

## Summary of the Plastic Alternatives Innovation Landscape

### Food Packaging

Functional Form Factor	Examples	Key Performance Criteria	Typical Materials	Alternatives	Desired End State	Comments
<b>Monolayer Films - Primary</b>	<ul style="list-style-type: none"> <li>- Salad bag</li> <li>- Meat wrap</li> <li>- Dry goods bag</li> </ul>	<ul style="list-style-type: none"> <li>- Moisture barrier (some)</li> <li>- Oxygen barrier</li> <li>- No color/ transparency</li> <li>- Printability (some)</li> <li>- Thermal processability/thermal sealing</li> <li>- Economics</li> </ul>	<ul style="list-style-type: none"> <li>- HDPE</li> <li>- LDPE</li> </ul>	<ul style="list-style-type: none"> <li>- New bio-based compostable polymer materials</li> <li>- Additives (starch, minerals) that reduce the use of virgin plastics</li> <li>- Additives or coatings that improve the performance (moisture resistance etc.) of fiber materials</li> <li>- Recycled input materials</li> </ul>	Composted	<ul style="list-style-type: none"> <li>- New materials have struggled with meeting moisture barrier criteria</li> <li>- Thermal processability is key for reaching the economics</li> </ul>
<b>Monolayer Films - Secondary</b>	<ul style="list-style-type: none"> <li>- Shrink wrap labels</li> <li>- Shrink wrap packaging</li> <li>- Pallet wrap</li> </ul>	<ul style="list-style-type: none"> <li>- Printability (some)</li> <li>- Thermal processability/thermal sealing</li> <li>- Economics</li> </ul>	<ul style="list-style-type: none"> <li>- HDPE</li> <li>- LDPE</li> </ul>	<ul style="list-style-type: none"> <li>- Secondary packaging / labels that are easy to separate from the primary packaging</li> <li>- New bio-based compostable polymer materials</li> <li>- Additives (starch, minerals) that reduce the use of virgin plastics</li> <li>- Additives or coatings that improve the performance (moisture resistance etc.) of fiber materials</li> <li>- Recycled input materials</li> </ul>	<ul style="list-style-type: none"> <li>- Recycled</li> <li>- Composted</li> </ul>	
<b>Multilayer Films - Primary</b>	<ul style="list-style-type: none"> <li>- Chip bag</li> <li>- Condiment sachet</li> <li>- Candy wrapper</li> </ul>	<ul style="list-style-type: none"> <li>- Oxygen barrier</li> <li>- Moisture barrier</li> <li>- Printability (some)</li> <li>- Thermal processability/thermal sealing</li> <li>- Economics</li> </ul>	<ul style="list-style-type: none"> <li>- PP / metal / LDPE</li> <li>- PET / Metal / LDPE</li> </ul>	<ul style="list-style-type: none"> <li>- New bio-based compostable polymer materials</li> <li>- Additives (starch, minerals) that reduce the use of virgin plastics</li> <li>- Additives or coatings that improve the performance (moisture resistance etc.) of fiber materials</li> <li>- Recycled input materials</li> </ul>	Composted	<ul style="list-style-type: none"> <li>- New materials have struggled with meeting high oxygen barrier criteria in long shelf-life applications</li> <li>- New materials have struggled with meeting moisture barrier criteria</li> </ul>
<b>Monolayer Rigid 3D Containers</b>	<ul style="list-style-type: none"> <li>- Meat tray</li> <li>- Fruit clam shell</li> <li>- Cups</li> <li>- Food service items</li> </ul>	<ul style="list-style-type: none"> <li>- Moisture compatibility</li> <li>- Thermal processability</li> <li>- Strength</li> <li>- Thermal stability (hot products)</li> <li>- Economics</li> </ul>	<ul style="list-style-type: none"> <li>- PS</li> <li>- PET</li> <li>- PP</li> </ul>	<ul style="list-style-type: none"> <li>- Additives or coatings that improve the performance (moisture resistance etc.) of fiber materials</li> <li>- Compostable bio-based polymers (PLA, PHA) alternatives</li> <li>- Reusable container systems</li> <li>- Recycled input materials</li> </ul>	<ul style="list-style-type: none"> <li>- Composted</li> <li>- Reused</li> </ul>	<ul style="list-style-type: none"> <li>- Attainable performance criteria enable fiber and bio-based polymers to compete</li> <li>- Fiber based items introduced PFAS (regrettable substitution) but currently being addressed</li> </ul>
<b>Multilayer Rigid 3D Containers</b>	<ul style="list-style-type: none"> <li>- Paper cup</li> <li>- Fast food packaging</li> </ul>	<ul style="list-style-type: none"> <li>- Moisture barrier</li> <li>- Strength</li> <li>- Thermal sealing</li> <li>- Economics</li> </ul>	<ul style="list-style-type: none"> <li>- Paper / PE</li> <li>- Paper / PLA</li> </ul>	<ul style="list-style-type: none"> <li>- Additives or coatings that improve the performance (moisture resistance, oxygen barrier etc.) of fiber materials</li> <li>- Reusable container systems</li> <li>- Recycled input materials</li> </ul>	<ul style="list-style-type: none"> <li>- Composted</li> <li>- Reused</li> </ul>	<ul style="list-style-type: none"> <li>- Alternative coatings have to provide thermal sealing ability in order to work with current manufacturing techniques</li> </ul>

