Disruptive Development of Fully Compostable Materials to Replace Commodity Bio-Plastics

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Contents

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Background

The environmental impact of plastic waste—particularly in the food packaging sector—has become an urgent challenge both globally and locally. Within the Park Royal food supply chain, one of the UK's largest and most concentrated industrial areas for food production and distribution, the reliance on non-degradable plastic materials contributes significantly to waste streams and undermines sustainability efforts.

Conventional plastics such as PET, PP, and PLA blends, while offering good performance, are often non-compostable, difficult to recycle in practice, and contribute to long-term environmental pollution. Existing biodegradable options either fall short in barrier performance, degrade too slowly, or are difficult to process using standard industrial methods.

To address these challenges, this project was launched to explore degradable thermoplastics as a potential breakthrough in sustainable packaging. These materials combine high gas barrier properties, biodegradability, and compatibility with industrial composting systems, making them highly attractive for food packaging. However, to unlock their full potential, significant technical work is needed to overcome processing limitations—especially low melt strength and moisture sensitivity.

By partnering with Brunel University London, this project brings together materials science, polymer processing, and sustainable design to create next-generation, compostable packaging solutions tailored for real-world use in the Park Royal supply chain. The goal is to not only reduce plastic waste but also to create a scalable, locally relevant materials platform that advances Net Zero goals while maintaining performance standards expected by the food industry.

Challenge

While the demand for compostable and sustainable packaging is growing rapidly, the industry faces significant barriers to replacing conventional plastics—especially in high-performance food packaging. The key challenge lies in **developing materials that are both industrially compostable and capable of meeting the mechanical, barrier, and processing demands of large-scale packaging operations**.

A promising degradable thermoplastic has emerged as a candidate material due to its excellent gas barrier properties and rapid biodegradability. However, it presents several **critical processing and performance limitations**:

- **Low melt strength**, making it difficult to process using standard extrusion, film blowing, or thermoforming equipment.

- **High moisture sensitivity**, leading to hydrolytic degradation during storage and processing.
- **Brittleness**, limiting its suitability for flexible packaging formats.
- **Incompatibility with high-throughput manufacturing processes**, which require consistency, robustness, and thermal stability.

As a result, despite its strong environmental potential, this degradable thermoplastic has seen **limited commercial use outside of niche sectors like medical devices**, where cost and complexity are less of a constraint.

To meet the specific needs of the Park Royal food supply chain, the project must overcome these barriers by developing **custom-blend formulations** and **optimized processing strategies** that retain compostability while delivering the performance expected of modern food packaging.

Work to date

Significant progress has been made in addressing the challenges of processing and applying degradable thermoplastics for sustainable food packaging. The project has focused on both **fundamental material characterisation** and **applied development work**, including prototype production in collaboration with Brunel University London.

1. Material Characterisation

To understand the baseline properties and behaviour of the degradable thermoplastic, a suite of advanced analytical techniques was employed:

- **Differential Scanning Calorimetry (DSC)** – Assessed thermal transitions such as melting and crystallisation points, helping define optimal processing windows.
- **Fourier Transform Infrared Spectroscopy (FTIR)** – Identified chemical structures and functional groups relevant to degradation behaviour and blend compatibility.
- **X-Ray Diffraction (XRD)** – Examined crystalline structure to determine how blending and processing affect mechanical performance and thermal stability.

These analyses provided critical insights into how the degradable thermoplastic behaves during thermal processing and where modification is needed to improve functionality.

2. Preliminary Extrusion Trials

Initial processing trials were conducted using the pure degradable thermoplastic. These trials highlighted:

- Very low melt strength, making it difficult to form stable films.
- High variability and sensitivity to moisture content, leading to inconsistent extrusion and brittleness in finished parts.

This confirmed the need for **formulation and processing improvements** to enable industrial viability.

3. Development of Custom Polymer Blends

To overcome these issues, the degradable thermoplastic was compounded with food-grade biodegradable polymers such as:

- **PBAT (Polybutylene adipate terephthalate)** – Improved flexibility and toughness.
- **PBS (Polybutylene succinate)** – Enhanced thermal resistance and elongation.
- **PLA (Polylactic acid)** – Contributed stiffness and structure.

Preliminary blends demonstrated **improved melt strength, flexibility, and film stability**, particularly under controlled moisture and temperature conditions.

