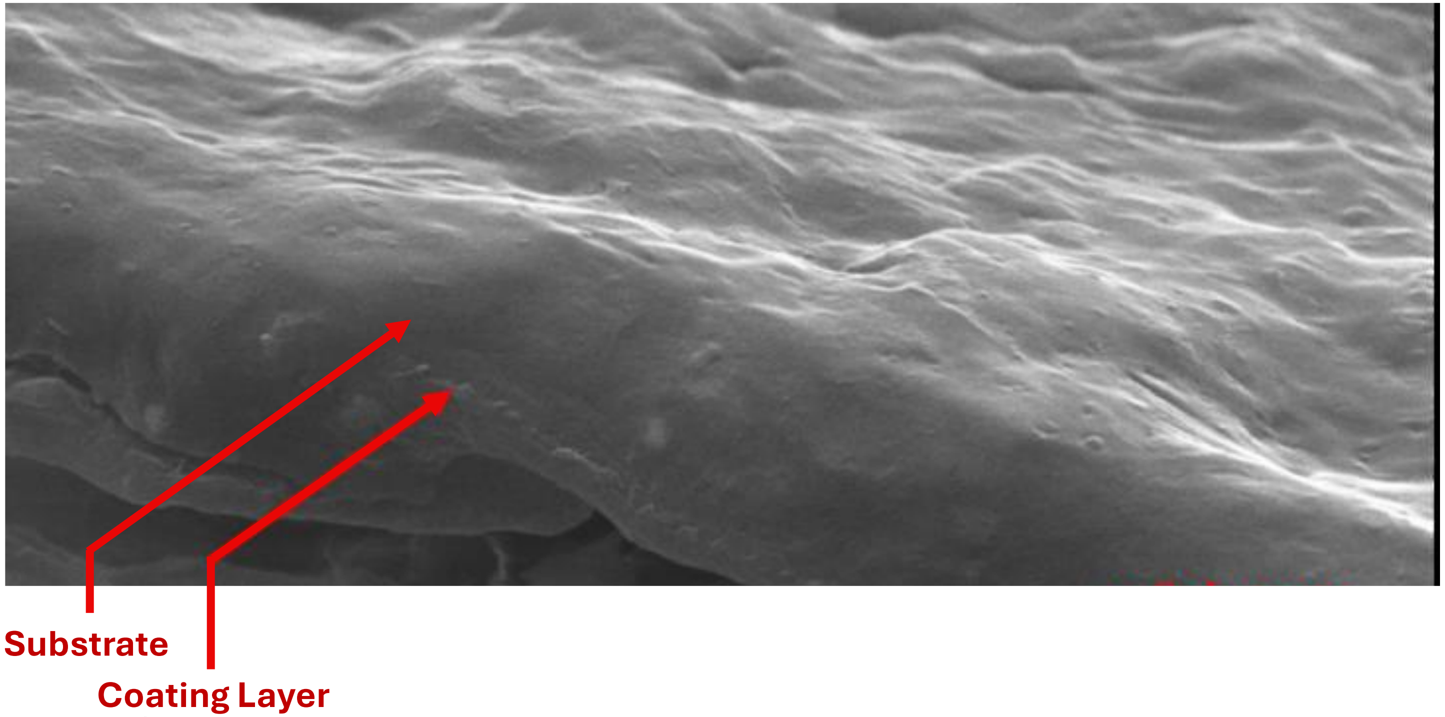
Formulating water-based Heat Seal Coatings



Polymeric emulsion

- Acrylic
- Polyurethane
- EVA
- EAA
- Vinyl acetate
- Polyvinyl alcohol

Tackifiers

- Natural Rosin
- Rosin ester
- Terpene
- Styrenated terpene

Antiblocking agents

- Waxes
- Silica
- Talc
- Fatty amides

Other Additives

- Defoamers
- Substrate wetting
- Thickeners

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Formulating water-based Heat Seal Coatings

Role of glass transition temperature in emulsion selection

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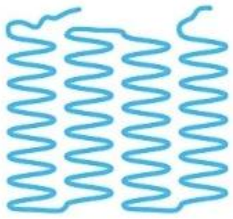
Amorphous Polymers have a random molecular structure.

