

3 Hot Topics in Spring 2024

CREATED FOR:



CREATED BY PTR
LEARN MORE AT :
www.PackagingTechnologyAndResearch.com

ABOUT PTR

Dr. Claire Sand thinks “all food packaging all the time”

Claire’s mission is to enable a more sustainable food system with science and value chain innovations that more sustainably increases food shelf life and prevents food waste

- 35+ years of food packaging experience
- Ranks innovative packaging science and value chain solutions to extend shelf life
- Generates implementation roadmaps and aligns business cases
- IFT Fellow, Riester-Davis-Brody life-time achievement in food packaging award recipient
- Doctorate in Food Science and Nutrition at University of Minnesota
- MS and BS in Packaging at Michigan State University



Owner



Adjunct Professor



Monthly Columnist



Current Leadership & Editorial Boards



Recent Awards



ABOUT PTR
Our Services – 5 Areas



More Sustainable Packaging

We help clients achieve more sustainable packaging with packaging solutions that are Rational, Defensible, and Achievable.

CLIENTS: PACKAGING AND FOOD COMPANIES AND ASSOCIATIONS

Increase Shelf Life & Prevent Food Waste

PTR's science-based packaging solutions increase food shelf life and prevent food waste.

CLIENTS: PACKAGING AND FOOD COMPANIES AND ASSOCIATIONS

Food Packaging Innovations

PTR helps businesses identify and enact meaningful packaging innovations that meet business goals.

CLIENTS: PACKAGING AND FOOD COMPANIES AND ASSOCIATIONS

Food Package Optimization & Problem-Solving

We fine-tune food packaging using material science, deep value chain, and cost-savings experience.

CLIENTS: PACKAGING AND FOOD COMPANIES AND ASSOCIATIONS

Food Packaging Expert & Witness

Dr. Claire Sand is a food packaging expert with 35+ years in industry and 18+ cases as an Expert Witness.

CLIENTS: ATTORNEYS WORKING ON FOOD AND BEVERAGE, PACKAGING & LABELING OR PATENT & INTELLECTUAL PROPERTY LITIGATION AND LAWSUITS

Learn more at www.PackagingTechnologyandResearch.com



**Future of
Food
Packaging**



**Active
Packaging**



**Intelligent
Packaging**



**Value Chain
Drivers**



Material Science



**Process &
Package
Interactions**



**Migration
Complexities**



**Global
Research
Institutes**



Food Waste



**Consumer
Research on
Sustainability**



**More
Sustainable
Packaging**

**Our solutions are
tailored to client
needs**

ABOUT PTR

Recent Project Work



More Sustainable Food System

- Developed a more sustainable packaging platform for technology and positioning in alignment with UNSDGs for a food company



Reduced Food Waste

- Identified and quantified 287 viable product, process, packaging, and systems solutions in the value chain (farm, distrib, mfr, retail & consumer) to reduce FLW by 1.1 Billion pounds for 7 Minnesota products



More Sustainable Packaging

- Identified and determined 6 more sustainable packaging options, using consumer research and LCA analysis, that communicate sustainability to ground beef consumers
- Identified, defined, and sourced more sustainable packaging structures that would not impact shelf life



Technology Roadmapping

- Built R&D pipeline to direct material development using new market & consumer switching drivers
- Lead cross-functional innovation team to identify packaging research needs, partners, and implementation paths
- Pinpointed the optimal intelligent packaging for major US food company R&D team



Cost Reductions

- Identified packaging cost reductions that reduced costs by 25% while keeping current package design.



Directed Market & Science Alignment

- Identified optimal product and package format focus for one of the world's leading specialty chemical companies to bring added shelf life through patentable packaging



Food Waste Reduction

- Ranked packaging solutions to reduce food waste by category impact and feasibility to channel research and development for multi-industry stakeholder groups for food and packaging companies



Technology Development

- Identified OTR and MVTR requirement within 30 categories
- Screen intelligent packaging solutions based on products and prototype 3-5 best viable options to meet defined success factors
- Developed and tested solutions to extend the shelf life of baked goods enabling conversion to "clean label"

