e-ISSN 2720-7226

Packaging Review

3/2025

OPEN ACCESS: WWW.PACKAGINGREVIEW.EU

SCIENTIFIC QUARTERLY JOURNAL
OF THE PACKAGING INDUSTRY

PLASTIC PACKAGING – SIGNS CONCERNING ENVIRONMENTAL ASPECTS

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Packaging Review

PUBLISHER / WYDAWCA:
Alfa-Print Sp. z o.o.
Świętokrzyska 14A Str. / 00-050 Warsaw, Poland
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www.packagingreview.eu

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Dear Readers!

The packaging industry today is undergoing profound transformation. Increasing consumer and brand-owner expectations, new regulatory requirements, and the growing importance of sustainable development place packaging safety at the very heart of innovation and responsibility. It is within this context that we will gather at the **Safe Packaging Conference** - an event that for many years has brought together business leaders, researchers, and regulatory experts.

The conference provides a unique forum to discuss how to design, test, and implement packaging that meets strict quality standards, protects consumer health and the environment, and at the same time addresses market demands. It is also a place to explore how technological innovation is reshaping production processes and to reflect on the trends that will define the industry's future.

We warmly invite you to join this important initiative. Together we can develop packaging solutions that are not only efficient and economically viable but above all safe. Full details and the complete program are available at **konferencja.opakowanie.pl**.

We look forward to seeing you in Sopot!

Stefan Jakucewicz, D.Sc, Ph.D, Prof. emeritus Warsaw University of Technology. A graduate of Łódź University of Technology in the field of cellulose and paper technology, as well as Warsaw University of Technology in the field of printing. From 1974 he was a researcher at TU Warsaw. Since September 2018 he has been a pensioner. The editor of the sections in the periodicals: Opakowania (Packaging) and Przegląd Papierniczy (Paper Review). Research interests: printing materials science, paper technology and printing techniques of various substrates, with particular emphasis on plastics and the production of printed packaging, production of banknotes and postage stamps (security prints), certification of new base materials for both classic and digital printing techniques. Author or co-author of over 300 scientific articles published in Ukrainian, Slovak and German national journals, and 70 scientific and scientific-technical books published in Polish, German, Slovak and Ukrainian.

Szanowni Państwo,

branża opakowaniowa znajduje się dziś w centrum dynamicznych zmian. Coraz większe wymagania konsumentów i właścicieli marek, nowe regulacje prawne, a także rosnąca presja na wprowadzanie rozwiązań zgodnych z zasadami zrównoważonego rozwoju sprawiają, że bezpieczeństwo opakowań nabiera kluczowego znaczenia. To właśnie w tym kontekście spotkamy się podczas konferencji **Bezpieczne Opakowanie** – wydarzenia, które od lat łączy środowisko biznesu, nauki i instytucji badawczych.

Konferencja jest przestrzenią do dyskusji o tym, jak projektować, testować i wdrażać opakowania, które spełniają rygorystyczne normy jakościowe, chronią zdrowie konsumentów i środowisko naturalne, a jednocześnie odpowiadają na potrzeby rynku. To także okazja, by zobaczyć, jak innowacje technologiczne zmieniają produkcję opakowań oraz jakie kierunki rozwoju będą kształtować naszą branżę w najbliższych latach.

Zapraszamy Państwa do udziału w tej wyjątkowej inicjatywie. Wspólnie możemy tworzyć rozwiązania, które są nie tylko efektywne i ekonomiczne, ale przede wszystkim bezpieczne. Szczegółowe informacje o konferencji i programie znajdą Państwo na stronie: **konferencja.opakowanie.pl**.

Do zobaczenia w Sopocie!

Dr hab. inż. Stefan Jakucewicz, em. prof. PW. Absolwent Politechniki Łódzkiej w zakresie technologii celulozy i papieru oraz Politechniki Warszawskiej w zakresie poligrafii. Od 1974 roku pracownik naukowo-dydaktyczny Politechniki Warszawskiej, od września 2018 emeryt. Redaktor działowy w czasopismach „Opakowanie" i „Przegląd Papierniczy". Zainteresowania naukowe: materiałoznawstwo poligraficzne, technologia papieru oraz techniki drukowania różnych podłoży ze szczególnym uwzględnieniem tworzyw sztucznych i produkcji opakowań drukowanych, produkcji banknotów oraz znaczków pocztowych (druki zabezpieczone), atestacja nowych materiałów podłożowych przeznaczonych tak do klasycznych, jak i cyfrowych technik drukowania. Autor lub współautor ponad 300 artykułów naukowych opublikowanych w czasopismach krajowych, ukraińskich, słowackich i niemieckich oraz 70 książek naukowych i naukowo- technicznych wydanych w językach polskim, niemieckim, słowackim i ukraińskim.

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DOI: 10.15199/42.2025.3.1

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OPEN ACCESS

➜ SUBMISSION RECEIVED: 26.06.2025 / REVISED: 17.07.2025 / ACCEPTED: 01.08.2025 / PUBLISHED: 22.09.2025

ACCOUNTING FOR PACKAGING UNDER EXTENDED PRODUCER RESPONSIBILITY (EPR) SCHEMES: A PRACTICAL GUIDE FOR SMEs

ROZLICZANIE OPAKOWAŃ W RAMACH PROGRAMÓW ROZSZERZONEJ ODPOWIEDZIALNOŚCI PRODUCENTA (ROP): PRAKTYCZNY PRZEWODNIK DLA MŚP

ABSTRACT: This article offers a practical roadmap for small and medium-sized enterprises (SMEs) navigating the growing complexity of Extended Producer Responsibility (EPR) schemes for packaging. With EPR regimes becoming legally binding across the EU, UK, and North America, non-compliance now carries real financial and reputational risks. The article unpacks how EPR fees are calculated, how packaging weights should be audited, and how financial liabilities must be recognized under accounting standards like IAS 37. It provides detailed guidance on integrating EPR costs into product-level profitability and outlines a right-sized compliance framework that even resource-constrained SMEs can implement. A real-life case study of GreenBite Ltd. shows how early data gathering and digital tools can turn regulatory burdens into strategic advantages.
Key words: Extended Producer Responsibility (EPR); Packaging Compliance; SME; Sustainability Accounting; IAS 37; Eco Modulation; Packaging Fees; Product Profitability; Green Taxation; Digital Product Passport

STRESZCZENIE: Artykuł przedstawia praktyczny przewodnik dla małych i średnich przedsiębiorstw (MŚP), które muszą zmierzyć się z rosnącymi wymogami wynikającymi z systemów Rozszerzonej Odpowiedzialności Producenta (ROP) za opakowania. W obliczu wprowadzania obowiązkowych regulacji ROP w Unii Europejskiej, Wielkiej Brytanii i Ameryce Północnej, brak zgodności wiąże się z realnym ryzykiem finansowym i wizerunkowym. Autor omawia szczegółowo sposoby kalkulacji opłat, audytu masy opakowań oraz księgowego ujęcia zobowiązań zgodnie z międzynarodowymi standardami rachunkowości (IAS 37). Przedstawiono także metody integracji kosztów ROP z rentownością produktów oraz uproszczony model zgodności możliwy do wdrożenia nawet przez małe firmy. Studium przypadku marki GreenBite Ltd. pokazuje, jak szybkie zebranie danych i zastosowanie narzędzi cyfrowych może przekształcić obowiązki regulacyjne w przewagę konkurencyjną.
Słowa kluczowe: Rozszerzona Odpowiedzialność Producenta (ROP); zgodność z przepisami opakowaniowymi; MŚP; rachunkowość zrównoważonego rozwoju; IAS 37; eko-modulacja; opłaty za opakowania; rentowność produktów; podatki ekologiczne; Cyfrowy Paszport Produktu

THE URGENCY OF EPR COMPLIANCE FOR SMES

Extended Producer Responsibility (EPR) is no longer a fringe policy experiment; it is becoming mainstream law across the world. The Organisation for Economic Cooperation and Development defines EPR as a framework in which "producers take responsibility for collecting, sorting and treating endoflife products" (OECD 2016). In practical terms, that responsibility now carries a pricetag. Sachs and Bowman argue that liability for the full lifecycle cost of packaging is "shifting from local government to the companies that profit from it" (Sachs & Bowman 2024, p. 14).