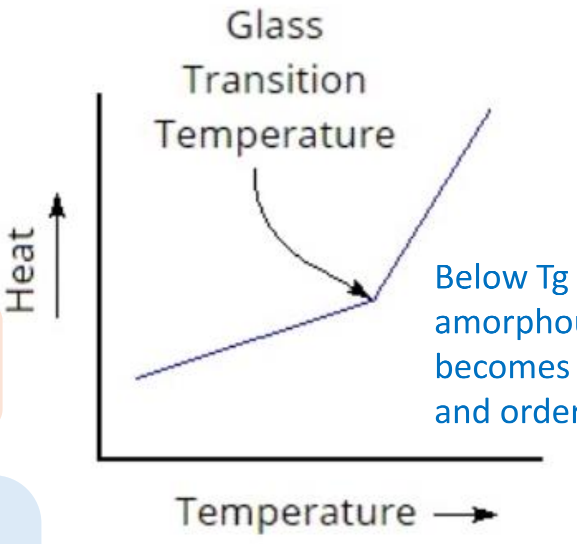
Tg is a phenomenon of amorphous polymers **ONLY!**

Below Tg: Due to lack of mobility, the polymers are hard and brittle like glass.

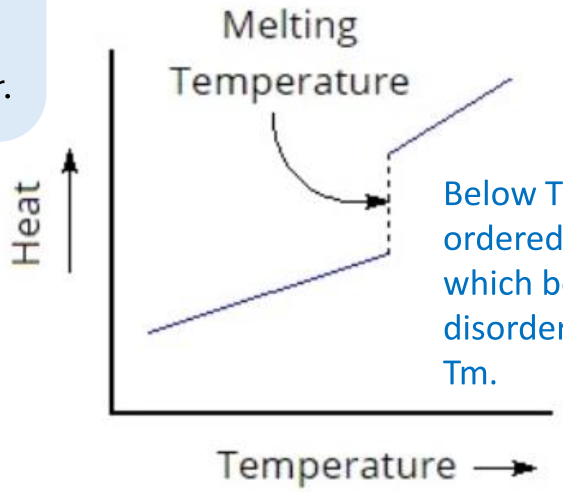
Above Tg: Due to some mobility, the polymers are soft and flexible like rubber.



Crystalline Polymers have a highly ordered molecular structure.



Below Tg is a disordered, amorphous solid, which becomes more mobile and ordered above Tg.



Below Tm it is an ordered crystalline solid which becomes disordered melt above Tm.

Formulating water-based Heat Seal Coatings

Effect of molecular weight of polymer on coating properties

Molecular weight of unreacted resin (Low → High)

Crosslink density	Decreases
Hardness	Decreases
Flexibility	Increases
Impact resistance	Increases
Solvent resistance	Decreases
Substrate wetting	Increases
Adhesion	Increases
Viscosity	Increases

Formulating water-based Heat Seal Coatings

Comparative analysis of commonly used emulsions

Emulsion Chemistry	Nature	Suitable substrates	Hydrolysis resistant	Price
Acrylic	Amorphous	Paper, film	Yes	Average
Polyurethane Dispersion	Semi crystalline	Paper, film, foil	Yes	High
Ethylene Acrylic Acid	Semi crystalline	Paper, film, foil	Yes	High
Ethylene vinyl acetate	Semi crystalline	Paper, film, foil	No	Average
Polyvinyl acetate	Amorphous	Paper	No	Low

Important Note:
Water based chemistries often have the capacity to provide coatings with lower heat activation temperatures – because of ease in formulation modifications.

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Benefits of low temperature sealing in water bases coating systems

- Lower sealing temperatures means **lower energy consumption**: a step towards a more sustainable, environmentally friendly manufacturing process.
- Helps to **eliminate ink smudging and fume generation** during blister making process.
- Reduces dwell times, **promoting high line speeds**.
- Low temperature sealing helps to **avoid multiple sealing defects** such as blister curl, air pockets, stress forming etc.
- Applying less heat to paper-backed structures also **avoids 'scorching' of the paper**