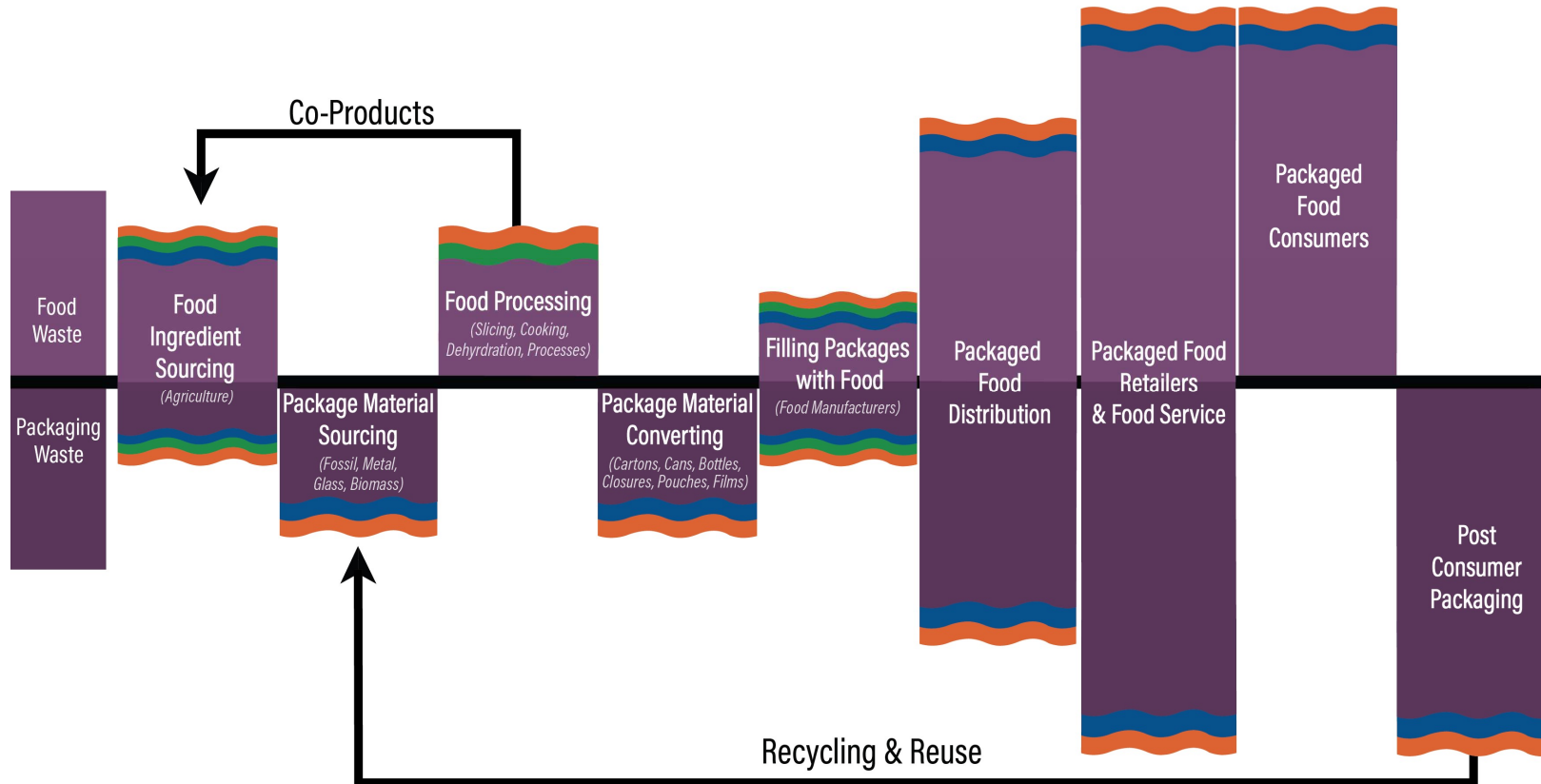
ABOUT PTR | Where We Work



PTR Prevents Food and Packaging Waste Where It Happens

Packaging Solutions
Product & Process Solutions
Value Chain System Solutions

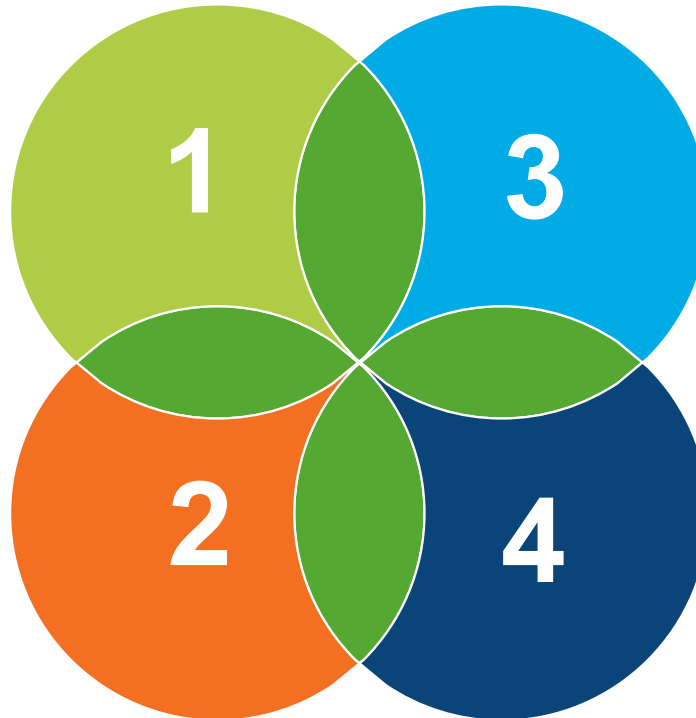
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3 Hot Topics

Successful approaches
to eliminating
Chemicals of Concern

Implementation of
intelligent packaging –
finally!



