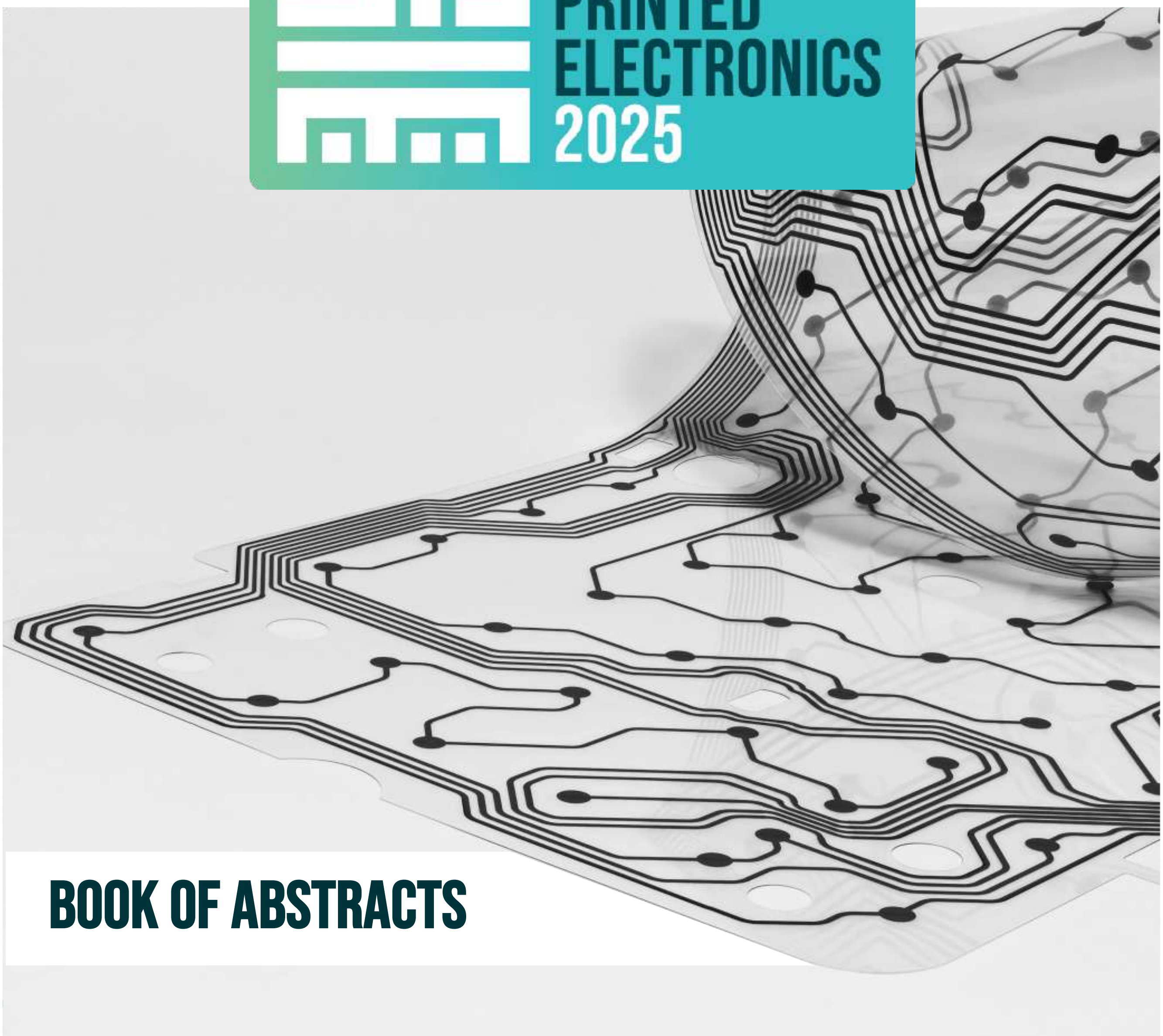
SUSTAINABLE PRINTED ELECTRONICS 2025



BOOK OF ABSTRACTS

TUESDAY 23RD TO THURSDAY 25TH OF SEPTEMBER 2025

KEDEA BUILDING,
ARISTOTLE UNIVERSITY OF THESSALONIKI, GREECE

www.exelisis-events.gr

SESSIONS

SUSTAINABLE PRINTED ELECTRONICS 2025

1. PRINTED ELECTRONICS & MANUFACTURING

This session will cover the latest advancements in the manufacturing processes of printed electronics, including techniques like inkjet printing, screen printing, and gravure printing. It will also discuss the integration of electronic components onto various substrates.

Session 1 Key Words - flexible electronics, organic Electronics, Thin-film electronics Conductive synthetics/polymer electronics, 3D structural electronics, large-area electronics, printing Technologies, Inkjet printing, aerosol-jet printing, electrohydrodynamic printing, screen printing, printing processes - additive manufacturing, self-assembly manufacturing, 3D printing, roll-to-roll manufacturing.

2. ADVANCED MATERIALS FOR PE

This session will focus on the development and use of advanced materials in printed electronics, such as conductive polymers, nanomaterials, and flexible substrates. It will explore how these materials enhance the performance and functionality of printed electronic devices.

Session 2 Key Words - Organic, inorganic, Metallic Nanoparticle Ink, carbon dots, graphene, multiwalled nanotubes, conductive polymers, nanocomposites, doped semiconductors, printed substrates, Polymers and their composites for flexible electronics, PET PLA substrates, PDMS, TPU, other polymers, Conductive polymers and polymeric composites, Bio-Based Polymeric Substrates

3. INK FORMULATIONS

This session will delve into the formulation of inks used in printed electronics, including the selection of materials, the impact of different formulations on device performance, and the challenges associated with achieving consistent and high-quality prints

Session 3 Key Words – functional materials and nanomaterials, conductivity, adhesives, curing methods, green solvents, 2D-Material Ink, D-Material Ink, Molecular Ink, UV-Curable Ink, solvent-based materials, functional inks, functional inks with sustainable and biobased polymer Metal Oxide Nanoparticle Ink, Liquid Metal-Based Inks, Direct Ink Writing (DIW), Solution Processing Techniques.

4. CLUSTERING SESSION

This session will include insightful presentations from several EU-funded project active in the field of the development of printed electronics, among which Sustain-a-print, SUINK, CircEL Paper, HyPELignum and REFORM EU projects will be highlighted.
Session 4 Key Words - flexible electronics, stretchable electronics, circular economy, green manufacturing, conductive inks, Sustainable circuit boards, additive manufacturing, functional electronics.

