Finnish bio-based materials project advances 100% cellulose-based film and coating technology as a scalable alternative to fossil-based packaging

Press release 10 June 2026

A new cellulose-based material platform developed in Finland responds to tightening regulatory requirements and industry pressure to both replace and reduce plastic in packaging, including emerging thresholds such as limiting plastic content to below 5 wt% in fibre-based materials. The technology enables transparent, high-performance films and coatings that match the functionality of plastics, while supporting industrial scalability and enabling simplified recycling or biodegradation across multiple environments.

VTT Technical Research Centre of Finland and LUT University have advanced fully cellulose-based film and coating materials through the F3 – Films for Future bio-based materials project, enabling the packaging industry to reduce and replace plastic while meeting performance and processing requirements. The materials combine plastic-like functionality with designed end-of-life performance: films are inherently biodegradable, while coatings are engineered for both recyclability within fibre-based systems and biodegradability where required.

The technology enables cellulose to be processed as a polymer rather than a fibre, resulting in transparent films with mechanical and barrier properties comparable to plastics. The development comes as regulation, including the EU Packaging and Packaging Waste Regulation (PPWR), is tightening requirements around recyclability, material composition, and lifecycle impact.

“Plastic films are one of the most widely used packaging formats, yet they are among the most difficult to recycle and a major source of persistent environmental pollution,” says **Ali Harlin**, Research Professor at VTT and one of the leading coordinators of the F3 project. “At the same time, we are working with manufacturers to help them meet evolving regulatory requirements while maintaining product protection, shelf life, and process efficiency. Cellulose materials open new sustainable solutions for packaging.”

The F3 material platform is designed to integrate with existing converting technologies and fit within current recycling streams or biodegradation pathways, depending on the application. Unlike many bio-based alternatives, it avoids the typical trade-off between functionality and end-of-life handling.

The project builds on advances in cellulose dissolution and regeneration, enabling the production of films with high transparency, mechanical strength, and barrier properties. Processing compatibility has been demonstrated with conventional methods such as thermoforming, supporting integration into existing industrial infrastructure.

“The cellulose films and coatings have already been demonstrated to have the properties to be processed in various package converting processes, which highlights their future potential,” says **Ville Leminen**, Professor of Packaging Technology at LUT University and the leader of LUT’s sub-project.

“Finding the right balance between functionality and sustainability is critical for the future of packaging. Through the F3 project, we have bridged this gap by developing fully plastic-free barrier coatings that deliver high performance without ecological compromise. Utilizing our off-line coating line, we are now able to commercialize these solutions on paper and board for

demanding food packaging applications," says **Carl-Erik Guttormsen**, Area Director at Colombier Finland.

Looking ahead, the platform could potentially open pathways beyond plastic replacement. The material can support multifunctional applications, including barrier coatings, antimicrobial or antioxidant functionality, and environmentally responsive packaging capable of reacting to humidity, gas composition, or pH. These capabilities are increasingly relevant as packaging technology advances toward active and intelligent systems.

"Value chain adoption of these platforms is essential for the ongoing transition towards fully renewable and recyclable technologies. We see chemistry as the key enabler for this transition," says **Mats Berg**, Sr Principal Scientist, Discovery & Innovation at Kemira.

Completed in March 2026, the F3 project has demonstrated the feasibility of producing cellulose-based films and coatings at pilot scale across multiple applications. For films, the results show potential as a standalone, transparent packaging material with inherent biodegradability. For coatings, the technology enables high-performance barrier layers that support recyclability in fibre-based packaging systems, while also offering biodegradability where required. The work involved collaboration between research organisations, industry partners, and funding bodies, with a focus on advancing the technology from laboratory development toward scalable manufacturing.

"The key challenge has not been whether alternative materials exist, but how to process them in a way that meets industrial requirements," says **Vinay Kumar**, Senior Scientist at VTT. "What has now been demonstrated is a future-ready material platform that offers an alternative to plastics, combining sustainability with the capability to integrate into existing manufacturing and recycling systems. We see strong potential to develop this further together with industry partners."

"From an industry perspective, scalability and system compatibility are critical factors," says **Riku Talja**, Development Manager at Metsä Board. "Solutions that align with current converting technologies and recycling infrastructure are far more likely to transition from pilot-stage innovation to industrial use."

The next phase will focus on scaling the technology toward commercial applications, with initial use cases in dry food packaging, bakery products, and fibre-based packaging requiring transparent barrier layers. The films provide oxygen barrier performance (Oxygen transmission rate, OTR below 1 cc/m2/day) comparable to conventional plastics at 23°C and 50% RH, while the coatings enable oxygen (OTR below 0.2 cc/m2/day) and grease barrier (KIT 12) functionality in recyclable fibre-based packaging systems.

Further development will target barrier performance under humid conditions, as well as the integration of multiple functionalities within a single material system. Digitalisation, including sensor-enabled or connected packaging, is also expected to play a role in future applications.

Beyond packaging, the material platform has potential applications in areas such as medical materials, electronics, and functional coatings, reflecting the broader role of cellulose as a renewable and versatile polymer in future material systems.

The development aligns with VTT's strategic mission to accelerate sustainable growth, renew industries, and support companies in scaling new technologies that contribute to the green transition.

F3 in a nutshell

In the Films for Future (F3) research project, VTT Technical Research Centre of Finland and LUT University developed new environmentally friendly packaging solutions with 34 industrial partners. The program was funded by the European Regional Development Fund (ERDF).

For additional information:

Media kit with pictures

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