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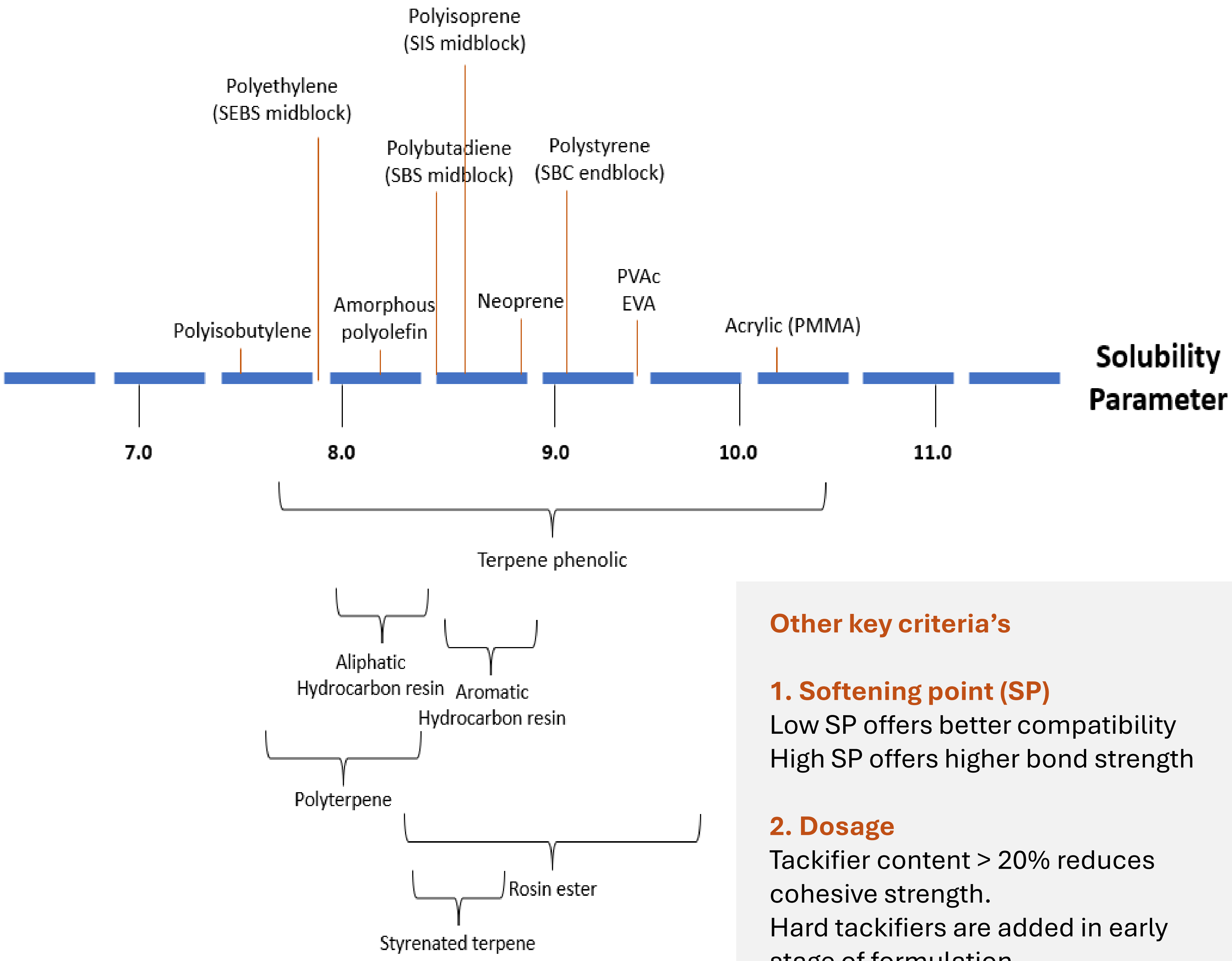
Formulating water-based Heat Seal Coatings

How to increase bond strength using tackifiers



Other key criteria's

1. Softening point (SP)
Low SP offers better compatibility
High SP offers higher bond strength

2. Dosage
Tackifier content > 20% reduces cohesive strength.
Hard tackifiers are added in early stage of formulation.
Soft tackifiers can be post blended