Conversion to PEF and
other bioderived and
recyclable polymers

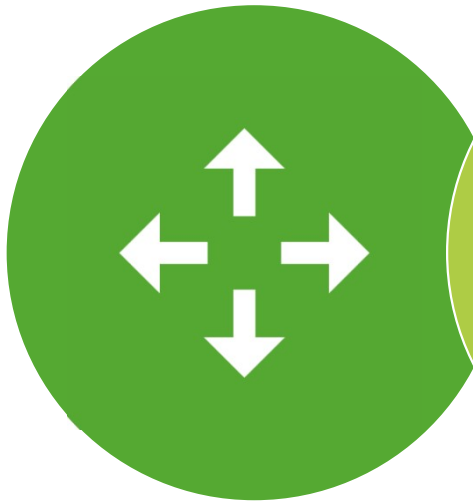
Q&A

Selected Sources of PFAS Primary Packaging

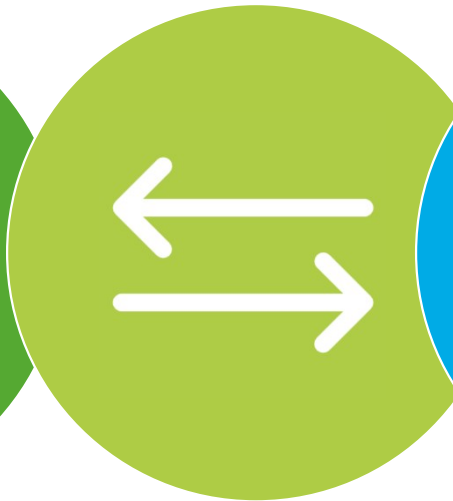
1 Primary Packaging	2 Secondary & Tertiary Packaging	3 Ingredients	4 Production Environment
Impart Improved Barrier Release Agents	Forming Materials	Improving Barriers	Providing Grease & Oil Resistance
For Thermoforming, blowmolding	Wetting and leveling agents, emulsifiers, foaming agents, or dispersants	Fluorination of PE was approved in 1983	Dry end coatings on paperboard and corrugated, and paper Lower the surface tension
	Emulsifiers assist in producing Teflon examples include the use of PFOA	Now used during forming of in HPDE, PP, PET blowmolded, thermoformed containers	Wet end use on paperboard
	Bond with functional groups such as acids and alcohols and/or take part in condensation polymerization of Nylon and PET	Primarily Polyfluoroalkyl substances	Coatings on hydroscopic polymers such as PLA, cellulose, starch, ethylenes, etc.
		Polymers fluorinated with hexafluoropropylene (HFP), tetrafluoroethylene (TFE), vinylidene fluoride (VDF) polymers	Packaging for Pet food, bakery, FOH fried foods

Roadblocks hinder many Drop In Solutions

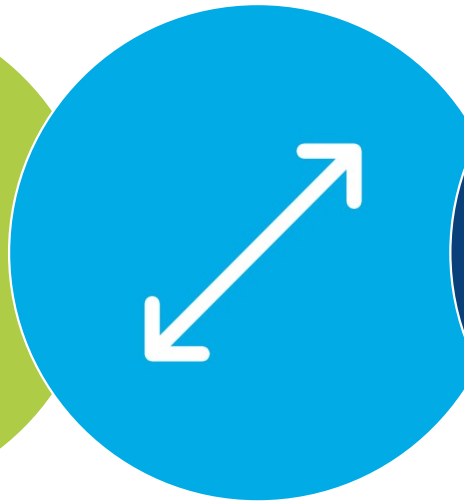
Release Agent Alternatives



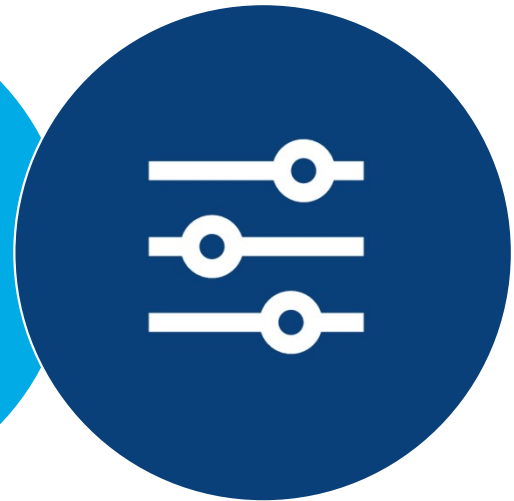
Forming Polymers Alternatives



Improved Barrier Alternatives



Improved Barrier Alternatives



Despite Industry efforts, PFAS is Still a Concern

Regrettable substitutions exist

- Industry experts know that substitutions may be regrettable
- This is a costly, and time-consuming game of whack-a-mole

Hiding behind regulations catches many off-guard

- Data was hidden from FDA
- GRAS status is dubious
- Harmonious regulatory action is delayed
- Reliance on voluntary abandonments