<b>Bottles / Jars / Other Long Shelf-Life Containers</b>	<ul style="list-style-type: none"> <li>- Water bottle</li> <li>- Beverage bottle</li> <li>- Ketchup recipient</li> <li>- Peanut jar</li> <li>- Tetrapak container</li> <li>- Lined metal cans</li> </ul>	<ul style="list-style-type: none"> <li>- Strength</li> <li>- Gas barrier</li> <li>- Moisture barrier</li> <li>- Corrosion resistance (some)</li> <li>- No color/ transparency (some)</li> <li>- Economics</li> </ul>	<ul style="list-style-type: none"> <li>- PET</li> <li>- PP</li> <li>- Glass</li> <li>- Lined metal</li> <li>- PE / Aluminum / Paperboard</li> </ul>	<ul style="list-style-type: none"> <li>- Redesign for reduced weight</li> <li>- Redesign for recycling</li> <li>- Nontoxic liners alternative to BPA</li> <li>- New bio-based compostable polymer materials</li> <li>- Additives (starch, minerals) that reduce the use of virgin plastics</li> <li>- Reusable systems</li> <li>- Recycled input materials</li> </ul>	<ul style="list-style-type: none"> <li>- Recycled</li> <li>- Composted</li> <li>- Reused</li> </ul>	<ul style="list-style-type: none"> <li>- New materials have struggled with meeting moisture, gas barrier, and economics criteria</li> <li>- Hard to separate/sort materials for recycling</li> </ul>
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### Home and Personal Care Products

Functional Form Factor	Examples	Key Performance Criteria	Typical Materials	Alternatives	Desired End State	Comments
<b>Monolayer Rigid 3D Containers</b>	<ul style="list-style-type: none"> <li>- Shampoo bottle</li> <li>- Cream jar</li> <li>- Hand soap pump</li> <li>- Sprayer</li> </ul>	<ul style="list-style-type: none"> <li>- Strength</li> <li>- Oxygen barrier</li> <li>- Moisture barrier</li> <li>- Corrosion resistance (some)</li> <li>- Economics</li> </ul>	<ul style="list-style-type: none"> <li>- PP</li> <li>- PET</li> <li>- HDPE</li> </ul>	<ul style="list-style-type: none"> <li>- Waterless formulations / products (dissolvable films pods, solids, slips)</li> <li>- Concentrate + reusable recipient solutions</li> <li>- Fiber based alternatives</li> <li>- Compostable bio-based polymers (PLA, PHA) alternatives</li> <li>- Recycled input materials</li> </ul>	<ul style="list-style-type: none"> <li>- Products that can be delivered without plastic recipients</li> <li>- Recyclable</li> <li>- Compostable</li> </ul>	<ul style="list-style-type: none"> <li>- We are seeing a diversity of promising approaches.</li> </ul>
<b>Multilayer Films</b>	<ul style="list-style-type: none"> <li>- Shampoo sachets</li> </ul>	<ul style="list-style-type: none"> <li>- Oxygen barrier</li> <li>- Moisture barrier</li> <li>- Printability (some)</li> <li>- Thermal processability/thermal sealing</li> <li>- Economics</li> </ul>	<ul style="list-style-type: none"> <li>- PP / metal / LDPE</li> <li>- PET / Metal / LDPE</li> </ul>	<ul style="list-style-type: none"> <li>- Waterless formulations / products (dissolvable films pods, solids, slips)</li> <li>- Fiber based alternatives</li> <li>- Multilayer films of new bio-based compostable polymer materials</li> <li>- Recycled input materials</li> </ul>	<ul style="list-style-type: none"> <li>- Products that can be delivered without plastic recipients</li> <li>- Recyclable</li> <li>- Compostable</li> </ul>	<ul style="list-style-type: none"> <li>- New materials have struggled with meeting high oxygen barrier criteria in long shelf-life applications</li> <li>- New materials have struggled with meeting moisture barrier criteria</li> </ul>
<b>Ingredients</b>	<ul style="list-style-type: none"> <li>- Moisturizers</li> <li>- Humectants</li> <li>- Thickeners</li> <li>- Emulsifiers</li> </ul>	<ul style="list-style-type: none"> <li>- Feel</li> <li>- Color</li> <li>- Brilliance</li> <li>- Inodorous</li> <li>- Ability to work well in formulations</li> </ul>	<ul style="list-style-type: none"> <li>- Silicones</li> <li>- Acrylates</li> <li>- Methacrylates</li> <li>- Paraffin</li> </ul>	<ul style="list-style-type: none"> <li>- New bio-based biodegradable materials</li> </ul>	<ul style="list-style-type: none"> <li>- Ingredients biodegrade after use</li> </ul>	<ul style="list-style-type: none"> <li>- P2 Science developed the only alternative for silicones that works well</li> </ul>