5. SUSTAINABILITY CIRCULARITY, SSBD, MARKET AND END OF LIFE

This session will discuss the sustainability and circular economy principles applied to printed electronics. It will cover strategies for designing for sustainability (SSbD), market trends, and the economic impact of sustainable practices in the industry.
Session 5 Key Words - governance, market standards, life cycle analysis, safe and sustainable by design, roadmaps, policies, Circular Economy, Sustainability Strategies, Market Trends, Economic Impact, SSbD (Safe and Sustainable by Design)

6. END USER DEVICES APPLICATIONS

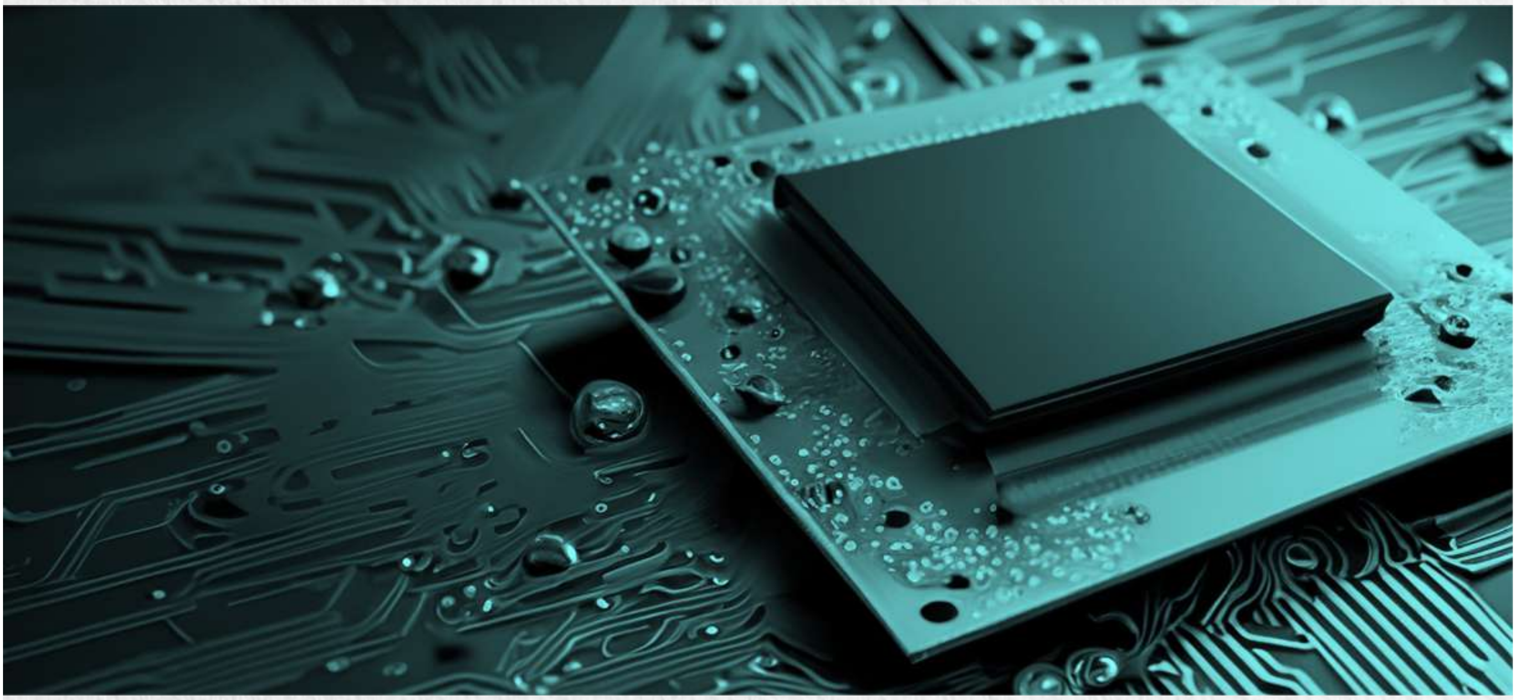
This session will showcase various applications of printed electronics in devices such as sensors, displays, batteries, and wearable technology. It will highlight real-world examples and discuss the potential for future innovations.
Session 6 Key Words - flexible and stretchable device, printed device, stretchable device, energy devices, conductive electrodes, applications of 3D-Printing Technology, Power supply, energy, consumer electronics, information display, flexible sensors, integrated circuit, consumer electronics, textiles-clothing, packaging, automotive, healthcare, pharmaceuticals, patient tracking to smart drug packaging, smart buildings. Bioelectronics and biosensors;

SESSIONS

SUSTAINABLE PRINTED ELECTRONICS 2025 | THESSALONIKI

INVITED SPEAKERS & THEMATIC AREAS

1.	**Prof. Vassilios Binas** (Assistant Professor of Physical Chemistry at AUTH)	Opening Talk
1.	**Prof. Gianmarco Griffini** (Politecnico di Milano)	Printed electronics & manufacturing
2.	**Prof. George Hadziioannou** (University of Bordeaux)	Advanced Materials for PE
3.	**Anna Marie Gorman** (CPI)	Ink formulations
4.	**Dr. Zachary Davis** (Danish Technological Institute)	Clustering Session
5.	**Dr. Panteleimon Panagiotou** (BayFor)	Sustainability Circularity, SSbD, market and end of life
6.	**Prof. Nikos Pleros** (Aristotle University of Thessaloniki)	Devices applications



CONFERENCE TIMETABLE

SUSTAINABLE PRINTED ELECTRONICS 2025 | THESSALONIKI

DAY 1 - TUESDAY 23 SEPTEMBER 2025

PRESENTATION TITLE	PRESENTER
Opening Talk	Prof. Vassilios Binas

CONFERENCE TIMETABLE

SUSTAINABLE PRINTED ELECTRONICS 2025 | THESSALONIKI

DAY 2 - WEDNESDAY 24 SEPTEMBER 2025

TIME	PRESENTATION TITLE	PRESENTER
S1: Printed Electronics & Manufacturing | CHAIRED: Dr. Zachary J. Davis (DTI)		
-	Polymers for light management in solar energy systems: harnessing multifunctionality for sustained performance	**Prof. Gianmarco Griffini** (Politecnico di Milano)
-	Aerosol Jet Printing: Technique Overview and Proof-of-Concept Demonstrations for Additive Manufacturing	**Maria Karani** (CERTH)
-	Halftone-Printing to Control the Resistance in Arbitrarily Shaped Areas	**Dr. Vanessa Tischler** (Alpen-Adria Universität Klagenfurt)
-	Furanoate polyesters: New biobased alternative substrates for printed electronics	**Prof. Dimitrios Bikiaris** (Aristotle University of Thessaloniki)
-	**Coffee Break & Session Poster**	
S2: Advanced Materials for PE | CHAIRED: Prof. Dimitrios Bikiaris (AUTH)		
-	Polymers, electronics and the genesis of polymer printed flexible electronics	**Prof. George Hadziioannou** (University of Bordeaux)
-	Development of green Lignin-MWCNTs hybrids for sustainable conductive materials	**Dr. Sofia Paraskevi Makri** (Creative Nano)
-	Carbon Nanofiber-Polylactic Acid LTO Composite filaments for the fabrication of 3D Printed Lithium ion Battery	**Muhammad Saqlain Iqbal** (University of Bari)
-	High-performance biobased substrates for printed electronics: The role of copolyesters based on PLA and poly (ethylene azelate)	**Rafail O. Ioannidis** (Aristotle University of Thessaloniki)
-	**Lunch Break**	