Between 2025 and 2027 the regulatory ground beneath the packaging industry is set to shift irreversibly. The newly agreed EU Packaging & Packaging Waste Regulation (PPWR) will apply directly in all twentyseven Member States from August 2026 (European Commission 2023a). In parallel the United Kingdom is rolling out its own scheme (DEFRA 2024), while five U.S. states – including Oregon and California – have enacted the

first American EPR statutes (Oregon DEQ 2024; CalRecycle 2025). The underlying message is identical: the polluter pays. For small and mediumsized enterprises (SMEs) this is not an abstract policy debate but a looming financial fact. In most jurisdictions an SME ceases to be "small" once it exceeds both a turnover threshold – for example £1 million in the United Kingdom – and a mass threshold, typically twentyfive tonnes of packaging placed on the market each year (DEFRA 2024, p. 6). Crossing those lines can happen quickly: one supermarket listing, one viral socialmedia post or a single financing round may propel an artisan brand past the exemption ceiling.

United Kingdom projections illustrate the stakes. DEFRA expects businesses to pay £1.4 billion in EPR fees during 2025, fourfifths of which will be recovered directly from brand owners (DEFRA 2023, p. 17). German regulators have already fined unregistered producers up to €200 000 and facilitated delistings on Amazon (Zentrale Stelle 2024, p. 9). Meanwhile, sustainabilitylinked loans routinely request evidence of EPR provisions, and auditors treat underaccruals as a potential material misstatement (KPMG 2024). The cheapest day for an SME to start counting grams of cardboard and plastic is today; each month of delay compounds data gaps, backfees and credibility risk.

HOW EPR RULES AND FEE STRUCTURES WORK AROUND THE WORLD

Although every national statute is drafted in its own legislative language, mature EPR systems share four moving parts. Registration and reporting come first: the producer opens an account with a *Producer Responsibility Organisation* (PRO) and periodically uploads packaging tonnage by material. Second, fee calculation follows a simple equation – base rate per kilogram multiplied by weight and then adjusted by an ecomodulation factor that penalises or rewards design choices such as colourants or recycled content (European Commission 2023b). Third comes payment: some jurisdictions bill quarterly, others annually, while depositreturn schemes collect cash up front. The fourth and final component is audit and enforcement, ranging from desktop reviews to unannounced factory inspections and public "nameandshame" lists.

Headline numbers vary sharply. In continental Europe the PPWR sets a deminimis of ten tonnes and €2 million turnover; firms above that line will report quarterly and face headline fees between €50 and €800 per tonne depending on material stream (European Commission 2023a, Annex III). The United Kingdom sets the threshold at twentyfive tonnes or £1 million, but once a producer exceeds fifty tonnes it must upload datasets twice a year (DEFRA 2024). Québec applies annual reporting to firms above fifteen tonnes (Éco Entreprises Québec 2024), while Oregon captures anyone that releases more than a single tonne (Oregon DEQ 2024, §4). Surcharges can be eyewatering: coloured PET, multilayer flexibles and polystyrene foam attract penalties of up to fifty per cent (European Commission 2023b). The practical implication is that SMEs need a fee calculator flexible enough to import fresh tariff tables every January and to apply ecomodulation multipliers. A handful of SKUs may live in a spreadsheet, but anything beyond a couple of hundred belongs in enterprise software such as SAP Responsible Design and Production™ or Microsoft Cloud for Sustainability™ (SAP 2024; Microsoft 2024).

FROM BILLS OF MATERIALS TO AUDITREADY WEIGHT DATA

EPR compliance rises or falls on the quality of weight data. Burritt and Christ remind us that "environmental data consist of information about material inputs – and outputs such as solid waste" (Burritt & Christ 2021, p. 31). Retrospective reconstruction under audit deadlines is therefore a false economy. The journey must begin inside the Bill of Materials (BoM), where every sales SKU references each component that leaves the factory gate: corrugated outer case, plastic window, inner tray, adhesive label and even the stretchwrap on the pallet if the destination market demands it.

Supplier declarations are widely accepted, but experienced auditors insist on weighandcount sampling as a second line of defence. Ten randomly selected units on a calibrated laboratory scale – thirty for very light components – provide a statistically sound average. Once captured, the figures must be mapped to the material categories recognised by each PRO. The United Kingdom follows OPRL codes (OPRL 2023), the European Union

uses PPWR Annex II (European Commission 2023a) and the United States leans on the How2Recycle® taxonomy (Green Blue 2025). A live crossreference table inside the ERP avoids lastminute spreadsheet acrobatics.

Four control questions keep auditors happy: *Do measured weights reconcile to purchase quantities? Have multimaterial items such as laminated pouches been split by mass percentage? Is voidfill captured? Have discontinued SKUs been blocked from the reporting feed?* A single "no" invites forced estimates, typically twentyfive per cent above tariff (DEFRA 2024, p. 22).

4 RECOGNISING AND DISCLOSING EPR FEES IN FINANCIAL STATEMENTS

International Financial Reporting Standard IAS 37 states that a provision must be recognised when an entity has a present obligation, an outflow of resources is probable and a reliable estimate can be made (IASB 2023). In EPR terms, the obligating event is the act of placing packaging on the market, not the eventual PRO invoice. Recognition therefore starts the moment a sales order ships or a contract manufacturer issues an advance shipping notice. Where exposure is immaterial often less than €50 000 per year auditors may accept an immediate expense; larger liabilities call for a provision, debiting EPR expense and crediting a liability account that unwinds on payment. Depositreturn regimes add a third variant: the consumer's cash deposit is recognised as a refundable liability until the bottle comes home.

Monthly accruals for instance €17 500 build the liability through the year; variances on invoice receipt flow through profit and loss. Disclosure notes typically explain the tonnage basis, tariff assumptions and any judgement used in estimating ecomodulation rebates (KPMG 2024). Analysts read those notes with growing interest, treating them as a proxy for a firm's readiness for the broader greentax agenda.

BRINGING EPR COSTS INTO THE HEART OF PRODUCT PROFITABILITY

Stakeholder expectations are moving beyond boilerplate environmental statements. The International Federation of Accountants argues that external audiences now demand "more financial information about the costs and benefits of environmental actions" (IFAC 2022, p. 7). Once EPR charges breach one per cent of cost of goods sold, burying them in overhead masks the true health of a product line. Leading finance teams therefore push fees to SKU level using ActivityBased Costing (ABC). The cost driver is intuitive: grams of packaging per unit multiplied by the jurisdictional fee per kilogram.

The leverage is dramatic. Consider a British beverage startup that migrates a 330 millilitre juice from a 210gram glass bottle to an 18gram lightweight PET container. Even though PET attracts a higher ecomodulated rate – €0.20 per kilogram versus €0.11 for flint glass – the weight delta slashes the unit fee from 2.3 cents to 0.36 cents and lifts gross margin by roughly six percentage points. ISO 14047 describes such lifecycle cost assessments as a "systematic process for evaluating the lifecycle costs of a product by identifying environmental consequences and assigning monetary value" (ISO 2021, clause 4.3). In boardroom discussions those numbers resonate more than abstract circulareconomy slogans.

GOVERNANCE, CONTROLS AND TECHNOLOGY: BUILDING A RIGHTSIZED COMPLIANCE FRAMEWORK

A workable compliance architecture for an SME does not require a battalion of consultants, but it does demand clarity of ownership. In the leanest model, Operations maintains Bills of Materials and carries out physical weighing; Finance owns the fee calculator and ledger entries; a parttime ESG Lead monitors regulatory changes and manages the PRO relationship. Burritt and Christ note that many organisations face "bursts of activity as new taxes raise actual costs" (Burritt & Christ 2021, p. 58); clear lines of responsibility prevent those bursts from becoming crises.