Shape-shifting supply chain

- Snapshots do not protect brands or consumers

Hodge-podge of local and retailer bans

Extensive incoming inspection is costly and is not in alignment with logistics

Value Chain provides the opportunity to... Future Proof Packaging

- Proactively Plan for the **Future** - Avoid kicking the can down the road with regrettable substitutions
- Build a more valued **safety-focused** relationship with regulatory agencies
- Build/rebuild **Trust** in all entities of the packaging value chain
- **Align** vs Entrap value chain partners
- **Collective work** builds a better shared future



A Future Proof Packaging Approach | Elements



Adjust to Reward Significance in Relationships

- Focus on the value in relationships
- Internalize relevant externalities
- Define meaningful incentive system for compliance between value chain entities
 - At all levels of organizations
- Address economic pressures in value chain by balancing costs and profits

A Future Proof Packaging Approach | Elements



Share Work

- Move beyond Taskforces to actual work
- Build a Chain of Custody to instill confidence
reduce fraud and add value
- Deliver on shared innovations
- Deliver on joint systems solutions
- Work toward harmonized standards to avoid a 2-tier system in which some citizens are protected for chemicals of concern by regulations and some are not

A Future Proof Packaging Approach | Case Studies



Manage Knowledge

- **Manage Human knowledge**
 - Involve inhouse and out-of-house seasoned experts
- **Manage Social Knowledge**
 - Focus collectively on sources of PFAS
 - Define what regrettable substitutions should not be used
- **Manage Structured Knowledge**
 - Define and share what is needed for joint systems solutions
 - Share knowledge transfer at all organizational levels

System solutions to replace for oil and grease resistance need in FOH QSR french fry cartons

- **Reduce oil in contact with packaging via a systems approach using one or all of these solutions**
- **Reformulate fries to**
 - Enhanced PME-based oil resistance so that less oil is adsorbed
- **BOH Processing to**
 - Adsorb oil prior to FOH packaging with diatomaceous earth or food grade clays
 - Use a 2-phase system in which oil is drained more extensively at a station before final FOH packaging
- **Non-PFAS plastic (reusable) packaging**
- **Package redesign to**
 - Employ a removeable plastic liner within FOH cartons
 - FOH cartons with a sealed low point with an adsorbent substance
 - FOH cartons dusted with an adsorbent substance
 - PFAS sensors on packaging for value chain use



ABOUT PTR Client Work | Build Innovation RoadMap



CLIENT PROFILE Major Packaging Company

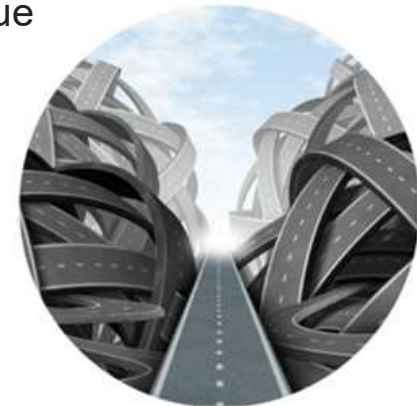
Large packaging supplier was starving for new growth in primary food packaging

SOLUTION

- PTR **pinpointed OTR, WVTR & mechanical** packaging requirements in 30 categories with 20,000+ products
- PTR focused on existing and new packaging solutions to:
 - Combat **food deterioration** mechanisms
 - Met **value chain needs**
 - Align with **emerging food processing** technology

RESULTS

- R&D dollars were prioritized within an innovation pipeline identifying short, to long term initiatives, level of complexity and the dollar value
- Replaced PET for the chilled food market
- Innovation continues



STRATEGIC
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ASSESSMENT

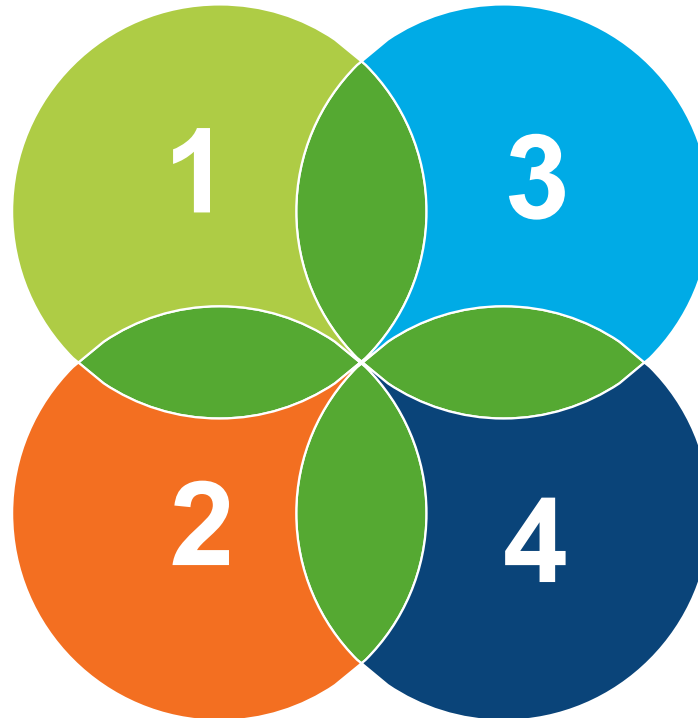


TECHNOLOGY

3 Hot Topics

Successful approaches
to eliminating
Chemicals of Concern

Implementation of
intelligent packaging –
finally!