CONFERENCE TIMETABLE

SUSTAINABLE PRINTED ELECTRONICS 2025 | THESSALONIKI

DAY 2 - WEDNESDAY 24 SEPTEMBER 2025

TIME	PRESENTATION TITLE	PRESENTER
	S3: Ink Formulations| CHAIRED: Dr. Cristian Rein (DTI)	
-	Closing the Loop: Sustainable and Cost-Effective Glucose Biosensors Through Circular and Digital Design	**Anna Marie Gorman** (CPI)
-	Novel PLA nanocomposites based on Ag and Cu nanoparticles: The Next Generation of Printed Electronics	**Lazaridou Kyriaki** (Aristotle University of Thessaloniki)
-	Washable Graphene-based Conductive Coating: The Impact of TPU Segmental Architecture on its final performances	**Ilaria Improta** Gennaro Rollo (National Research Council - CNR)
-	From Copper Particles into Conductive Inks for Sustainable Membrane Switches	**Dr. Sol Gutierrez** (Danish Technological Institute)
-	**Coffee Break**	
	S4: Clustering Session | CHAIRED: Dr. Michele Ponzelli (AXIA INNOVATION GmbH)	
-	Sustainable and Circular Materials for Printed Electronics: The Sustain-a-Print Project	**Dr. Zachary Davis** (Danish Technological Institute)
-	Towards sustainable End-of-Life strategies for printed electronics: Recycling and material recovery approaches from the REFORM project and beyond	**Dr. Max Torrellas** (AIMPLAS)
-	Electronics from renewables: the HyPELignum project	**Kealie Vogel** (EMPA)
-	High-performance biobased substrates for printed electronics: The role of copolyesters based on PLA and poly(ethylene azelate)	**Gerhard Domann** (Fraunhofer ISC)
-	Sustainable conductive polylactic acid ink for digital printing	**Leire Sanchez-Duenas** (TEKNIKER)
	GALA DINNER	

CONFERENCE TIMETABLE

SUSTAINABLE PRINTED ELECTRONICS 2025 | THESSALONIKI

DAY 3 - THURSDAY 25 SEPTEMBER 2025

TIME	PRESENTATION TITLE	PRESENTER
S5: Sustainability Circularity, SSbD, market and end of life | CHAIRED: Dr. Ioanna Deligkiozi (AXIA INNOVATION GmbH)		
-	EU-funds in the scope Horizon Europe Framework funding for Research	**Dr. Panteleimon Panagiotou** (BayFor)
-	Life cycle assessment of two ecodesigned printed electronic devices	**Lou Bernard** (Lomartov)
-	Lignin as component of sustainable printed electronics: An overview of IP landscape	**Sotiria Tzampazidou** (AXIA Innovation)
-	Chemical Recycling of PLA and Its Copolyesters with Poly(Ethylene Azelate) via Microwave-Assisted Alkaline Hydrolysis	**Nikos Bikiaris** (Aristotle University of Thessaloniki)
-	Implementing Safe-and-Sustainable-by-Design (SSbD) in Early-Stage Materials Development: Insights from the GreenOmorph Project	**Dr. Elisabeth Schwarz-Funder** (JOANNEUM RESEARCH)
-	**Coffee Break & Session Poster**	
S6: Devices & Applications | CHAIRED: Dr. Elizabeth Shaw (CPI)		
-	Plasmonics and Photonics for High-Performance Biochemical and Environmental Sensing Applications	**Prof. Nikos Pleros** (Aristotle University of Thessaloniki)
-	Printed Cellulose-Based Sensors for Process Optimisation and Structural Health Monitoring	**Arunjunai Raj Mahendran** (WOOD KPLUS)
-	A Sustainable Printed Platform for Sweat-Based Kidney Disease Monitoring	**Daniel Corzo** (Silicon Austria Labs)
-	Eco-Conscious Printed Sensors on Algae-based and Cellulose Substrates for Health and Environmental Monitoring	**Emily Bezerra** (Silicon Austria Labs)
-	**Lunch Break**	

BOOK OF ABSTRACTS

SUSTAINABLE PRINTED ELECTRONICS 2025 | THESSALONIKI

SUSTAINABLE PRINTED ELECTRONICS 2025

ORAL PRESENTATIONS

SUSTAINABLE PRINTED ELECTRONICS 2025

From Copper Particles into Conductive Inks for Sustainable Membrane Switches

Authors:
Sol Gutiérrez, Danish Technological Institute

Abstract ID: 80
Submitted: July 28, 2025
Event: SPE2025

Presenter Name: Sol Gutiérrez
Presenter Preference: Oral Presentation
Status: Accepted

Copper's exceptional electrical conductivity and natural abundance position it as a sustainable alternative to silver in printed electronics. However, challenges in oxidation resistance, dispersion stability, and ink formulation have limited its adoption. This work addresses these barriers through scalable green synthesis methods to produce copper nanoparticles, combined with systematic particle engineering strategies that optimize size, shape, and surface chemistry to enhance conductivity. By controlling nanoparticle morphology and employing tailored surface coatings, we achieve resistivity as low as 63 mΩ/□ using flash sintering methods, while maintaining stability during storage and processing.

The practical implementation of these copper inks is demonstrated in membrane switch devices, a cornerstone of flexible electronics. Climate chamber studies reveal copper's susceptibility to humidity and temperature varies significantly with ink formulation strategies, informing robust design approaches. Current challenges focus on improving adhesion to PET substrates, where the conductivity of copper tracks outperforms silver, but formulation optimization is critical to enhance interfacial bonding. Ongoing efforts prioritize refining sintering protocols, testing additives to overcome PET's low surface energy and non-polar nature. This work bridges green nanoparticle synthesis with industrial-scale conductive ink production, paving the way for sustainable alternatives in wearable electronics and beyond.