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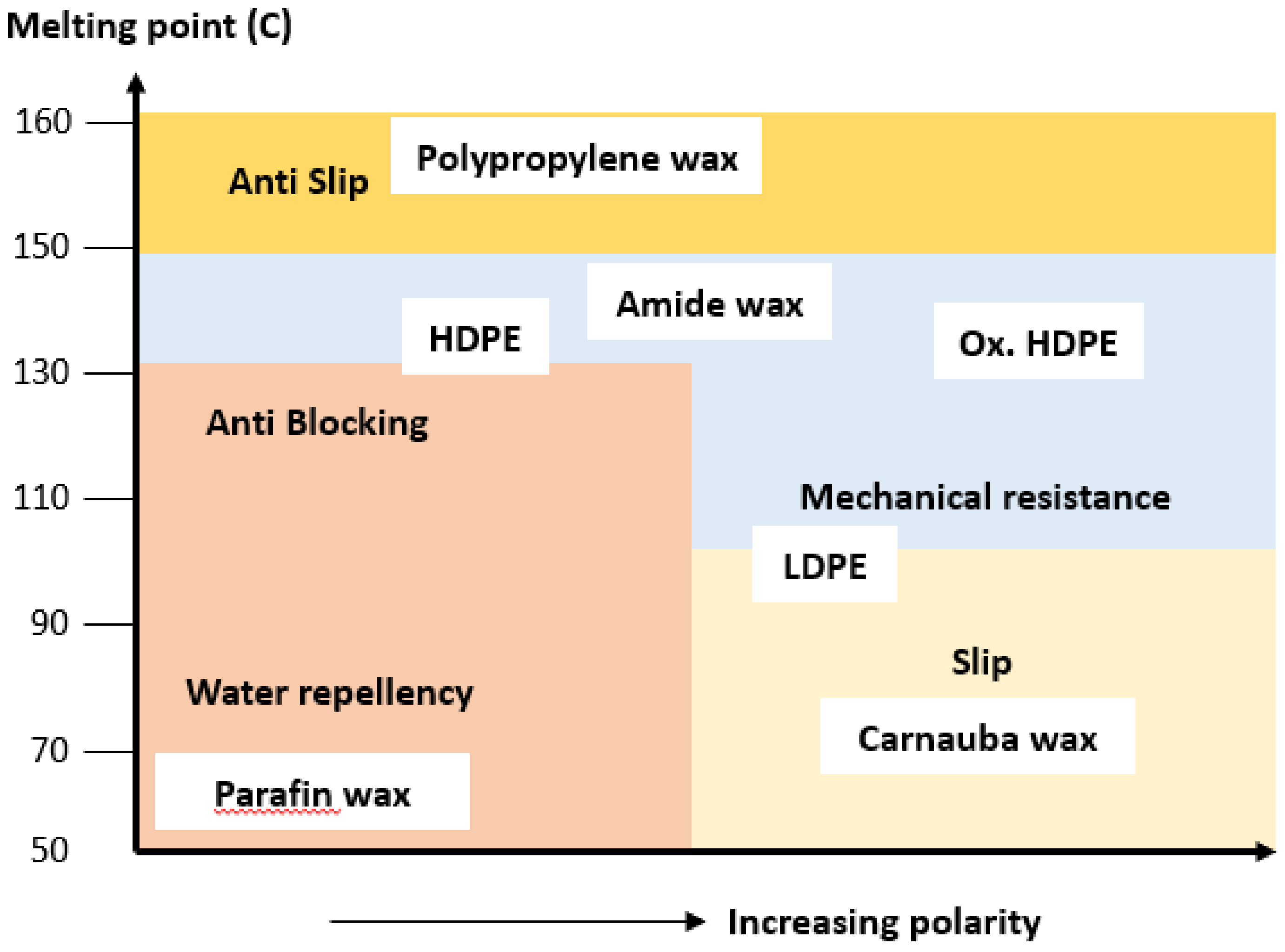
Formulating water-based Heat Seal Coatings

Selecting waxes for antiblocking properties



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Formulating water-based Heat Seal Coatings

Additive	Reduction in static surface tension	Reduction in dynamic surface tension	Foaming tendency	Impact on heat sealing
Sulfosuccinate	Medium – good	Good	Strong	Bad
Alcohol alkoxylate	Low	Very good	Low	No impact
Polyether modified siloxane	Good	Medium	Medium	Bad
Fluorosurfactant	Very good	Low	Very Strong	Bad
Acetylenediol and derivatives	Medium – good	Very good	Low	No impact