Conversion to PEF and other
bioderived and recyclable
polymers

Q&A

Intelligent Packaging Technology I Overview

RESPONSIVE PACKAGING



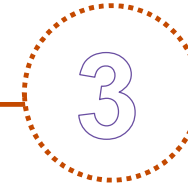
- Responsive Packaging senses, communicates, and then acts to extend the shelf life
- Sensors sense stimuli and then release compounds to retard degradative reactions
- Responses are tailored for internal or external stimuli such as light, temperature, O₂, microbial growth, or moisture

SENSORS THAT DEFINE SHELF LIFE



- Allows for supply chain, package and product formula changes because shelf life is determined in the actual supply chain and product
- Added value is in decreasing food waste and allowing flexibility with shelf life based on conditions at which the product has been exposed

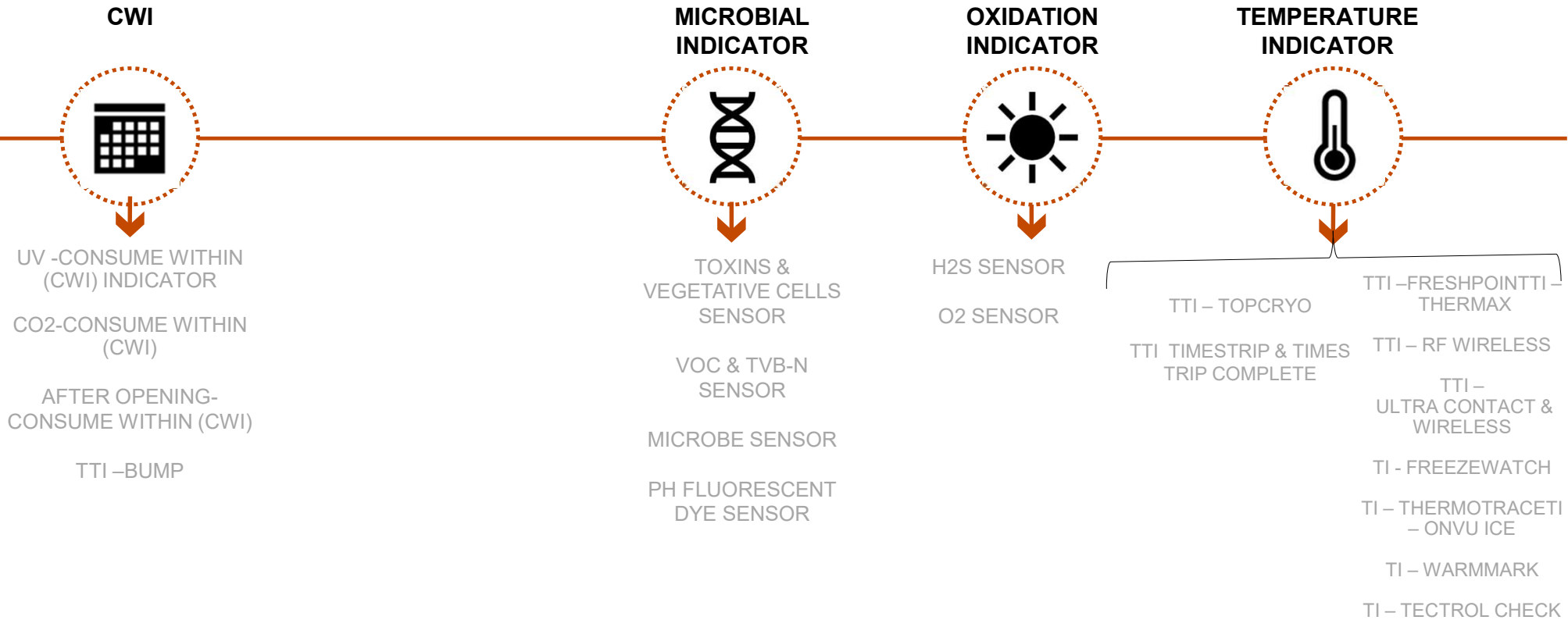
TRACK AND TRACE AND ENHANCED BRANDING



- QR codes have the IoP/IoT low potential with changing web-based delivery to consumers and supply chain
- NFC and RFID sensors have the most potential when consumer interfaces are integrated with track and trace needed within the supply chain
- A balanced cost and benefit of the technology in between the supply chain and brand owner is needed