Washable Graphene-based Conductive Coating: The Impact of TPU Segmental Architecture on its final performances

Authors:
Ilaria Improta, Institute of Polymers, Composites and Biomaterials, National Research Council, P.le E. Fermi, 1, 80055 Portici (Naples), Italy
Gennaro Rollo, Institute of Polymers, Composites and Biomaterials, National Research Council, P.le E. Fermi, 1, 80055 Portici (Naples), Italy
Giovanna G. Buonocore, Institute of Polymers, Composites and Biomaterials, National Research Council, P.le E. Fermi, 1, 80055 Portici (Naples), Italy
Marco Fiume, Institute of Polymers, Composites and Biomaterials, National Research Council, P.le E. Fermi, 1, 80055 Portici (Naples), Italy
Simona Del Ferraro, INAIL- DiMEILA-Laboratory of Ergonomics and Physiology, Monte Porzio Catone, 1, 00078 Roma, Italy
Vincenzo Molinaro, INAIL- DiMEILA-Laboratory of Ergonomics and Physiology, Monte Porzio Catone, 1, 00078 Roma, Italy
Marino Lavorgna, Institute of Polymers, Composites and Biomaterials, National Research Council, P.le E. Fermi, 1, 80055 Portici (Naples), Italy

Abstract ID: 78
Submitted: July 15, 2025
Event: SPE2025

Presenter Name: Ilaria Improta
Presenter Preference: Oral Presentation
Status: Accepted

The development of sustainable, water-based conductive coatings is essential for advancing eco-friendly wearable and printed electronics. A key challenge remains in achieving high electrical conductivity and wash durability, which depend heavily on the compatibility between the polymer matrix, conductive fillers, and the target substrate.

This study investigates a simplified approach to formulating washable conductive coatings by directly integrating few-layer graphene (FLG, 2.5 wt%) into four different commercially available bio-based thermoplastic polyurethanes (TPUs), blended with polyvinylpyrrolidone (PVP). The focus is on understanding how the segmental architecture of each TPU affects filler dispersion, mechanical integrity, and electrical performance.

The coatings were applied onto flexible substrates (fabric and paper) using a scalable bar-coating process and characterized for morphology, thermal behavior, conductivity, and wash resistance.

Results reveal that the hard-to-soft segment ratio of the TPU plays a critical role in determining both filler distribution and substrate compatibility. TPUs with a higher hard segment content favor interaction with hydrophobic surfaces, while those with more soft segments enhance adhesion to hydrophilic substrates. Increased soft segment content also

improves the internal distribution of conductive fillers, promoting the formation of continuous percolation paths and higher conductivity.

These findings highlight the importance of TPU segmental structure and hydrogen bonding in tuning coating performance. This comparative analysis offers practical insights for selecting optimal polymer matrices based on substrate type and application, supporting the development of durable, high-performance, and washable electronic textiles and paper-based devices.

Halftone-Printing to Control the Resistance in Arbitrarily Shaped Areas

Authors:
Vanessa Tischler, Institute for Smart Sensor Technologies, Alpen-Adria Universität Klagenfurt; Ubiquitous Sensing Laboratory (USElab)
Jose Manoj, Advanced Sensor & Electronics Technologies (ASET), Silicon Austria Labs; USElab
Hubert Zangl, Institute for Smart Sensor Technologies, Alpen-Adria Universität Klagenfurt; USElab)
Jürgen Kosel, Advanced Sensor & Electronics Technologies (ASET), Silicon Austria Labs; USElab

Abstract ID: 76
Submitted: July 15, 2025
Event: SPE2025

Presenter Name: Vanessa Tischler
Presenter Preference: Oral Presentation
Status: Accepted

An investigation into controlling the electrical resistance of printed conductive tracks via halftone-printing is presented. Halftone-printing or gray-scaling is a widely used technique in graphical print for color variations, by filling the pattern with small dots covering only a certain percentage of the actual area, the so-called fill factor[1]. Thereby, widely varying shades are possible, which, combined with color mixing in the CMY-scheme allows the use of a small set of inks and hence a streamlined printing process. However, to the best of our knowledge when this technique was used for electrical resistance modulation, it was realized with precisely controlled inkjet-printing or lithography techniques[2], [3].

We present a facile sheet resistance modulation by screen-printed conductive tracks, varying reliably from 0.15 Ω/square to 4.3 Ω/square (or less reliably to 14 Ω/square), after optimization. With this technique these variable tracks can be printed in a single step without the need to design commonly used meander structures, making it highly suitable for arbitrary shapes. Furthermore, we printed on PET using a widely available silver-particle ink and commercial screens. Overall, this technique has the potential to streamline commercial prints, as variations of more than one order of magnitude in electrical resistance can be screen-printed in a single step, without complicated design or need for several different inks.

References: in the uploaded file due to word limit

Printed Circuit Boards based on Paper? Challenges that have to be considered and potential solutions.

Authors:
Gerhard Domann, Fraunhofer ISC

Abstract ID: 75
Submitted: July 8, 2025
Event: SPE2025

Presenter Name: Gerhard Domann
Presenter Preference: Oral Presentation
Status: Accepted

The targets set by the EU for the recollecting and recycling rate of e-waste are still not being met. This has a negative impact on sustainability and reduces the resilience of the European electronics industry for valuable materials.
This paper discusses a new approach to producing printed circuit boards that are easier to recycle than traditional FR4 boards. The core of the development is the use of paper and other more sustainable materials to establish a PCB technology for electronics that is in line with the implementation of the circular economy concept.

The mission of the CircEL-Paper project funded by the European Commission (Grant agreement ID: 101070114): a modification of paper to meet the above requirements, which also enables electroplating processes and VIA technologies, but also printing technologies with environmentally friendly metal ink formulation, bio-based dielectrics and encapsulation materials, (conductive) adhesives and resistors. All materials used are examined by means of life cycle analyses and toxicological tests. The recyclability of each modification is examined and, if necessary, an adapted recycling technology is developed.

Lignin as component of sustainable printed electronics: An overview of IP landscape

Authors:
Sotiria Tzampazidou, AXIA Innovation, Fritz-Hommel-Weg 4, 80805 München, Germany
Michele Ponzelli, AXIA Innovation, Fritz-Hommel-Weg 4, 80805 München, Germany
Vasilis Maris, AXIA Innovation, Fritz-Hommel-Weg 4, 80805 München, Germany
Ioanna Deligkiozi, AXIA Innovation, Fritz-Hommel-Weg 4, 80805 München, Germany
Sofia P. Makri, Creative Nano PC, 43 Tatoiou, Metamorfosi, 14451 Athens, Greece
Alexandros Zoikis-Karathanasis, Creative Nano PC, 43 Tatoiou, Metamorfosi, 14451 Athens, Greece

Abstract ID: 71
Submitted: June 30, 2025
Event: SPE2025

Presenter Name: Sotiria Tzampazidou
Presenter Preference: Oral Presentation
Status: Accepted