4. Prototyping and Application Testing with Brunel University

In partnership with **Brunel University London**, early-stage packaging prototypes have been developed using these custom blends. Activities include:

- **Film blowing and sheet extrusion trials** to evaluate processing behaviour on lab-scale equipment.
- **Thermoforming trials** to explore rigid packaging applications such as trays and containers.
- **Mechanical and barrier testing** of the prototypes to validate performance against real-world packaging requirements.

Results have been promising, with multiple formulations demonstrating **good balance between compostability, processability, and structural performance**.

Approach and Methodology

The project adopts a multi-phase, interdisciplinary approach combining materials science, polymer engineering, and packaging design to create scalable, compostable alternatives to conventional plastics used in the Park Royal food supply chain. The work begins with the selection of a base degradable thermoplastic known for its excellent barrier properties and rapid biodegradation. To enhance its performance, this material is compounded with food-safe biodegradable polymers such as PBAT (for flexibility), PLA (for stiffness), and PBS (for thermal stability). Advanced material characterisation techniques—including Differential Scanning Calorimetry (DSC), Fourier Transform Infrared Spectroscopy (FTIR), and X-ray Diffraction (XRD)—are used to evaluate thermal behaviour, chemical structure, and crystallinity, informing blend design and processing parameters. Processing trials, including extrusion, film blowing, and thermoforming, are conducted to assess melt strength, stability, and moisture sensitivity, with optimisation of temperature, drying, and shear conditions. In collaboration with Brunel University London, pilot-scale packaging prototypes (e.g., films, trays) are fabricated and tested for mechanical strength, barrier performance, and industrial compostability. An iterative development cycle ensures continuous refinement of formulations, guided by lab results and real-world packaging requirements. This practical, application-led methodology ensures the development of compostable packaging solutions that are both technically viable and commercially relevant.

Results and Impact

The project adopts a multi-phase, interdisciplinary approach combining materials science, polymer engineering, and packaging design to create scalable, compostable alternatives to conventional plastics used in the Park Royal food supply chain. The work begins with the selection of a base degradable thermoplastic known for its excellent barrier properties and rapid biodegradation. To enhance its performance, this material is compounded with food-safe biodegradable polymers such as PBAT (for flexibility), PLA (for stiffness), and PBS (for thermal stability). Advanced material characterisation techniques—including Differential Scanning Calorimetry (DSC), Fourier Transform Infrared Spectroscopy (FTIR), and X-ray Diffraction (XRD)—are used to evaluate thermal behaviour, chemical structure, and crystallinity, informing blend design and processing parameters. Processing trials, including extrusion, film blowing, and thermoforming, are conducted to assess melt strength, stability, and moisture sensitivity, with optimisation of temperature, drying, and shear conditions.

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Next Steps

Building on the promising results to date, the next phase of the project will focus on refining the custom polymer formulations to further improve performance, processability, and compostability. This includes optimising blend ratios, enhancing moisture resistance, and fine-tuning thermal properties to align with industry-specific requirements. Additional pilot-scale trials will be conducted with Brunel University to expand prototype development across a broader range of packaging formats, including multilayer films and thermoformed containers. Mechanical, barrier, and shelf-life testing will continue under simulated commercial conditions to ensure real-world viability. In parallel, the project will engage with packaging manufacturers and food businesses within the Park Royal supply chain to validate compatibility with existing equipment and gather feedback on performance and functionality. The team will also initiate formal compostability certification processes to support regulatory approval and market readiness. These next steps are designed to move the project from lab validation to scalable application—positioning the degradable thermoplastic blends as a credible, sustainable alternative to conventional plastic packaging.

Moving forward we would like to explore other form of this polymer which can replace other waste streams such as Foamed sheet packaging such as Polystyrene. This area of research would lead to new develops in insulation, packaging and much more.

Summary Table

Metric	**Figure**	**Context**
Plastic in household waste	9%	70% of that is packaging
London packaging use	2 m tonnes/year	~250 kg per person
Packaging recycling rate	44% (household), 33% (commercial)	
Carbon footprint	~2 m tonnes CO_2e/year	Half of London's transport
Park Royal packaging waste	Dominated by plastics & cardboard	Food supply chain activity

Implications for the Project

These figures highlight an urgent need to reduce packaging waste—particularly in industrial areas like Park Royal, where plastic and cardboard packaging dominate. With low recycling rates and high carbon impact at the London level, developing fully compostable, high-performance packaging alternatives can significantly contribute to waste reduction, circularity, and Net Zero goals.