Intelligent Packaging

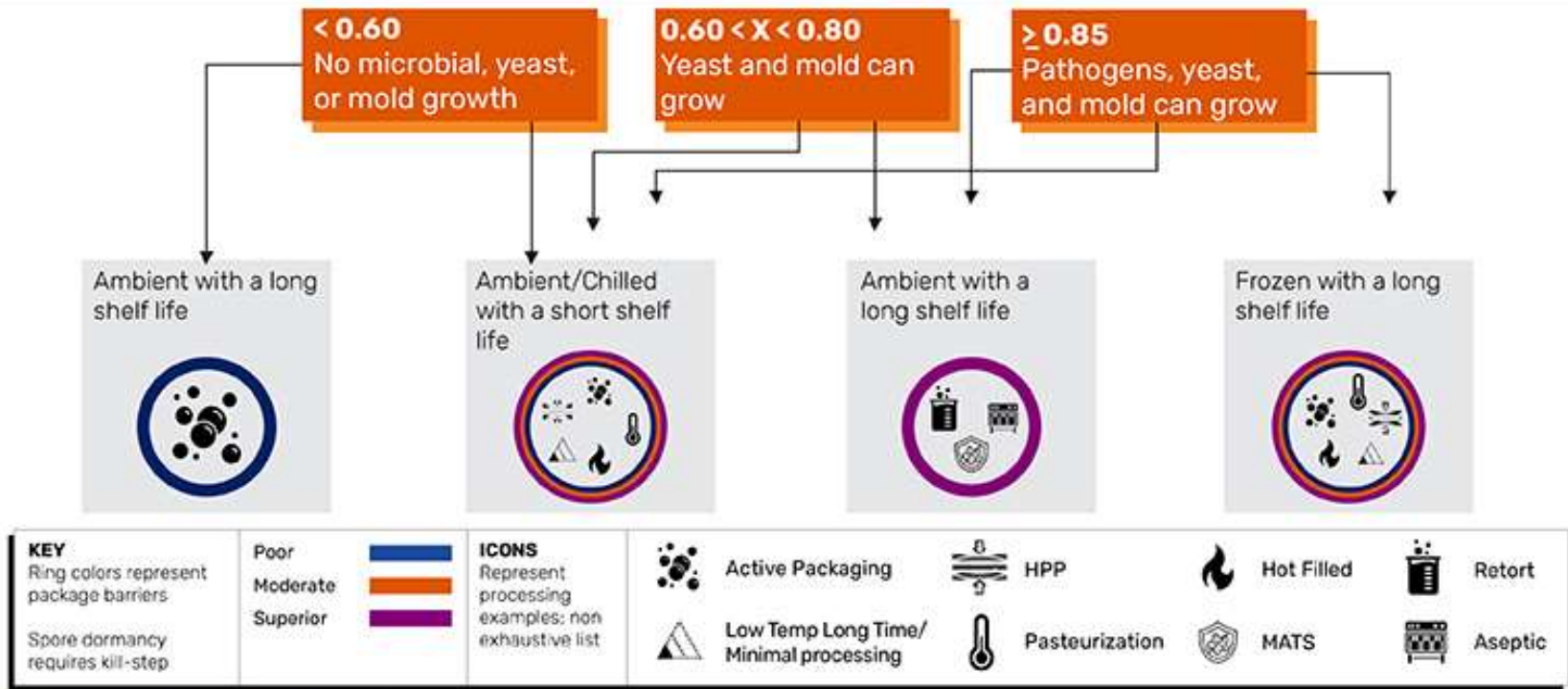
Sensors that define shelf life



How it happens

Modeling degradation kinetics is product and package specific

Prevent Microbial Growth



Modeling degradation kinetics is refined

Response function

$$F(X) = kt = k_{I_{ref}} \exp\left(\frac{-E_{a_i}}{R} \left(\frac{1}{T} - \frac{1}{T_{ref}}\right)\right) t$$

For variable temperature distribution

$$F(X)_t = \int_0^t k[T(t)] dt = k_{I_{ref}} \int_0^t \exp\left(\frac{-E_{a_i}}{R} \left(\frac{1}{T} - \frac{1}{T_{ref}}\right)\right) dt$$

Using effective temperature

$$F(X)_t = k_{I_{ref}} \exp\left(\frac{-E_{a_i}}{R} \left(\frac{1}{T_{eff}} - \frac{1}{T_{ref}}\right)\right) t$$

QSRs invest in food safety with Intelligent Packaging

Frozen Food Company

SITUATION

Listeria growth is undetectable below 3cfu/ml and product could contain *Listeria* due to lack of a tight cold chain

SOLUTION



Screened, ranked, and sourced intelligent packaging options to detect <3cfu/ml *Listeria monocytogenes* in prepared food



Defined value chain benefits - improved food safety and reduce labor - to build the business case for top ranked option

RESULTS

- ✓ **Eliminated risk** of *Listeria* in QSR products
- ✓ Charted **intelligent packaging as a competitive advantage**
- ✓ **Confidence** in the entire value chain that the product is safe for consumption
- ✓ Switch from a “*when in doubt, throw it out*” mentality that **reduced food waste by 15%**
- ✓ **Expanded sales** due to less food waste

Opportunity for brands

Brands optimize production and logistics

- Save \$
 - Less unsaleables at Retail
 - Avoid fees - food waste banned in Vermont
 - Optimize preservatives
- Expand distribution
- Provide on demand information
- Increase shelf life