It is estimated that around 62 million tonnes of e-waste were generated in 2022. This is expected to rise to 82 million tonnes by 2030, while the recycling rate is projected to drop to 20% if no major changes are made. In order to effectively address the growing demand, it is essential to explore innovative approaches that prioritize reuse, repairability, and high-quality recycling. Recyclable Printed electronics (PE), offer a promising solution well-suited for circular electronics production. Based on Safe and Sustainable by Design (SSbD) frameworks, PE can support a more sustainable lifecycle—from design to end-of-life—by enabling products that are easier to disassemble, recycle, or even biodegrade. Lignin and other biomass products emerge as promising materials for sustainable PE due to their abundance and potential to replace fossil-based materials.
The Sustain-a-Print (SaP) project, an EC funded research (GA 101070556), targets the development of sustainable materials and formulation for the PE industry. As the PE field matures and the Intellectual Property (IP) landscape rapidly evolves, strategic IP positioning is critical for companies to secure a competitive advantage. In this study an extensive patent analysis was performed, providing insights related to emerging trends and key players. The outcomes of this analysis guide technology developers and help them identify their freedom to operate. The development of lignin-carbon hybrids, a promising material for conductive ink formulations, illustrates the practical application of the current patent assessment.

Sustainable conductive polylactic acid ink for digital printing

Authors:
Leire Sanchez-Duenas, Surface Chemistry & Nanotechnologies Unit, Fundación TEKNIKER, Inaki Goenaga 5, 20600 Eibar, Spain
Chirag Mevada, Faculty of Information Technology and Communication Sciences, Tampere University, Tampere, Finland
Estibaliz Gómez, Surface Chemistry & Nanotechnologies Unit, Fundación TEKNIKER, Inaki Goenaga 5, 20600 Eibar, Spain
Estibaliz Aranzabe, Surface Chemistry & Nanotechnologies Unit, Fundación TEKNIKER, Inaki Goenaga 5, 20600 Eibar, Spain
Matti Mantisalo, Faculty of Information Technology and Communication Sciences, Tampere University, Tampere, Finland
J.L.Vilas-Vilela, Department of Physical Chemistry, Faculty of Science and Technology, University of the Basque Country, UPV/EHU, Barrio Sarriena s/n, 48940 Leioa, Spain

Abstract ID: 68
Submitted: June 30, 2025
Event: SPE2025

Presenter Name: Leire Sanchez-Duenas
Presenter Preference: Oral Presentation
Status: Accepted

In the recent decades, electronic waste has become a problem, due to the increase of electronic demand and the programmed obsolescence. This constitutes an environmental concern leading to the need of developing new sustainable systems. Sustainability could be ensured by reducing the used materials or by using bio-based or biodegradable materials. Printed electronics represent a good opportunity to achieve this objective, by developing new sustainable inks. Printed electronics inks are formulated using four main group materials: the functional material, responsible of the ink electrical properties; the binder and the solvent, which carry the functional material; and some additives to control specific properties. A proper composition selection is needed to ensure sustainability and functionality. Electrical conductivity is a critical parameter for printed electronics. Conductivity is commonly achieved by using precious metals (silver, gold, etc.) as the functional material, exposing conductivities up to 10^7 S/m. Nevertheless, for specific applications, lower conductivities can be considered and other sustainable materials presenting electrical conductivity, should be considered, such as biobased carbon particles. These, in combination with a biodegradable binder, and an ecofriendly solvent, are a good choice for developing greener electronics.

For that reason, TEKNIKER has been working on the development of a new sustainable conductive carbon ink, using polylactic acid (PLA, a biodegradable polymer), as the binder. The obtained ink is suitable for digital printing, obtaining conductivities about 10^3 S/m, which are suitable for specific applications. The obtained conductivity value of the ink is comparable to high conductive carbon inks available on the market.

A Sustainable Printed Platform for Sweat-Based Kidney Disease Monitoring

Authors:
Daniel Corzo, Silicon Austria Labs

Abstract ID: 67
Submitted: June 29, 2025
Event: SPE2025

Presenter Name: Daniel Corzo
Presenter Preference: Oral Presentation
Status: Accepted

Chronic kidney disease (CKD) affects over 100 million people in Europe and is projected to become the fifth leading cause of death by 2040. Current detection methods rely on laboratory-based blood tests, which are invasive and often inaccessible outside clinical settings. As a result, the disease frequently remains undiagnosed until it reaches advanced stages. The KERMIT project, funded by the Horizon Europe Pathfinder programme, is developing a skin-worn patch to non-invasively detect CKD biomarkers (Cystatin-C, creatinine, and urea) from sweat. KERMIT’s innovation lies in the integration of electrochemical biosensors, microfluidics, printed battery, and wireless communication alongside a single microchip resulting in sustainable single-use platform fabricated entirely through additive manufacturing.

The core of our approach relies on 3 principles, reduce material usage through simplification and miniaturization, include bio-based and biodegradable materials, and reduce the need of external electronic components. For the sensors, we formulated inks using MXenes and carbon-based nanoparticles to enhance binding sites for antibodies and aptamers resulting in high electrochemical performance. For the sweat collection microfluidic system, we selected bio-based polymers and optimized laser patterning and screen-printing parameters to enhance sweat transport, reduce protein adsorption, and simplify end-of life disposal. We produced a low-power iontophoresis system alongside a printed battery for on-demand sweat extraction, eliminating the need for external stimulation or power sources. By combining these material choices and design optimizations, KERMIT aims to shift CKD monitoring from episodic to continuous care, with the potential to improve patient outcomes, reduce costs, and pave the way for sustainable medical diagnostics.

Electronics from renewables: the HyPELignum project

Authors:
Kealie Vogel, Empa
Valerio Beni, RISE
Akshat Sudheshwar, Empa
Gustav Nyström, Empa
Nadia Malinverno, Empa
Monica Arnaudo, Empa
Carlos Enrique Gómez Camacho, Empa
Didier Beloin-Saint-Pierre, Empa
Roland Hischier, Empa
Claudia Som, Empa

Abstract ID: 66
Submitted: June 27, 2025
Event: SPE2025

Presenter Name: Kealie Vogel
Presenter Preference: Oral Presentation
Status: Accepted

Transitioning to sustainable electronics is essential for both a carbon-neutral and resilient future. The EU-funded HyPELignum project aims to prove that net-zero carbon emissions in electronics manufacturing are achievable through a holistic approach that rethinks materials, processes, and end-of-life strategies. Central to the project is the integration of additive manufacturing (specifically hybrid printed electronics) with low-impact, biogenic materials such as native wood and lignocellulosic polymers. These renewable substrates are chosen for their abundance, versatility, and growing relevance to EU sustainability and strategic autonomy goals.