## Textiles and Apparel

Functional Form Factor	Examples	Key Performance Criteria	Typical Materials	Alternatives	Desired End State	Comments
<b>Fibers / Fabrics</b>	<ul style="list-style-type: none"> <li>- Polyester</li> <li>- Nylon</li> <li>- Elastane / polyurethane fibers and fabrics</li> </ul>	<ul style="list-style-type: none"> <li>- Burst strength</li> <li>- Tensile strength</li> <li>- Abrasion resistance</li> <li>- Ability to be dyed and finished using current manufacturing techniques</li> <li>- Weight</li> <li>- Hand feel / drape</li> <li>- Breathability / moisture handling</li> <li>- Skin irritation potential</li> </ul>	<ul style="list-style-type: none"> <li>- PET</li> <li>- Nylon</li> <li>- PU</li> </ul>	<ul style="list-style-type: none"> <li>- Take back and reuse or recycle systems</li> <li>- Recycled input materials</li> <li>- New bio-based compostable polymer materials</li> </ul>	<ul style="list-style-type: none"> <li>- Reused</li> <li>- Recycled</li> <li>- Composted</li> </ul>	Long development cycle for new fibers involving working with a complex supply chain
<b>Breathable Waterproof Membranes</b>	PTFE Gore Tex membrane	<ul style="list-style-type: none"> <li>- Water proofness</li> <li>- Breathability</li> <li>- Ability to be laminated using current techniques</li> <li>- Wash resistance</li> </ul>	PTFE	New bio-based PTFE free materials	<ul style="list-style-type: none"> <li>- Recycled</li> <li>- Composted</li> </ul>	The outdoor industry brands are looking for alternatives to the Gore Tex PTFE membranes
<b>Artificial Leather</b>	<ul style="list-style-type: none"> <li>- Handbags</li> <li>- Shoe uppers</li> </ul>	<ul style="list-style-type: none"> <li>- Strength</li> <li>- Flexibility</li> <li>- Abrasion resistance</li> <li>- Moisture resistance</li> <li>- Economics</li> </ul>	<ul style="list-style-type: none"> <li>-PU</li> <li>-PVC</li> </ul>	<ul style="list-style-type: none"> <li>- New bio-based compostable materials</li> <li>- Take back and reuse or recycle systems</li> </ul>	<ul style="list-style-type: none"> <li>- Reused</li> <li>- Recycled</li> <li>- Composted</li> </ul>	New materials have struggled with moisture resistance and strength / flexibility performance criteria
<b>3D Shapes</b>	<ul style="list-style-type: none"> <li>- Shoe soles, inner soles</li> <li>- Wetsuits</li> <li>- Accessories</li> </ul>	<ul style="list-style-type: none"> <li>- Strength</li> <li>- Elasticity</li> <li>- Resistance</li> <li>- Resilience</li> </ul>	<ul style="list-style-type: none"> <li>- PU</li> <li>- Rubber</li> <li>- Neoprene</li> </ul>	<ul style="list-style-type: none"> <li>- New bio-based compostable materials</li> <li>- Take back and recycling systems</li> </ul>	<ul style="list-style-type: none"> <li>- Reused</li> <li>- Recycled</li> <li>- Composted</li> </ul>	Leadership from new brands such as AllBirds
<b>Poly Bag Packaging</b>	<ul style="list-style-type: none"> <li>- Packaging for garments in transit</li> <li>- Primary packaging for e-commerce</li> </ul>	<ul style="list-style-type: none"> <li>- Transparency</li> <li>- Printability (some)</li> <li>- Moisture resistance (some)</li> <li>- Economics</li> </ul>	LDPE	<ul style="list-style-type: none"> <li>- Reuse</li> <li>- Recycled input materials</li> <li>- New bio-based compostable polymer materials</li> </ul>	<ul style="list-style-type: none"> <li>- Recycled</li> <li>- Reused</li> </ul>	There are several brand initiatives to address this issue