A simple annual calendar underpins discipline. The first quarter closes the prioryear tonnage, often with an external laboratory verifying the heaviest SKUs. April and July bring dataset uploads to the UK regulator; October hosts an internal controls walkthrough; and December finalises the provision and the boardlevel environmental report. Technology does the heavy

lifting. Handheld barcode scanners at goodsreceipt prevent misclassification; cloud portals such as Valpak's Collect automate tariff updates and XML filings (Valpak 2024); API connectors push live BoM data from ERP systems to the fee engine, ensuring each shipment accrues the correct charge overnight. Auditors expect at least five years of weigh tickets, supplier declarations and versioncontrolled BoMs ideally stored in a searchable ESG data vault.

FROM THEORY TO PRACTICE: THE GREENBITE STORY AND THE ROAD AHEAD

When Londonbased snack brand GreenBite Ltd. closed its SeriesA financing in January 2024, the duediligence list contained an unfamiliar demand: evidence of EPR compliance. Until then the founders had never weighed a cardboard sleeve. Within two weeks they recruited a parttime data analyst; by March she had mapped eighty per cent of SKUs to Bills of Materials. In May the company deployed a cloud fee calculator and filed its first automated submission. October delivered a tangible win: switching a yoghurt tub from polystyrene to polypropylene saved an estimated £18 000 in fees and unlocked an OnPack Recycling Label that boosted supermarket shelf appeal. GreenBite's first PRO audit closed in January 2025 with no findings; its EPR bill fell from 4.2 to 2.9 per cent of revenue, and its valuation ticked upward.

Three lessons emerge. First, treat EPR like VAT – a statutory obligation that deserves system support rather than spreadsheet heroics. Second, weigh early and often; nothing hurts more than discovering midaudit that the historic weights belong to an obsolete spec. Third, invite packaging engineers to finance meetings; once designers understand the fee formula they can decarbonise and decost simultaneously.

The rulebook will tighten again soon. From 11 August 2026 every unit of packaging sold in the EU must carry a Digital Product Passport accessible by QR code (European Commission 2023c, Art. 9). Early adopters will enjoy lower ecomodulation fees and faster customs clearing; laggards will face emergency relabelling at their own expense. Blockchainanchored batch identifiers, once experimental, are entering pilots led by the Ellen MacArthur Foundation and GS1 (Ellen MacArthur 2025; GS1 2024). SMEs that integrate massbalance accounting and chainofcustody data now will face fewer surprises tomorrow – and may earn premium status in a market that increasingly rewards transparency.

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REVIEWED ARTICLE

DOI: 10.15199/42.2025.3.2

OPEN ACCESS

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➜ **SUBMISSION RECEIVED: 29.07.2025 / REVISED: 06.08.2025 / ACCEPTED: 18.08.2025 / PUBLISHED: 22.09.2025**

SUSTAINABLE PACKAGING IN PRACTICE – HOW D4PACK SUPPORTS THE SME SECTOR

ZRÓWNOWAŻONE OPAKOWANIA W PRAKTYCE – JAK D4PACK WSPIERA SEKTOR MŚP

ABSTRACT: The article presents the concept and implementation process of the international research project D4PACK, aimed at supporting small and medium-sized enterprises in designing sustainable packaging. The main outcome of the project will be a decision-support tool for packaging selection based on environmental, economic, and technological data. The results of the first pilot phase, conducted in four Central European countries, are discussed, along with the most common barriers to implementing sustainable solutions in SMEs. Special attention is given to the regulatory context (PPWR, SUP, CSRD) and the role of project partners in creating and testing the tool. D4PACK addresses the urgent need for decision-making support for companies lacking their own R&D resources.
Key words: D4PACK, EGET, sustainable packaging, PPWR, circular economy, SME, risk analysis, packaging decisions, Interreg, agri-food sector, environmental innovations

STRESZCZENIE: Artykuł przedstawia założenia oraz przebieg realizacji międzynarodowego projektu badawczego D4PACK, którego celem jest wsparcie małych i średnich przedsiębiorstw w projektowaniu zrównoważonych opakowań. Głównym rezultatem projektu będzie narzędzie wspomagające podejmowanie decyzji opakowaniowych w oparciu o dane środowiskowe, ekonomiczne i technologiczne. Omówiono rezultaty pierwszej fazy pilotażu, prowadzonego w czterech krajach Europy Środkowej, oraz wskazano najczęściej występujące bariery wdrażania zrównoważonych rozwiązań w MŚP. Szczególną uwagę poświęcono kontekstowi regulacyjnemu (PPWR, SUP, CSRD) oraz roli partnerów projektu w tworzeniu i testowaniu narzędzia. D4PACK stanowi odpowiedź na pilną potrzebę wsparcia decyzyjnego dla firm nieposiadających własnych zasobów badawczo-rozwojowych.
Słowa kluczowe: D4PACK, EGET, opakowania zrównoważone, PPWR, circular economy, MŚP, analiza ryzyka, decyzje opakowaniowe, Interreg, sektor rolno-spożywczy, innowacje środowiskowe

INTRODUCTION

The modern packaging industry stands at a critical turning point. Under growing regulatory pressure, consumer demands, and global environmental challenges, companies in the agri-food sector must rethink their approach to packaging design and use. It is no longer only about aesthetics, functionality, and price – today, climate impact, recyclability, and compliance with increasingly strict EU regulations are equally important.

According to the proposed new Packaging and Packaging Waste Regulation (PPWR, COM(2022) 677) of the European Parliament and Council, by 2030 all packaging placed on the EU market must be recyclable, and its weight and volume must

be reduced to a minimum. At the same time, more and more enterprises are subject to the Corporate Sustainability Reporting Directive (CSRD), which includes reporting on packaging's environmental impact. The industry thus faces a dual challenge: to act responsibly while keeping pace with regulatory and market demands.

Large corporations have their own R&D departments, employ LCA, ESG, and compliance specialists, and draw on legal and strategic consultancy. In contrast, small and medium-sized enterprises – which make up 99% of companies in the EU – often lack such resources. In practice, this means making decisions under uncertainty, without access to tools that would enable reliable comparison of packaging options from environmental, economic, and logistical perspectives.

D4PACK was created precisely to meet these needs – an international research initiative implemented under the Interreg Central Europe programme. Its goal is to develop tools to help SMEs make informed, data-based packaging decisions rather than relying on guesswork. The project aims to produce a digital tool that will allow companies to easily assess risks, costs, and benefits of different packaging strategies.

CHALLENGES FOR SMES IN THE CONTEXT OF SUSTAINABLE PACKAGING

For SMEs operating in the food sector, packaging transformation is not only an environmental issue but also an organisational, financial, and strategic challenge.

Firstly, many companies lack specialist knowledge in materials science, life cycle assessment (LCA), or EU regulatory compliance. Decisions are often based on intuition, supplier marketing claims, or pressure from retail chains. This creates a risk of investing in solutions that do not deliver real environmental benefits – or even worsen the situation (e.g., supposedly "eco" compostable films without industrial processing infrastructure).

Secondly, implementing new packaging requires testing, analysis, and time – all of which generate costs that smaller firms cannot bear without external support. There is a lack of tools to quickly compare scenarios: What happens if we change the grammage? Is it worth investing in monomaterials? How will the unit cost and raw material availability change?

Thirdly, regulatory changes are rapid and unpredictable. Instead of strategic planning, SMEs often act reactively – implementing changes only when facing fines or contract risks.

The D4PACK project seeks to level the playing field – giving companies a tool to make decisions as effectively as global players, but with far smaller budgets and lead times.

D4PACK – ORIGINS, GOAL, PARTNERS

D4PACK is a joint initiative of research institutions, industry organisations, and technology partners from five Central European countries. Its overarching aim is to develop a decision-support tool for SMEs designing sustainable packaging.

The project leader is Confindustria Verona, and the consortium includes: Cracow University of Economics, Łukasiewicz – Łódź Institute of Technology, Campden BRI Hungary, PROMA-PACK Ltd, Innoskart, the Slovenian Chamber of Agriculture and Forestry, and the Czech Federation of Food Industries. PwC – a leading global consulting firm with experience in risk analysis, sustainability, and strategic business advisory – serves as an advisory partner.