HyPELignum combines four key elements: (i) energy- and material-efficient additive manufacturing, (ii) biogenic substrates, (iii) low-impact metals, and (iv) novel, highly integrated, energy-efficient components. The project will develop four demonstrators: 1) eco-friendly PCBs (ecoPCBs) using plywood and engineered lignocellulosic boards, 2) sensor/actuator integration on large wooden construction elements, 3) smart sensorised furniture, and 4) recyclable polymer systems with covalent adaptable networks enabling component separation at end-of-life.

The project not only advances technical feasibility but aligns with broader societal goals, positioning wood-based electronics as a viable pillar of Europe’s carbon-neutral transition and autonomy goals, supported by a holistic sustainability assessment to evaluate the impacts of the developed materials and production methods.

Initial assessments of the wood-based building blocks used in the demonstrators confirm their potential, but emphasize their carbon footprints depend on sourcing, processing, and end-of-life pathways. Ongoing assessments of the first demonstrators developed within the project are seeking to validate the anticipated sustainability benefits of wood-based electronics.

Eco-Conscious Printed Sensors on Algae-based and Cellulose Substrates for Health and Environmental Monitoring

Authors:
Emily Bezerra, 1 Silicon Austria Labs GmbH, Sensor Systems, 9524, Villach, Austria. 2 École Polytechnique Fédérale de Lausanne (EPFL), Laboratory of Bio/CMOS Interfaces, CH-2000 Neuchâtel, Switzerland.

Abstract ID: 64
Submitted: June 26, 2025
Event: SPE2025

Presenter Name: Emily Bezerra
Presenter Preference: Oral Presentation
Status: Accepted

The growing issue of electronic waste (e-waste) has driven the need for sustainable and environmentally friendly approaches in electronics manufacturing. This work focuses on the development of metal-free sensors on biosourced substrates for healthcare and environmental monitoring, addressing the urgent need to reduce the environmental footprint of disposable electronics. By employing bio-based substrates, such as agar derived from red algae and biodegradable cellulose, along with eco-friendly materials like carbon-based electrodes and the conducting polymer PEDOT:PSS, these devices offer a sustainable alternative to traditional electronics that rely on non-degradable plastics and toxic metals.

In the healthcare domain, an all-carbon glucose monitoring sensor was printed on an algae-based substrate. The sensor demonstrated accurate electrochemical detection of glucose within blood physiological ranges, with minimal interference from other biological species, ensuring reliable performance. This offers a promising solution for affordable, disposable health monitoring devices that minimize e-waste. For environmental applications, aerosol jet printing was used to fabricate semi-transparent humidity and temperature sensors on biodegradable cellulose substrates, capable of detecting changes with features as small as 13 µm.

These fully printed, eco-friendly sensors mark a significant step toward sustainable electronics by reducing reliance on harmful materials and promoting biodegradable options. Such innovations not only support environmental monitoring and healthcare applications but also contribute to global efforts to minimize the impact of e-waste, offering a blueprint for the next generation of green electronics.

Development of green Lignin-MWCNTs hybrids for sustainable conductive materials

Authors:
Sofia Paraskevi Makri, CREATIVE NANO PC
Stefania Koutsourea, CREATIVE NANO PC
Alexios Grigoropoulos, CREATIVE NANO PC
Ioanna Deligkiozi, CREATIVE NANO PC
Alexandros Zoikis-Karathanasis, CREATIVE NANO PC

Abstract ID: 61
Submitted: June 18, 2025
Event: SPE2025

Presenter Name: Sofia Paraskevi Makri
Presenter Preference: Oral Presentation
Status: Accepted

The environmental concerns of electronic industry waste have driven the development of sustainable materials for green electronics. In this study, lignin-based hybrids with multi-walled carbon nanotubes (MWCNTs) were synthesized via an environmentally benign, ultrasonication-based method in aqueous medium, without the use of organic solvents or hazardous chemicals. Two hybrid formulations mainly composed of lignin, a biomass product and MWCNTs at concentrations of 10% and 20% MWCNTs were developed and characterized physiochemically through analytical techniques. Physical interactions between lignin and MWCNTs improved the dispersion and colloidal stability of the resulting hybrids as evaluated by hydrodynamic diameter and zeta potential values through Dynamic Light Scattering (DLS). SEM and TEM micrographs revealed the formation of a lignin matrix embedding a percolated CNT network. Broadband Dielectric Spectroscopy (BDS) was utilized to determine the conductivity of hybrids. Conductivity ranged from 5 to 6 × 10^{-2} S/cm for both hybrids, notably close to the conductivity of raw MWCNTs, despite the hybrids containing up to 90 wt% of insulating lignin. Electrochemical study of hybrids showed enhanced electron transfer and overall redox performance as well as increased electroactive surface areas-up to 21 times higher than unmodified electrodes-demonstrating improved electron transfer kinetics. These findings encourage the potential of lignin-MWCNT hybrids as sustainable, conductive fillers in electronic and sensing applications, offering a green alternative to conventional materials.

Acknowledgement: The project has received funding from the European Union under Grant Agreement No. 101070556 (Sustain-a-Print).

Towards sustainable End-of-Life strategies for printed electronics: Recycling and material recovery approaches from the REFORM project and beyond

Authors:
Max Torrellas, AIMPLAS

Abstract ID: 59
Submitted: June 17, 2025
Event: SPE2025

Presenter Name: Max Torrellas
Presenter Preference: Oral Presentation
Status: Accepted

The transition to sustainable printed electronics (PE) requires solutions for end-of-life (EoL) management, including the development of effective recycling and material recovery strategies. This contribution presents ongoing efforts within the EU-funded REFORM project and complementary activities focused on the recycling of electronics.

In REFORM, multiple recycling approaches are being validated to address the complex composition of PE systems. The selection of recycling strategies is informed by stakeholder insights and current waste collection policies and practices, ensuring system-compatible solutions. These include simulations of industry sorting scenarios using different technologies.

To complement physical separation methods, the feasibility of material recovery is explored. Bio-recovery of valuable metals is explored as a low environmental impact alternative for the extraction of metals (Ag) from electronic waste. In parallel, chemical recycling alternatives are also explored. Metal recovery from PE waste is key in ensuring resource efficiency and reduces the need for virgin metal extraction, aligning with circular economy objectives. Beyond REFORM, AIMPLAS leverages its expertise in electronics recycling to advance the recyclability of PE materials with pilot recycling infrastructure.