Post-Consumer Waste and Food handling efficiency occurs

- More efficient circular economy
 - Aid in collection & sorting
 - Packaging Chain of Custody to enable use of recycalate
- Add post-consumer value to packaging
- Less landfill space - food waste
- Linked to Food Chain of Custody enables Secondary Market recovery

Technology continues to advance

- More options exist
- Costs lowered
- Shifted from time and temperature monitors to matching kinetics of degradative reactions
- Shifting from sensing degradation to acting to preserve food

ABOUT PTR

Client Work | Restore Confidence for Food Safety



CLIENT PROFILE Major Food Company

RTE brand at QSRs faced major food safety concerns

SOLUTION

- Identified optimal solution to address a **food safety concern & restore brand confidence**
- Ranked specific intelligent packaging - to be calibrated to accurately **match listeria growth kinetics** - solutions for a specific product
- **Prototyped** 3-5 best viable options to meet defined success factors
- Managed development **relationship** between supplier and brand
- **Built business case** to garner higher price for intelligent packaging

RESULTS

- Competitive advantage with intelligent packaging to lower labor costs
- Eliminated food safety as a concern unlike competitors
- Connected with reduced food waste platforms on UNSDGs
- Expanded sales 15% due to less waste

STRATEGIC GUIDANCE

ASSESSMENT

TECHNOLOGY



CLIENT PROFILE Major Packaging Supplier

Core technology to inhibit microbial growth needed focus to enter food packaging industry

SOLUTION

- Ranked, based on **market size**, foods needing this antimicrobial effect
- **Ranked packaging formats** for formats-rigid, paperboard, flexible
- Assessed **competitive set**
- Identified 5 most viable company **targets for market entry**
- Determined **value chain criteria** needed for buy in and scale-up



STRATEGIC
GUIDANCE



ASSESSMENT



TECHNOLOGY

RESULTS

- Focus on specific structures
- Market introductions in meat and eggs



Future of intelligent packaging



Bayesian decision making



Energy

- Printed batteries



Responsive Science

- Active packaging linkage to release preservatives
- Chlorine dioxide, ZnO, ethanol



Material science

- Paperboard substrate to detect and act



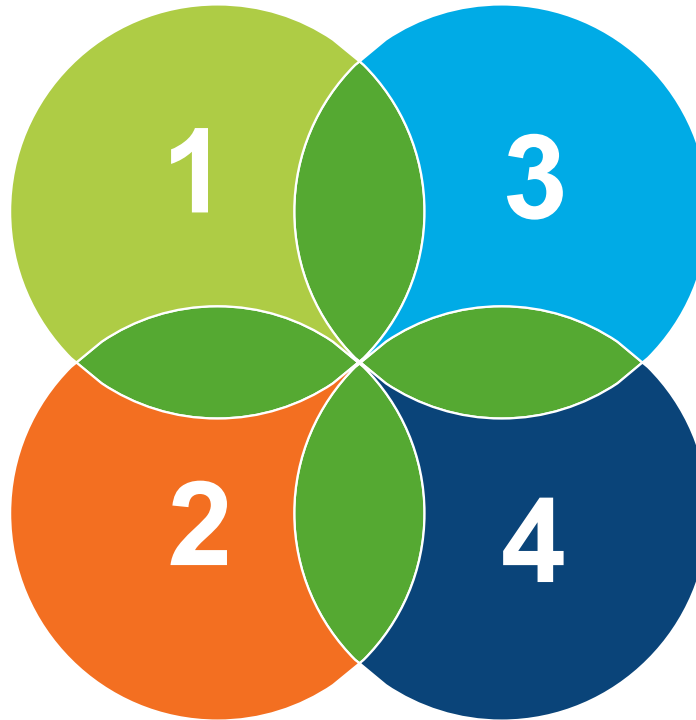
Reading

- Reading package shelf life via phone sensors
- Reactive inks

3 Hot Topics

Successful approaches
to eliminating
Chemicals of Concern

Implementation of
intelligent packaging –
finally!



Conversion to PEF and
other bioderived and
recyclable polymers

Q&A

Polyethylene Furanoate (PEF)



Application

- PEF is used as a replacement for polyethylene terephthalate (PET) in beverage bottles
- Carbonated beverages, juices, water, alcoholic beverages, sauces, dressings, oils, and other liquid food and beverages.