Some partners are responsible for research and testing, others for implementation aspects, and PwC for innovation risk assessment. This multi-layered structure ensures scientific robustness on the one hand and market usability on the other.

D4PACK is funded under the Interreg Central Europe programme and is based on the concept of an integrated Technology Transfer Service (TTS), at the heart of which will be the EGET tool.

EGET – A DIGITAL COMPASS FOR SMES

EGET is a digital tool designed to help SMEs evaluate packaging in terms of sustainability compliance, cost-effectiveness, and implementation risk.

The tool will be available online and based on a database enabling the analysis of various packaging scenarios. By answering a series of questions, the user will receive recommendations on material choice, design strategy, and regulatory compliance. EGET is not a full-scale LCA tool

but a practical interface tailored to SME resources and competencies, supporting operational decision-making.

PILOT ACTIONS – TESTING THE TOOL IN SME REALITIES

One of the key elements of D4PACK is pilot testing – practical trials of the decision-support system (DSS) in real SME environments within the packaging sector. The activities are divided into two stages:

1. Stage 1 – Case studies of 12 companies from Italy, Hungary, Czechia, and Slovenia. Partners conducted in-depth interviews and scenario analyses to understand current needs, limitations, and expectations regarding packaging.
2. Stage 2 – Testing the EGET beta version in 60 companies, assessing interface quality, accuracy of results, and potential for application in real purchasing and production processes.

Pilot coordination is led by Łukasiewicz – ŁIT. Testing is scheduled to conclude in autumn 2025, with the final version of EGET to be made available on an open-access basis as part of the integrated TTS platform.

The pilots involved dozens of agri-food companies from the meat, dairy, and fruit-vegetable industries – sectors selected for their sensitivity to product shelf life, logistics, sanitary requirements, and the need for strong protection against external factors.

MEAT SECTOR

For meat processing companies, the main issues were extending product shelf life while reducing plastic content. Vacuum and modified atmosphere packaging (MAP) remain dominant technologies, often requiring multi-layer film structures that are difficult to recycle but ensure tightness and microbiological safety.

Firms reported limited access to alternative materials meeting quality, logistics, and environmental requirements simultaneously. Cost constraints were another significant barrier, with most "eco" options entailing a substantial increase in unit costs.

DAIRY SECTOR

Challenges in the dairy sector primarily concerned ensuring microbiological protection for sensitive products (e.g., yogurts, curd cheese) and maintaining packaging stability under varying temperature conditions – particularly in export to regions with unstable infrastructure. Smart labelling to improve shelf-life management and batch identification was also important.

FRUIT AND VEGETABLE SECTOR

Fruit and vegetable packers focused on reducing packaging materials and using paper and cardboard as plastic alternatives. Ventilation (e.g., via film perforation) and moisture control were critical, especially for fresh produce requiring natural "breathing."

COMMON BARRIERS IDENTIFIED IN PILOTS

Despite sectoral and local differences, pilot actions revealed common challenges across SMEs in Central Europe:

- High cost of sustainable materials, especially per unit of product.
- Limited technical information on alternative packaging and lack of unified comparison standards.
- Technological constraints from existing machinery – e.g., incompatibility with new materials.
- Difficulty in assessing economic feasibility – need for simple tools to calculate costs and benefits during planning.
- Need for educational support and access to expert knowledge, including legal regulations such as PPWR and the Single-Use Plastics Directive (SUP).

Partners are now analysing these barriers and tested solutions to adapt EGET's functions to actual SME needs and ensure its effectiveness across varied operating conditions.

CONCLUSIONS AND OUTLOOK

D4PACK stems from the belief that the shift toward sustainable packaging must not remain the privilege of large corporations. SMEs also need support in navigating the complex landscape of regulations, costs, technologies, and consumer expectations. Without analytical tools and expert backing, packaging decisions are often intuitive, reactive, or random – slowing down the green transition of the agri-food sector as a whole.

With EGET, companies will be able to quickly, reliably, and affordably compare different packaging options in terms of cost, risk, and environmental or regulatory compliance. While EGET will not replace business decisions, it will ground them in solid data rather than assumptions.

Although the project focuses on the food sector, the D4PACK methodology and the tool itself can also be successfully applied in cosmetics, pharmaceuticals, or chemicals. Long-term plans include expanding the database to cover paper and glass packaging and integrating it with B2B platforms, digital product passports, and systems monitoring secondary raw material availability.

The TTS platform, with EGET at its core, could serve not only as an operational tool but also as an advisory and educational hub. Plans include integrating it with regional technology support systems, innovation incubators, and material clusters – democratising access to the knowledge and competencies needed for informed decision-making.

D4PACK will not solve all the packaging industry's problems, but it can remove one of SMEs' main growth barriers: the lack of access to knowledge and data at the decision-making moment. And that is already a significant leap forward.

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REVIEWED ARTICLE

DOI: 10.15199/42.2025.3.3

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OPEN ACCESS

➜ SUBMISSION RECEIVED: 01.07.2025 / REVISED: 14.07.2025 / ACCEPTED: 30.07.2025 / PUBLISHED: 22.09.2025

PLASTIC PACKAGING – SIGNS CONCERNING ENVIRONMENTAL ASPECTS

OPAKOWANIA Z TWORZYW SZTUCZNYCH - ZNAKI DOTYCZĄCE ASPEKTÓW ŚRODOWISKOWYCH

ABSTRACT: Signs and graphic symbols connected with the environment protection, placed on the plastic packaging may support the activities connected with the correct waste management. They deliver information concerning identification of polymer materials, their suitability for different forms of recycling and also, disposal of the waste; it is intended for the users, consumers, municipal service companies, packaging waste-processing plants and for other "links in the packaging chain".
Key words: plastic packaging, environmental marking

STRESZCZENIE: Znaki i symbole graficzne związane z ochroną środowiska umieszczane na opakowaniach z tworzyw sztucznych mogą wspomagać działania związane z prowadzeniem prawidłowej gospodarki odpadami. Dostarczają użytkownikom, konsumentom, firmom usług komunalnych, zakładom przetwarzającym odpady opakowaniowe oraz innym „ogniwom łańcucha opakowaniowego" informacji w zakresie identyfikacji materiałów polimerowych, przydatności do różnych form recyklingu, a także postępowania z odpadami.
Słowa kluczowe: opakowania z tworzyw sztucznych, znakowanie środowiskowe

TYPES OF SIGNS

Signs and graphic symbols, being placed on the packaging may supply the significant information connected with the environmental protection and the correct waste management. The aim of marking may include easing of segregation, confirmation of meeting the requirements for the specified recovery methods by a given packaging, indication of the ways for the appropriate waste management and identification of the systems of the packaging collection within the frames of the binding organizational-legal solutions. Due to the diversification of polymer materials, employed in production of packaging, it has a special meaning in the case of unitary packaging which generate the waste in the households. The information transferred in a form of signs is readable, easier noticeable and it reaches quicker the addressers. It causes the defined associations, has an impact on imagination and is received by the children and the youth what has also a high educational meaning.

The signs connected with the environmental aspects may be classified into the following groups:

- Identifying packaging material;
- Confirming the satisfaction of the specified requirements or environmental criteria, e.g.: suitability for material recycling, or organic recycling – composting, iteration of rotations, content of renewable raw materials, reduction of CO_2 emission;
- Specifying the content of the recycled raw material in packaging;
- Illustrating the organizational-legal system connected with the packaging waste management;
- Indicating the correct proceeding with the packaging after its utilization.