Printed Cellulose-Based Sensors for Process Optimization and Structural Health Monitoring

Authors:
Arunjunai Raj Mahendran, Kompetenzzentrum HOlz GmbH, WOOD KPLUS
Nitin Gupta, Kompetenzzentrum Holz GmbH, WOOD KPLUS

Abstract ID: 57
Submitted: June 13, 2025
Event: SPE2025

Presenter Name: Arunjunai Raj Mahendran
Presenter Preference: Oral Presentation
Status: Accepted

The transition toward sustainable industrial practices demands innovative materials that not only reduce environmental impact but also enable intelligent monitoring of products throughout their lifecycle. Sensors made from renewable raw materials, such as paper, offer a compelling alternative to conventional polymer-based sensors.This research presents the development of cost-effective, flexible paper-based sensors tailored for integration into composite materials. Unlike traditional sensors, which are often added as external elements and risk poor adhesion or compatibility, these sensors are embedded during manufacturing. Developed in collaboration with a specialized paper supplier, the sensor substrate has been optimized to ensure precise sensor patterns and reliable performance in harsh processing environments. The sensors are capable of detecting critical parameters such as curing behavior and moisture uptake, offering valuable insight into both the material state and structural condition. Sensor substrate optimization allows for the printing of well-defined, high-performance sensing elements. The sensors enable real-time monitoring of key factors such as moisture and curing, supporting predictive maintenance and improved resource efficiency. Overcoming challenges related to sensor integration in composites by eliminating external elements and ensuring strong bonding within the matrix. The technology addresses the growing market demand for sustainable, embedded sensor solutions aligned with environmental targets.

Aerosol Jet Printing: Technique Overview and Proof-of-Concept Demonstrations for Additive Manufacturing

Authors:
Maria Karani, Scientific Personnel
Nickolas Vlachos, Affiliated Researcher
George Karagiannakis, Researcher A

Abstract ID: 53
Submitted: June 12, 2025
Event: SPE2025

Presenter Name: Maria Karani
Presenter Preference: Oral Presentation
Status: Accepted

Aerosol Jet printing (AJP) is an advanced additive manufacturing technique that enables the high-resolution deposition of functional inks[1][i]—such as conductive nanoparticles, polymers, and biological materials—onto diverse substrates including rigid, flexible, and few-mm-rough surfaces. The process operates by atomizing the ink into a fine aerosol mist, typically via ultrasonic or pneumatic methods, which is then carried by a gas stream through a virtual impactor to remove oversized droplets, ensuring a narrow particle size distribution[2]. The focused aerosol stream is subsequently directed through a converging nozzle and collimated by a sheath gas, enabling precise deposition with feature sizes as small as 20 μm. This maskless, non-contact, open-air deposition method allows for the creation of complex geometries with high aspect ratios and minimal overspray, making it particularly suitable for applications in microelectronics, biosensors, and conformal printed devices[3]. Additionally, the low processing temperatures involved in AJP render it compatible with temperature-sensitive materials, positioning the technology at the forefront of flexible and wearable electronics manufacturing[4].

In this study, a comprehensive examination of the capabilities of the AJP technique is conducted through the presentation of representative proof-of-concept demonstrations and active research initiatives. These illustrative cases serve as a foundation for an in-depth discussion on the technique's potential for advancing applications across diverse technological domains.

Life cycle assessment of two ecodesigned printed electronic devices

Authors:
Lou Bernard, Lomartov S.L.
Ignacio Zurano, Lomartov S.L.
Enrique Moliner, Lomartov S.L.
Isaac Herraiz, Lomartov S.L.
Mihaela Mirea, Lomartov S.L.

Abstract ID: 50
Submitted: June 10, 2025
Event: SPE2025

Presenter Name: Lou Bernard
Presenter Preference: Oral Presentation
Status: Accepted

The primary objective of Sustain-a-Print (SaP) project is to develop novel life-cycle pathways for printed electronics (PE) to achieve circularity. This involves redesigning PE products and manufacturing processes, using biobased and compostable materials and promoting closed-loop recycling of the metals used in conductive inks. Two PE devices were developed in SaP following ecodesign principles: a biosensor and a membrane switch.

Life cycle assessment (LCA) was used to calculate the environmental impacts of the ecodesigned PE devices, identifying key environmental hotspots and comparing them with the original devices produced under a linear economy model. A cradle-to-cradle approach was adopted, meaning that the scope of the assessment covers the production of the new materials, novel manufacturing processes and the end of life (EoL) of the PE devices. Special focus was placed on the EoL solutions proposed for the various components.

The ecodesigned biosensor shows a significant reduction in weight, mainly due to lower use of substrate and ink. This results in decreased environmental impacts, as lower quantity of metals —responsible for most of the environmental burden— is required, and a substantial portion is assumed to be recovered at the EoL. In contrast, the ecodesigned membrane switch uses more material, as the new copper ink is less conductive than the silver ink in the original device. Nonetheless, the environmental impacts of the new devices are still notably lower than its baseline, due to the lower impacts of copper compared to silver and the potential for metal recovery at EoL.

Chemical Recycling of PLA and Its Copolyesters with Poly(Ethylene Azelate) via Microwave-Assisted Alkaline Hydrolysis

Authors:

Nikos Bikiaris, Laboratory of Polymer and Colors, Chemistry and Technology, Department of Chemistry, Aristotle University of Thessaloniki, GR-541 24 Thessaloniki, Greece;

Rafail Ioannidis, Laboratory of Polymer and Colors, Chemistry and Technology, Department of Chemistry, Aristotle University of Thessaloniki, GR-541 24 Thessaloniki, Greece;

Dimitrios Bikiaris, Laboratory of Polymer and Colors, Chemistry and Technology, Department of Chemistry, Aristotle University of Thessaloniki, GR-541 24 Thessaloniki, Greece;

Abstract ID: 48
Submitted: June 2, 2025
Event: SPE2025

Presenter Name: Nikos Bikiaris
Presenter Preference: Oral Presentation
Status: Accepted

Polylactic acid (PLA), a bio-base, biodegradable and compostable aliphatic polyester, has garnered increasing attention as a sustainable alternative to petrochemical-based plastics. However, the end-of-life management of PLA, especially in the context of its increasing use in printed electronic applications, remains a challenge. In this work, we explore a rapid and energy-efficient chemical recycling pathway for PLA and PLA-based copolyesters via microwave-assisted alkaline hydrolysis. By applying microwave irradiation in the presence of aqueous NaOH solutions, we achieved accelerated depolymerization of PLA and its copolyesters into their monomers, primarily lactic acid and azelaic acid, under mild conditions (≤125 °C, <15 min). Furthermore, the presence of long, aliphatic co-monomers in PLA copolyesters based on poly(ethylene azelate) (PEAz), was found to influence the rate of hydrolysis, promoting chain mobility and facilitating backbone cleavage. The recovered acids were characterized via NMR confirming the efficient breakdown of the polymer chains. This approach offers a promising route toward closed-loop recycling of PLA-based materials, supporting circular economy principles. The process is scalable, cost-effective, and environmentally benign, positioning microwave-assisted hydrolysis as a valuable tool in sustainable polymer/electronic waste valorization.