Manufacturers

1. Avantium (Netherlands)
2. Synvina (Netherlands)
3. Converter ALPLA Werke Alwin Lehner GmbH

Commercialized

- **Albert Heijn PEF juice bottles:** high barrier
- **Carlsberg's Green Fiber Bottle:** This is a paper bottle that is made from sustainably sourced wood fiber and lined with a thin layer of PEF. Limited markets in 2023
- **Danone's evian+:** Bottles made from 100% recycled PET and a small amount of PEF. The PEF is used as a barrier layer to protect the product from oxygen
- **Avantium's Dawn:** Range of ready-to-drink (RTD) beverages in bottles made from 100% PEF. Scaling up. Uses “forestry waste” and lignin
- **Coca-Cola's PlantBottle:** PEF considered as a barrier layer

PEF | Green Production

Synthesized from FDCA and ethylene glycol



Patented in 1946

Inability to remove metal catalysts during traditional polycondensation process presented environmental problems

More sustainable methods were developed using:

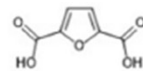
- Rapid ring-opening polymerization (ROP) and other technique
- Non-metal or enzymatic ionic catalysts
- Derived from 2,5-furandicarboxylic acid (FDCA) and ethylene glycol

PEF | Improved Barrier

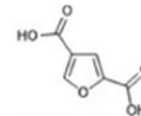
Barrier properties exceed PET

- PEF has 30x barrier to CO₂ vs PET
- PEF has higher sorption of CO₂ due to polarity of furan ring
- But diffusion through PEF is lower due to restricted rotations

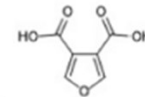
- PEF has a more restrictive less linear structure
- PEF has a Furan ring vs PET Benzene ring
- PEF building blocks are less linear than PET building blocks



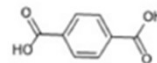
2,5-furandicarboxylic acid
(2,5-FDCA or FDCA)



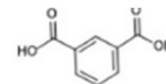
2,4-furandicarboxylic acid
2,4-FDCA



3,4-furandicarboxylic acid
3,4-FDCA



terephthalic acid
(TPA)



isophthalic acid
(IPA)

PEF | Comparable Thermal resistance and Mechanical Properties

Similar thermal resistance to PET

- Melt temp = 215C (420F)
- Glass transition temp = 80C (176F)
- Stability = 350C (662F)



Slightly lower mechanical properties than PET

- High elongation
- Very ductile at high molecular weight
- More brittle than PET due to less ability to structurally rotate

PEF | Sustainability



Recyclable

- Up to 2% within PET or paperboard
- Research on the enzymatic degradation to FDCA building blocks is promising
- PET & PEF specific enzymes has been identified

More sustainable production

- Other means to generate building blocks
- Renewable-based monomers related to FDCA such as thiophene derivatives

More sustainable means to achieve barrier

- Use as a nanoparticle or nano coating for poor barrier structures

ABOUT PTR

Client Work | Construct Specific Innovation Pipeline



CLIENT PROFILE Major Food Company

Pillars but not clear view on how to achieve them

SOLUTION

- **Identified technologies** needed to achieve 4 defined pillars
- Isolated and **selected common technologies** to meet the needs of different brands
- Defined technologies as **scalable-, pilot-, R&D-stage** to meet varied and specific brand needs
- Mapped out **resource commitment** needed to capture technology and weighed against market size and brand dynamics

RESULTS

- Innovation pipeline to direct package development
- Developing 2 core technologies in active packaging
- IP
- Value chain impact

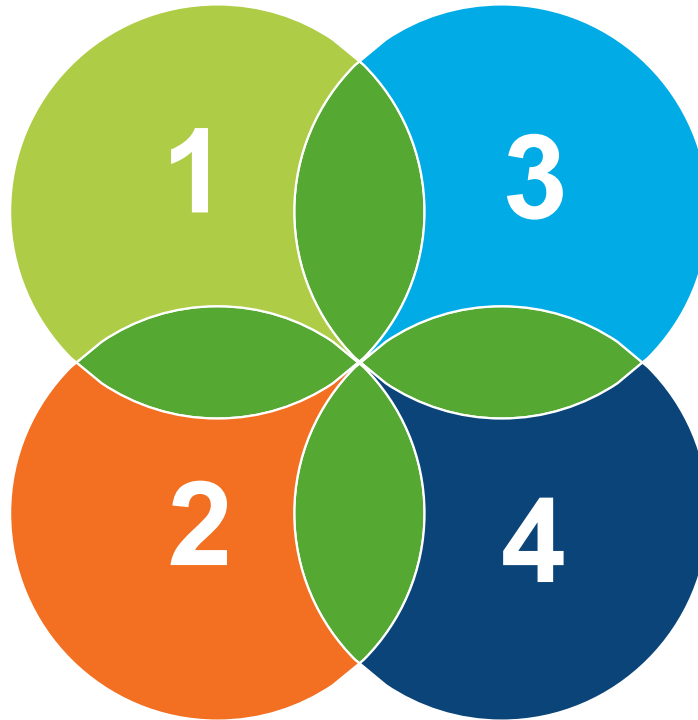


STRATEGIC GUIDANCE ASSESSMENT TECHNOLOGY

3 Hot Topics

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Conversion to PEF and
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Q&A

Future of Food Packaging

Scale-specific
supply chains

ESCAPE
the cluster for
true innovation

Material
Meshes

Beyond the
Bling
Intelligent

Beta
Packaging

AI integrated
Package
Research

Applied
Nanotechnology

Focused
Active
Packaging

Hack
the Hack

Shareability
DIY

Intuitive
Design &
Handling

...



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