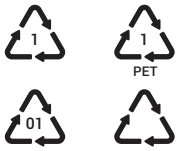
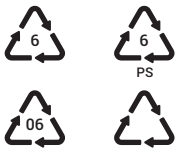
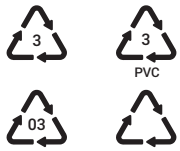
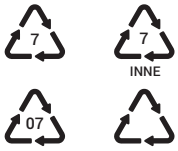
SIGNS IDENTIFYING THE PACKAGING MATERIAL

In the European Union, the voluntary system of identification for different packaging materials was introduced by Directive 94/62/EC[1]. To make the collection easier, and for the repeated use and recovery, including also recycling, it specified the identification system, covering abbreviation (sign) of packaging material and the corresponding numerical code. The mentioned signs should be placed on the packaging or on a label. They should be well visible and legible (even after opening of packaging) and indelible. The system for identification covering the symbol and numerical code for different packaging materials is specified in the Decision of the European Commission 97/129/EC[2].

In Poland, in respect of the packaging material identification since 2015, there has been binding regulation in the matter of defining the patterns of marking the packaging[3], published in addition to art.15 of the Act on Packaging and Packaging Waste Management[4]. The mentioned signs as contained in the above regulation have been presented in Tab.1 and 2.

In connection with the necessity to limit the impact of certain plastic packaging on the environment in relation to beverage cups, Directive 2019/904/EC established the requirements for the packaging concerning their marking in respect of the appropriate waste management methods or non-indicated methods of their disposal and, also the presence of plastics. The detailed way of marking was contained in the Regulation 2020/2151/EU[5]. The detailed way of marking was found in the Regulation 2020/2151/EU[6] and it became binding since 3 July, 2021. Fig. 1-3 illustrate the signs which should be placed on the cups.

TAB.1. THE SIGNS, IDENTIFYING POLYMER CONTENT IN PLASTIC PACKAGING

Packaging material	Signs on packaging
Polyethylene terephtalate	1 PET 
Polypropylene	5 PP 
High-density polyethylene	2 HDPE 
Polystyrene	6 PS 
Vinyl polychloride	3 PVC 
Low-density polyethylene	4 LDPE 
Other plastics	7 INNE 

1 European Parliament and Council Directive 94/62/EC of 20 December 1994 on packaging and packaging waste

2 Commission Decision 97/129/EC of 28 January establishing the identification system for packaging materials pursuant to European Parliament and Council Directive 94/62/EC on packaging and packaging waste (Official Journal L 050, 20/02, 1997)

3 The Regulation of the Minister of Environment dating back to 3 September 2014 in the matter of defining the patterns of marking the packaging (Official Journal of Laws of 2014, item 1298)

4 The Law on packaging and packaging waste management (Official Journal of Laws, 2024, items 927, 1911)

5 Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment (OJ L 155/1, 12.6. 2019)

6 Commission implementing Regulation (EU) 2020/2151 of 17 December 2020 laying down rules on harmonized marking specifications on single-use plastic products listed in part D of the Annex to Directive (EU) 2019/904 pf the European Parliament and of the Council on the reduction of the impact of certain plastic products on the environment (OJ L 428/57, 18.12. 2020)

TAB.2. SIGNS, IDENTIFYING THE PARTICULAR MATERIALS IN THE MULTI-MATERIAL PACKAGING WITH THE PARTICIPATION OF PLASTICS

Arrangement of materials	Signs on packaging
Paper and cardboard/plastics	81
Paper and cardboard/ /plastics/aluminum	84
Paper and cardboard/plastics /aluminum/ galvanized steel sheets	85
Plastics/aluminum	90
Plastics/galvanized steel sheets	91
Plastics/different metals	92
Glass/plastics	92

x - symbol of material, dominating in the packaging

FIG.1. MARKING IN A FORM OF OVERPRINT, REQUIRED ON THE CUPS MADE PARTIALLY FROM PLASTIC

FIG.2. MARKING IN A FORM OF OVERPRINT REQUIRED ON THE CUPS MADE OF PLASTIC

FIG.3. MARKING IN A FORM OF EXTRUSION, REQUIRED ON THE CUPS MADE OF PLASTIC

FIG.4. SIGN OF *MÖBIUS LOOP* AS A DECLARATION OF THE SUITABILITY FOR RECYCLING ACCORDING TO STANDARD PN-EN ISO 14021:2016

MARKS, CONFIRMING THE MEETING OF THE SPECIFIED REQUIREMENTS OR ENVIRONMENTAL CRITERIA

SUITABILITY FOR MATERIAL RECYCLING (MATERIAL RECYCLABILITY) – DECLARATION OF THE PRODUCER

The entrepreneurs may independently perform the assessment of respect of suitability of the packaging for recycling based upon the criteria contained in the legal acts or standards. In the case of satisfying the mentioned requirements, they may mark the packaging with the appropriate sign. For example, a mark indicating the suitability for the material re-processing has been defined in standard PN-EN ISO 14021:2016[7]. It is known under the name Möbius loop (Fig.4). The mentioned sign is a graphic form of the producer's declaration concerning satisfying the requirements in respect of the possibilities of recyclability of a given material.

In the national legal system – according to the act on packaging and packaging waste management – the packaging may be marked with the sign of recyclability if they meet the requirements of standard PN-EN 13430[8]. The model of sign as contained in the regulation on the matter of the patterns of packaging marking is given in Fig.5.

7 PN-EN ISO 14021:2016. Environmental labels and declarations – Self-declared environmental claims (Type II Environmental Labeling)

8 PN-EN 13430:2007 Packaging – Requirements for recyclable packaging by material recycling

FIG.5. NATIONAL (POLISH) SIGN OF THE PACKAGING SUITABILITY FOR RECYCLING

FIG.6. SIGN OF *THE SUITABILITY FOR RECYCLING*, THE TRIMAN RECYCLING LOGO, USED IN FRANCE

In France, the sign indicating the suitability for recycling was introduced in 2015 (The Triman recycling logo). The unit packaging coming from households and being marked with the mentioned sign, is subjected to selective collection for recycling and it should be placed in the appropriate container for the waste collection. The pattern of the discussed sign is given in Fig.6.

SUITABILITY FOR RECYCLING – SYSTEMS OF CERTIFICATION

The entrepreneurs may obtain the confirmation of the packaging suitability for recycling in a form of document, issued by the certifying institution. The procedure of assessment runs on the grounds of the requirements contained in standards or based upon the own criteria, developed by the certifying unit. Certification: *Made for Recycling* is carried out by organization Interseroh. The packaging is tested in conformity with the methodology, developed in agreement with the institutes: Bavarian Institute of Applied Research and Fraunhofer Institute for Process Engineering and Packaging. The customer receives a report, containing the evaluation of the recycling potential of packaging in 20-score scale and the certificate. The possibility of employing the sign, illustrated in Fig.7 may be obtained, however, for the packaging which was evaluated at least on 18 scores.

German Institute Cycloc-HTP in Aachen leads certification of packaging (*Certificate of Recyclability of Packaging*) on the grounds of own methodology of evaluating the recycling processes where the secondary raw material is produced[9].

FIG.7. LOGO GRANTED BY INTERSEH

The result of the mentioned evaluation indicates a real suitability of packaging for recycling. In the case when the total assessment is positive, the packaging is classified in one of the mentioned above classes:

- Class C, suitable for recycling, recycling rate <50% (minimum recycling);
- Class B, suitable for recycling, rate 50% - 70% (average recycling);
- Class A, suitable for recycling, recycling rate >70% - 90% (good recyclability);
- Class AA, suitable for recycling, recycling rate >90% - 95% (high suitability of recycling);
- Class AAA, suitable for recycling, recycling rate >95% (perfect recyclability);
- Class AAA+, suitable for recycling, recycling rate 100% (complete recyclability).

The sign used by Institute Cyclos-HTP for the certification of the recyclability is given in Fig.8.