Understanding Substrate Wetting Additives

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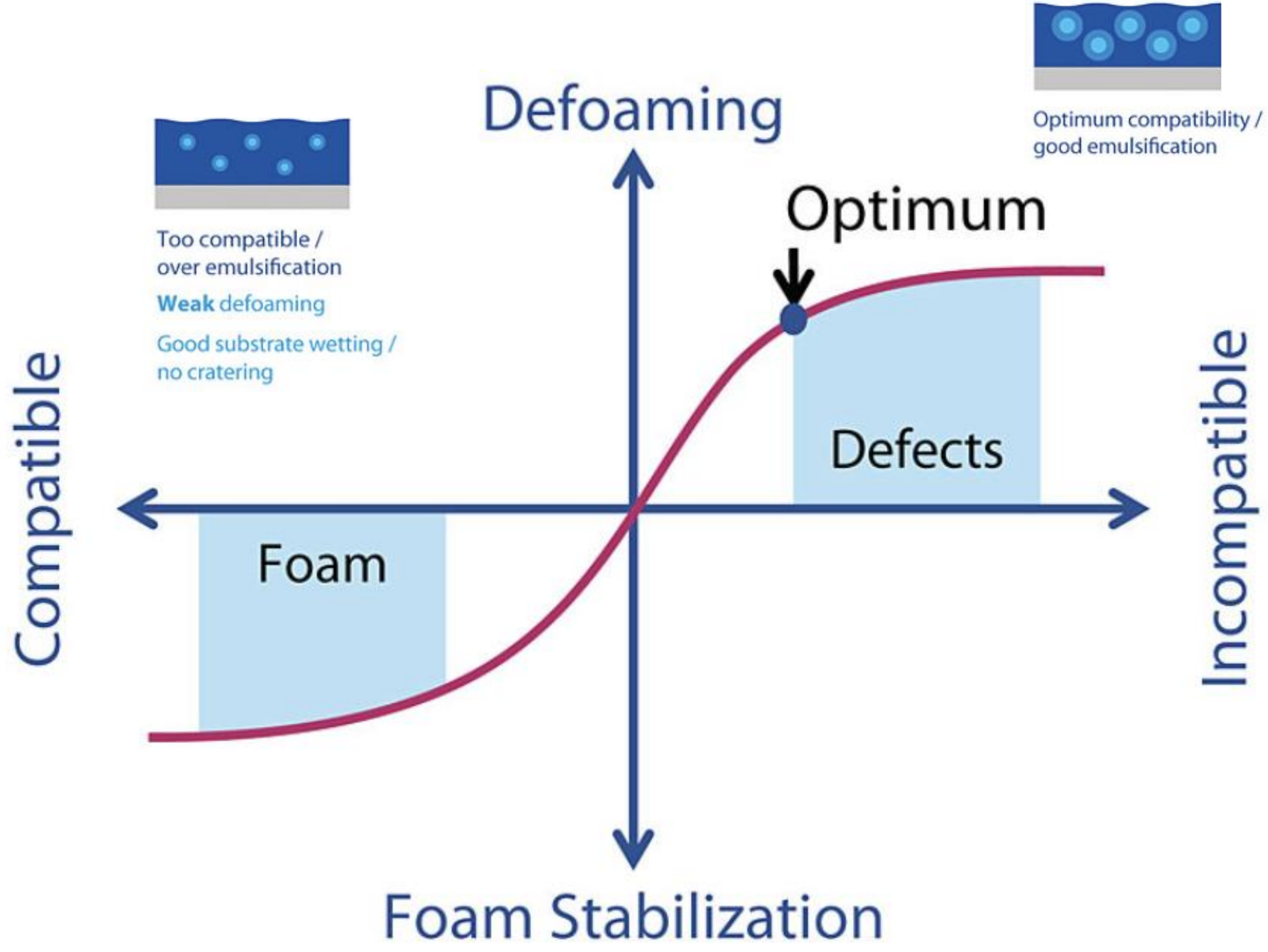
Formulating water-based Heat Seal Coatings

Selecting optimum Defoamer



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Product Overview

Emulsions for Heat Sealing

Texcryl HL-50
For paper-paper sealing

Texane FS-35
For aluminum/paper laminates

Texane TA-41
For difficult to bond substrates

Heat Seal Coatings

Texobond BL-1020
Blister Coating

Texobond F-107
Low COF Foil HSL

Texcryl HS-2028
Paper Pouch Heat Sealing

Process Aid Additives

Texsil DF-142
Silicone Defoamer

Texcryl AB-51
Antiblocking Agent

Texcryl ST-60
Acrylic Associative Thickener

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Innovation

We are constantly developing new products and enhancing existing ones to provide our customers a technological edge.

Sustainability

For us, sustainability is not just a word but a way of doing business – ensuring environmentally responsible future.

Customized solutions

We believe in long term partnerships and collective growth, by providing our research services on an individual level.

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