FIG.8. SIGN OF INSTITUTE CYCLOS-HTP EMPLOYED IN THE CERTIFICATION OF THE RECYCLABILITY

The system of certification: *Certified as Recyclable* was introduced in Great Britain within the frames of the implemented initiative *The On-Pack Recycling Label* for plastic rigid packaging

9 [https://www.cyclos-htp.de/publications/r-a-catalogue/]

FIG.9. SIGN OF OBTAINING THE CERTIFICATE OF RECYCLABILITY INTRODUCED IN GREAT BRITAIN

FIG.10. SIGN OF OBTAINING THE CERTIFICATE OF RECYCLABILITY, AS INTRODUCED BY J.S. HAMILTON POLAND

FIG.11. SIGNS INFORMING ABOUT THE SUITABILITY OF PACKAGING FOR COMPOSTING (CONFIRMATION OF OBTAINING THE CERTIFICATE)

FIG.12. LOGO OF DIN CERTCO CONFIRMING THE GRANTING OF CERTIFICATE OF SUITABILITY FOR COMPOSTING (COMPOSTABILITY) IN THE CONDITIONS OF THE HOUSEHOLD COMPOSTER

and flexible packaging. In the future, it will be extended on all packaging materials. The mentioned system is aimed at confirmation that the specified types of packaging are subjected to collection, classification and then, processing by the recycling plants[10]. The sign anticipated for the packaging which obtained the discussed certificate is given in Fig.9.

In Poland, the system of certification of the packaging suitable for material recycling was introduced by J.S. Hamilton Poland Ltd in 2021. The certificates are issued in three categories according to the amount of packaging weight suitable for recycling. In the case of packaging of category I, it is possible to recycle 90 – 100% of the weight, for category II, it is 80 – 89% whereas for category III, it amounts to 60 – 79%.

Certification of packaging suitable for organic recycling (compostability) is carried out by the certifying unit DIN CERTCO in Berlin. Criteria for the certification are based upon standard EN 13432[11]. Placing the logo of compostability on the packaging supplies information that it should be subjected to the system of collection together with the biowaste (organic waste) directed to industrial composting plants. The signs confirming granting of the certificate are given in Fig.11.

The certifying unit DIN CERTCO introduced also certification of the products, including the packaging suitable for composting in the conditions of the household composters. The sign confirming the suitability for such conditions of composting is given in Fig. 12.

The system of certification confirming the suitability of the packaging for composting in the industrial and household conditions is conducted by the certifying unit TÜV AUSTRIA, with the application of sign *OK compost* (Fig.13) and *OK homecompost* (Fig.14).

In the USA, the certification of the suitability for composting is carried out based on standard ASTM D6400. The logo of compostability, as given in Fig.15, is granted by the American Council for Composting and the Institute of Biodegradable

FIG. 13. SIGN INFORMING ABOUT THE SUITABILITY OF PACKAGING FOR COMPOSTING

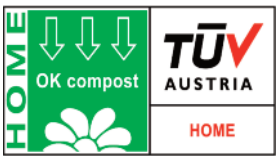


FIG.14. SIGN INFORMING ABOUT THE SUITABILITY OF PACKAGING FOR COMPOSTING IN THE HOME COMPOSTERS

10 [https://www.recycling-magazine.com/2020/09/24/new-recyclability-certificaiton-scheme/]

11 EN 13432:2000 Packaging – Requirements for packaging recoverable through composting and biodegradation – Test scheme and evaluation criteria for the final acceptance of packaging

FIG. 15. LOGO INFORMING ABOUT THE SUITABILITY FOR COMPOSTING IN THE USA (CONFIRMATION OF OBTAINING THE CERTIFICATE)

Products in the case when the packaging meets the requirements of the mentioned above standard.

In Poland, J.S. Hamilton issues the certificates of biodegradable and compostable products. Logo, confirming the requirements in this respect, is illustrated in Fig.16.

SIGNS FOR THE RE-USE PACKAGING

In the national regulation in the matter of defining the patterns of marking the packaging, there has been found the sign for the re-use packaging (Fig.17). The mentioned sign should be applied in the case of meeting the requirements contained in standard PN-EN 13429, one of the harmonized standards, issued to Directive 94/62/ EC.

The example of the sign for reused packaging, as employed in Germany, is shown in Fig.18.

THE CONTENT OF RAW MATERIALS FROM RENEWABLE SOURCES – CERTIFICATION SYSTEMS

Some certifying units run the systems for certification of the packaging, confirming the content of renewable raw materials. The types of the signs, used within the frames of the mentioned certification by DIN CERTO are illustrated in Fig.19 whereas the signs used by TÜV AUSTRIA are given in Fig.20.

SIGN OF CO_2 REDUCTION

In 2007, Carbon Trust, organization supported by the British Government, introduced a new marking of the products with the label of carbon reduction (Carbon Reduction Label) which indicates the reduction (lowering) of CO_2 emissions, accompanying various processes during the whole life cycle of a given product. For packaging, there is used a label: *Reducing CO_2 Packaging or Carbon Neutral Packaging*, with the

FIG.16. THE SIGN, CONFIRMING THE BIODEGRADABILITY AND COMPOSTABILITY, AS BEING USED BY J.S. HAMILTON

FIG.17. SIGN FOR THE REUSED PACKAGING

FIG.18. SIGN FOR THE REUSED PACKAGING, EMPLOYED IN GERMANY

FIG.19. DIN CERTO SIGNS, CONFIRMING THE CONTENT OF RAW MATERIALS FROM RENEWABLE SOURCES: A) CONTENT ABOVE 85%; B) CONTENT IN THE LIMITS OF 50 – 85%; C) CONTENT EQUAL TO 20 -50%

FIG.20. THE SIGNS, CONFIRMING THE CONTENT OF RAW MATERIALS FROM THE RENEWABLE SOURCES; THE NUMBER OF STARS ON THE RIGHT SIDE OF THE SIGN SPECIFIES THE PERCENTAGE CONTENT.

FIG.21. LABEL OF CO_2 REDUCTION FOR PACKAGING

FIG.22. LABEL OF NEUTRAL PACKAGING IN RESPECT OF CO_2 EMISSION

application of the method based upon the British Standard PAS 2060. The signs employed within the frames of the discussed certification, are given in Fig.21-22[12].

THE CONTENT OF THE RAW MATERIALS FROM RECYCLING IN THE PACKAGING

Apart from the sign of the suitability for the reused processing, standard PN-EN ISO 14021 considers also the possibility of declaring the information on the content of raw material from recycling in a given packaging. Sign of *Möbius Loop* in the case of the content of raw material from recycling is given in Fig. 23.

FIG.23. SIGN OF *MÖBIUS LOOP* IN THE CASE OF THE CONTENT OF RAW MATERIALS COMING FROM RECYCLING

FIG. 24. GRAPHIC FORM OF LOGO GREEN POINT

FIG.25. GRAPHIC FORM OF RESY LOGO

FIG. 26. SIGN, INDICATING THAT THE PACKAGING IS SUBJECTED TO THE SYSTEM OF COLLECTION, ORGANIZED BY THE LOCAL AUTHORITIES (ACC. TO CSN 77 0053)

THE SIGNS OF BELONGING TO THE ORGANIZATIONAL-LEGAL SYSTEM CONNECTED WITH THE PACKAGING WASTE MANAGEMENT

In many countries of the European Union, the entrepreneurs introducing the products in packaging to the market have been burdened with the duty of recovering and recycling of the packaging waste. The mentioned duty is implemented via the license fees, paid to the organization of recovery for the application of the specified signs placed on the packaging.

Green Point, being employed by the organizations of recovery, grouped in PRO EUROPE organization is the example of such sign. The discussed organizations, in conformity with the introduced organizational-legal system, receive the payments connected with the costs of the collection of the packaging waste, from the entrepreneurs who introduce their products in packaging to the market. The mentioned payment are dependent on the weight of the introduced packaging, on the type of the materials from which they are made, and also, on their volume or space. The sign of the *Green Point* is a reserved trademark; it is illustrated in Fig.24. In Poland, the license for use of the mentioned logo is held by the organization of recovery, REKOPOL. In Germany, RESY GmbH company employs, similarly as in the case of *Green Point*, the system of license payments for transport (external) packaging made from cardboard and paper. The entrepreneur who has paid the license payment for packaging, is entitled to place the mentioned sign in a graphic form on the discussed packaging (Fig.25).

SIGNS INDICATING THE APPROPRIATE DISPOSAL OF THE PACKAGING AFTER USE

In certain countries, e.g. in the Chechia, the producers when introducing the products in packaging to the market, were obliged to define the method of disposal of the packaging after their use. In the case of packaging which are subjected to the system of collection in conformity with the systems, organized by the local authorities, the sign contained in the Czech standard CSN 77 0053 was introduced. It is illustrated in Fig.26.

12 [https://www.carbontrust.com/]

KONRAD SZUSTAKIEWICZ, Ph.D.

PLACE CONFERENCE – TRENDS AND SOLUTIONS IN PACKAGING TECHNOLOGY

On 26-28 May 2025, the prestigious European PLACE Conference took place at the Le Meridien Hotel in Munich, bringing together leading experts, managers from research centres and companies, mainly from Europe. The main theme of the event was the latest trends and solutions in packaging technology, with a particular focus on multilayer plastic as well as paper packaging. Speakers focused on both packaging solutions as well as research techniques used to test the properties of packaging materials.

The event started with a welcome to the guests and introductions by Anna Helgert, Sven Sängerlaub and Peter Lamboy. This was followed by a keynote lecture in which Dr Günter Schubert, a member of TAPPI, addressed the challenges facing the packaging industry – how to find a balance between sustainability goals and primary packaging requirements.

Next on the agenda was a presentation on the welding properties and thermal strength of classic aluminium-free and so-called mono-laminates, given by Dr. Günter Schubert and

Ralph Jänchen from the Fraunhofer Institute for Process Engineering and Packaging IVV in Dresden.

The post-lunch session entitled. "Fundamentals of extrusion coating" began with Louis Piffer of Davis-Standard discussing the differences between extrusion coating and adhesive lamination, indicating which process may be more suitable depending on the application.

Sylvie Vervoort of Dow Benelux B.V. then presented the rheological tools used in the coating process. Maria Eriksson from Tetra Pak discussed the relationship between material properties and rheology in the context of beverage cartons.

The afternoon session entitled. "Extrusion and Laminating Processes and Technologies" was opened by Anna Helgert from Dow Chemical Ibérica S.L., who presented the impact of extrusion-coated polyethylene on the organoleptic properties of flexible packaging and liquid cartons. Dominique Jan and Petra Hollacher from INEOS presented how the use of extrusion-based pilot plants can support the development of modern packaging solutions.

In turn, Ouissam Abbas, Linda Van den Bossche and Marie-Paule Van Den Eede from ExxonMobil Chemical Europe LLC presented the processes involved in lamination of flexible packaging, showing the behind-the-scenes of the technology. At the end of the session, Jürgen Scheperjans from Morchem asked a thought-provoking question: is sustainability and efficiency really a contradiction in terms?

The second day of the conference started with the session 'Thermal welding - Old challenges - new opportunities'. The event discussed both classic challenges and the latest developments in the areas of thermal welding, barrier structures and packaging circularity. The first session presented research on the adhesion of maleic anhydride-modified polymers to aluminium and the effect of temperature on this process (Uwe Süßmann, Mitsui Chemicals Europe; Günter Schubert). Dr Christoph Dietrich (Amcor Flexibles Singen GmbH) discussed an innovative approach to creating breakable lids for reusable stainless steel containers.

Next, Peter A. Gellerich (Uhlmann) and Lena Bracken (TU Dresden) presented the thermomechanical theory of local delamination in pharmaceutical blisters, describing the 'buckling' phenomena of heat-sealed laminates. Petri Myllytie (Borealis) presented a breakthrough approach to high-performance mono-material PE packaging using coating and extrusion lamination.

After a coffee break, the session focused on the barrier properties of packaging materials.

Andreas Stenzel (IVV) presented a dynamic characterisation of permeation processes in polymer films. Davide Pomati (BOBST) invited participants to reflect on the past of paper and board packaging as a pathway to the development of future-proof barrier structures. Andreas Roos (Mocon-Ametek) addressed the difficulties of measuring barrier layers on porous substrates, and Bernhard Kainz (DOW) presented modern fibre packaging with a dispersion-based barrier coating.

After lunch, the thematic block on circularity (PPWR) began.

Karlheinz Hausmann (DOW) spoke about the design of packaging films in the spirit of a circular economy. Alex Degeest (INEOS) presented good practices within the Operation Clean Sweep initiative. Esra Kücükpinar (Fraunhofer IVV) presented new concepts for flexible packaging with PE recyclate and

barrier layers. In turn, Frederik Grønborg and Quentin LePiouff (Nordic Grafting) spoke about the compatibilisation of multilayer polymer materials, crucial for their recycling.

After the midday coffee break, the focus was on sustainability and new extrusion-based technologies. Ben Raven (Sabic) presented sustainable solutions in extrusion coating and Louis Bourgeus (INEOS) emphasised that sustainability is not just about recycling. Dominic Hohensinn-Pintar (Nordson) presented breakthrough developments in extrusion head technology, accelerating the implementation of innovative designs.

The final session of the second day focused on quality and control in film production: Alexandra Albuna (Borealis) discussed the use of mechanically recycled polypropylene in packaging films, Martin Lehmkoester (Dr. Schenk GmbH) presented intelligent quality control systems for extrusion and coated films, Oliver Hissmann (OCS Service GmbH) presented an analysis of so-called 'good' and 'bad' gels affecting the quality of film products.

The final day of the conference was marked by the reduction of polymer plastics, paper alternatives, new surface technologies and R&D innovations in the field of packaging materials.

The lectures started with a session entitled. 'Paper-based solutions and plastic reduction'. Mats Käldström (Walki Group) presented new fibre-based packaging materials as an alternative to polymer plastics. Yong Zheng (MICA Corporation) discussed the role of so-called primers in sustainable flexible packaging, highlighting their importance for adhesion and recycling. Robert Huber (BASF) presented research on the compostability of extrusion-coated paper without the formation of permanent microplastics. Ulf Nyman (Tetra Pak) presented key technological aspects in the design of sustainable packaging materials.

The second session was devoted to surface modifications - adhesion and its control. Anna Sadzik (HS Albstadt-Sigmaringen) presented the possibility of functionalising surfaces at the nanoscale through the graphitisation of fatty acid chlorides, improving the performance of packaging. Alexander Tillmans (TU Clausthal) and Leif Girnth (Derichs Walzenmanufaktur) discussed roller cleaning using plasma technology to increase the efficiency of film production. Florian Brehmer (AFS) presented the history and modern applications of corona treatment, discussing its environmental impact. Matthias Bucher (HS Albstadt-Sigmaringen) examined the effects of different levels of recyclate and plasma treatment on the surface energy of polypropylene films.

The final content session focused on the latest scientific developments: Marion Sterner (Gruppo X) presented a novel process enabling high paper extensibility in the transverse direction. Felix Lange (IVV) presented a cost-effective method for determining process windows in thermoforming, using PCR materials as an example. Bram Bamps (Hasselt University) presented the results of the MultiRec case study, comparing the properties of stretch films containing native plastic and PCR. Konrad Szustakiewicz (Wrocław University of Science and Technology) presented the results of the effect of multiple processing of polyolefin films by extrusion blow moulding on their properties. After a short coffee break, the conference was officially concluded, summarising the intensive days full of knowledge, innovation and exchange of experience.

The event provided participants with a wealth of practical and scientific information on the latest technologies in coating, lamination and sustainable packaging, while raising important questions about the future of the industry. The organisers have announced the next edition of the conference without giving details at this time.

FOT: HOLGER SCHUBERT

URSZULA SZELUGA, Ph.D., D.Sc.

INTERNATIONAL CONFERENCE SILESIAN MEETINGS ON POLYMER MATERIALS – POLYMAT 2025

On May 29, 2025, the International Conference "Silesian Meetings on Polymer Materials - POLYMAT 2025" was held in Zabrze. The conference was organized by the Centre of Polymer and Carbon Materials of the Polish Academy of Sciences and was supported by the National Agency under the Welcome to Poland project no. BNP/WTP/2023/1/00015. The scientific event was also under the auspices of the Committee of Chemistry of Polish Academy of Sciences, the Polish Chemical Society, as well as scientific journals and local media, including the Materials, the Packaging Review, Przemysł Chemiczny, Nasze Zabrze Local Newspaper, Zabrze TV and Zabrze Cultural Information Centre.

The aim of the Conference was to exchange current knowledge and provide an opportunity to share experiences in the field of polymer chemistry, closely related to the synthesis, characterization, modification and application of polymers in climate protection, as medical solutions and multifunctional polymer composites. The Conference was an excellent platform to integrate the scientific community of universities and institutes, students, experts and engineers actively working in the field of precisely constructed polymers for new applications. The Conference continues a long-standing tradition of fostering scientific dialogue on polymer materials in Silesia, building on the *International Polymer Seminars (GSP)*, held biennially from 1995 to 2008, *the Polymers on the Odra River POLYOR2011, and the Silesian Meetings on Polymer Materials POLYMAT* conferences organized in 2014, 2016, and 2022. Over the years, these events have attracted numerous respected scientists and experts from around the world, including Prof. Brigitte Voit, Prof. Rainer Haag, Prof. Stergios Pispas, Prof. Axel Müller, Prof. Christopher Barner-Kowollik, Prof. Richard Hoogenboom, Prof. Sigbritt Karlsson, Prof. Jean-Francois Lutz, Prof. Harm-Anton Klok, Prof. Yusuf Yagci, Prof. Jürgen P. Rabe, Prof. Heikki Tenhu, Prof. Ann-Christine Albertsson, and Prof. Krzysztof Matyjaszewski.

This year's conference consistently attracted great interest from the polymer research community in Poland and around the world, with more than 200 participants. Distinguished international scientists kindly agreed to give invited plenary lectures. It was a great honor for the Organizers to host:

- Prof. Minna Hakkarainen from KTH Royal Institute of Technology (Stockholm, Sweden) with the lecture *Designing polymers for circularity*
- Prof. Baki Hazer from Kapadokya University (Nevşehir, Turkey) with the lecture *Antioxidant and antibacterial efficiency of natural compounds attached to the olefin polymers*
- Prof. Jannick Duchet Rumeau from Ingénierie des Matériaux Polymères of Institut National des Sciences Appliquées (Lyon, France) with the lecture *Designing and tailoring the interfaces in the carbon filled composites*
- Prof. Bela Ivan from HUN-REN Research Centre for Natural Sciences (Budapest, Hungary) with the lecture *Nanostructured polymer conetworks, their gels and nanohybrids*

– Prof. Holger Frey from Johannes Gutenberg University (Mainz, Germany) with the lecture *Isomerization of poly(ethylene glycol) to rPEG: A strategy for the evasion of immune recognition*

The plenary complete lectures of the Conference are available at the YouTube link:
https://youtube.com/live/b3Jg5bl2jt8?feature=share

The program of the POLYMAT 2025 meeting included three poster sessions, which provided an exceptional opportunity for young participants to present the results of their research, as nearly 160 poster presentations related to:

(1) Synthesis, modification and characterization of polymers
(2) Polymer materials for medical applications and environmental and climate protection
(3) Multifunctional polymer composite materials

Six prizes funded by the NAWA project were awarded to the most noteworthy posters:

– M. Bochenek, B. Mendrek, W. Wałach, A. Foryś, J. Kubacki, Ł. Jałowiecki, J. Borgulat, G. Płaza, A. Klama-Baryła, A. Sitkowska, A. Kowalczuk, N. Oleszko-Torbus *Poly(2-oxazoline)s functionalized with chelating agents for antibacterial applications*
– A. S. Pillai, N. Maciejewicz-Kamiński, P. Sać, M. El Fray *Tailoring supramolecular thermosensitive hydrogels: chain length-driven structural and functional dynamics*
– K. Aleksandrov, E. Dimitrov, S. Doleva, Y. Hristov, N. Toncheva-Moncheva, S. Rangelov *Synthesis of polyester cyclic-brush polymers – innovative platforms for drug and polynucleotide delivery*
– M. Dębowski, J. Chazarkiewicz, M. Nowak, K. Przypaśniak, P. A. Guńka, A. Ostrowski, J. Zachara, Z. Florjańczyk, J. Ostrowska *Zinc phenylphosphates – hybrid 1D and 2D polymers with potential for application as PLA nucleating agents or components of smart materials*
– Sandra Paszkiewicz, I. Irska, K. Walkowiak, B. Dudziec, M. Barczewski *Optimizing multilayer bio-based polyester laminates using the Taguchi loss function for multi-criteria evaluation of processing conditions*
– Š. Potocký, M. Kočí, P. S. Wrobel, M. Godzierz, O. Szabó, S. Pusz, A. Kromka *Room temperature gas sensing performance of carbon-based heterostructure sensors*

Additionally, two prizes from the Chemistry Committee of the Polish Academy of Sciences were awarded to:

– Z. Kroneková, L. Jankovič, H. Zhukouskaya, M. Hrubý, J Kronek *Preparation of organo-modified montmorillonites with improved biocompatibility for decontamination of hazardous molecules*
– K. Kurtyka, A. Gawron, M. Godzierz, B. Trzebicka, M. H. Rümmeli *Post-mortem analysis of lithium-ion battery electrodes based on hollow 3D graphitic structures*

The Conference was also attended by representatives of companies including Altium sp. z o.o., Anton Paar sp. z o.o., A.P. Instruments sp. z o.o., Chemat sp. z o.o., Hass sp. z o.o., Labsoft sp. z o.o., Pik Instruments sp. z o.o., Polygen sp. z o.o. and Waters sp. z o.o.

ANNA NARUSZKO, M.Sc.

PRINT ENHANCEMENT. COATING

A new textbook, *Print Enhancement. Coating*, authored by Prof. Svitlana Khadzynova, Prof. Svitlana Havenko, and Prof. Stefan Jakucewicz, has just been published by the Lodz University of Technology. This is a highly detailed and reliable study that fills an important gap in the domestic professional literature. Aimed both at students of printing-related disciplines and at industry practitioners, it serves as a comprehensive compendium on coating techniques, materials, and technological nuances – from traditional analog methods to modern digital solutions.

Right from the introduction, the authors emphasize the importance of coating as one of the key methods of print enhancement, comparing it with other techniques such as hot/cold-stamping or laminating. The clear distinction between full-surface and spot varnishing, as well as between on-line and off-line methods, provides a solid foundation for further technological discussion.

Particularly noteworthy is the second chapter, devoted to the structure and properties of coatings. This is the most extensive section of the textbook, covering a wide spectrum of substances used in both analog and digital printing. The authors describe in detail not only the chemical composition of different types of varnishes (oil-based, dispersion, UV, solvent-based, or specialty), but also their curing processes, advantages, limitations, and disposal issues. Such a comprehensive approach adds immense value to the publication.

The third chapter offers a review of conventional coating systems – from offset, through flexography and screen printing, to gravure. The reader will find not only descriptions of each method but also detailed explanations of coating unit designs, anilox roller parameters, and the properties of plates and blankets used. The authors also address technological challenges, post-coating processing issues, and the impact of ink selection on coating quality.

The fourth chapter, which focuses on digital coating methods, also deserves attention. These relatively new but rapidly developing technologies are presented through discussions of both the use of transparent toners in electrophotography and inkjet techniques employing transparent inks. The inclusion of this subject confirms the timeliness and forward-looking nature of the publication.

The final part of the book concentrates on quality control of coatings – an area often underestimated in the production process. The authors present methods for assessing resistance and durability, as well as ways to measure technical parameters, making the textbook useful not only for technologists but also for quality control departments in printing houses.

The publication as a whole is characterized by clarity of editing and logical structure. The table of contents is very detailed, making it easy to quickly locate specific topics. A rich collection of illustrations, tables, and diagrams supports the assimilation of knowledge, while the technical terminology is applied consistently and intelligibly.

This textbook stands out not only for its in-depth treatment of the subject but also for its practical approach to the challenges of varnishing in print. It can serve as an educational tool at the academic level, while also functioning as an everyday reference for specialists in production, technology, and quality departments. It is available exclusively in printed form from the Lodz University of Technology Press, in the price of 65 PLN.

Packaging Review

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