Acknowledgements

Funded by the European Union under the GA no 101070556. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or RIA. Neither the European Union nor the granting authority can be held responsible for them.

Implementing Safe-and-Sustainable-by-Design (SSbD) in Early-Stage Materials Development: Insights from the GreenOmorph Project

Authors:
Elisabeth Schwarz-Funder; Sara Carniello; Ingrid Kaltenegger; Ruzica Luketina; Michael Brenner-Fließer, JOANNEUM RESEARCH mbH

Abstract ID: 43
Submitted: May 28, 2025
Event: SPE2025

Presenter Name: Elisabeth Schwarz-Funder
Presenter Preference: Oral Presentation
Status: Accepted

The Safe-and-Sustainable-by-Design (SSbD) framework aims to embed safety, sustainability, and circularity into innovation from the earliest research stages. Yet, applying SSbD in early-stage R&D is challenging, especially when materials and applications are still under development.

In the EU-funded GreenOmorph project, we explore how SSbD can guide the development of material and process development for sustainable electronics. Even without finalized product designs or value chains, we demonstrate which SSbD steps can already be implemented, and which tools proved to be most effective.

Key challenges include limited data for hazard screening, evolving life cycle considerations, and trade-offs between performance and sustainability. While some material data (e.g., toxicity or performance) exists for some materials, other aspects - such as life cycle or social impacts - remain unclear. Iterative assessment approaches help address these gaps and integrate SSbD principles progressively.

To illustrate, piezoelectronic materials developed within GreenOmorph were evaluated using the SSbD framework. Early-stage assessments defined performance targets, selected low-impact technologies, and explored possible integration routes.

A key insight is that assessing all SSbD dimensions in parallel is more effective than a strict step-by-step approach. From the beginning, we expanded our focus beyond hazard assessment to include life cycle and social aspects.

Printed electronics add complexity, as applications and supply chains are not yet clearly defined. Engaging technical teams to develop exemplary use cases is essential for progressing assessments and integrating SSbD into design.

By sharing insights from GreenOmorph, we show how SSbD can be adapted to data-scarce, early R&D contexts, supporting innovation aligned with long-term sustainability goals.

High-performance biobased substrates for printed electronics: The role of copolyesters based on PLA and poly(ethylene azelate)

Authors:
Rafail O. Ioannidis, Laboratory of Polymer and Colors, Chemistry and Technology, Department of Chemistry, Aristotle University of Thessaloniki, GR-541 24 Thessaloniki, Greece
Nikolaos D. Bikiaris, Laboratory of Polymer and Colors, Chemistry and Technology, Department of Chemistry, Aristotle University of Thessaloniki, GR-541 24 Thessaloniki, Greece
Zoe Terzopoulou, University of Ioannina, Department of Chemistry, Ioannina
Nikolaos Nikolaidis, Laboratory of Polymer and Colors, Chemistry and Technology, Department of Chemistry, Aristotle University of Thessaloniki, GR-541 24 Thessaloniki, Greece
Christian Rein, Danish Technological Institute (DTI), Denmark
Dimitrios N. Bikiaris, Laboratory of Polymer and Colors, Chemistry and Technology, Department of Chemistry, Aristotle University of Thessaloniki, GR-541 24 Thessaloniki, Greece

Abstract ID: 37
Submitted: May 23, 2025
Event: SPE2025

Presenter Name: Rafail O. Ioannidis
Presenter Preference: Oral Presentation
Status: Accepted

The environmental accumulation of fossil-derived, non-biodegradable, and non-recyclable polymers poses one of the most pressing challenges of contemporary society. Projections indicate that by 2050, global plastic waste generation will exceed 10 billion tons. Among the range of bio-based polymers, poly(lactic acid) (PLA) has attracted growing attention from both the academic and industrial sectors, owing to its thermal properties comparable to that of conventional petroleum-based polymers. Thus, the present study aims to develop non-toxic, sustainable substrates to replace fossil-based materials currently used in printed electronics.

Copolymerization was selected as a strategic approach to tailor the properties of PLA, enabling the synthesis of novel, biobased, and flexible copolyesters based on poly(ethylene azelate) (PEAz). Accordingly, PLA-b-PEAz blocky copolyesters were prepared through the ring-opening polymerization (ROP) of L-lactide, using PEAz as a macroinitiator. A plethora of characterization techniques were conducted in detail to investigate the overall performance of the materials for the targeted application. In order to test the scalability of the materials, cast film extrusion was employed to produce sheets based on PLA-b-PEAz copolyesters. Both the PLA and copolyesters were tested as substrates for biosensors and printed electronic applications.

Acknowledgements

Funded by the European Union under the GA no 101070556. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or RIA. Neither the European Union nor the granting authority can be held responsible for them.

Novel PLA nanocomposites based on Ag and Cu nanoparticles: The Next Generation of Printed Electronics

Authors:
Lazaridou Kyriaki, Laboratory of Polymer and Colors, Chemistry and Technology, Department of Chemistry, Aristotle University of Thessaloniki, GR-541 24 Thessaloniki, Greece
Ioannidis Rafail, Laboratory of Polymer and Colors, Chemistry and Technology, Department of Chemistry, Aristotle University of Thessaloniki, GR-541 24 Thessaloniki, Greece
Klonos Panagiotis, Department of Physics, National Technical University of Athens, Zografou Campus, GR-15780, Athens, Greece
Bikiaris Dimitrios, Laboratory of Polymer and Colors, Chemistry and Technology, Department of Chemistry, Aristotle University of Thessaloniki, GR-541 24 Thessaloniki, Greece

Abstract ID: 32
Submitted: May 19, 2025
Event: SPE2025

Presenter Name: Lazaridou Kyriaki
Presenter Preference: Oral Presentation
Status: Accepted

Amid intensifying environmental concerns, the pursuit of sustainable alternatives to conventional plastics is paramount. Polylactic acid (PLA) is a promising candidate due to its biodegradability, bio-based nature, compostability, and recyclability. This environmentally benign polyester is noted for thermal properties similar to fossil polymers and sustainable large-scale production.

Within this context, Silver (Ag) nanoparticles offer excellent conductivity, stability, durability, and printability. Copper (Cu) nanoparticles are also prominent in research due to their antimicrobial properties, low cost, and enhance polymer mechanical, thermal, and barrier performance. However, PLA nanocomposites with these NPs, particularly for printed electronics (PE), are relatively unexplored. Developing innovative, low-cost processing methods for PE using PLA substrates with Ag/Cu NPs is an emerging research area.

This research endeavors to synthesize PLA/Ag nanocomposites via in situ ROP/melt extrusion, and PLA/Cu via melt extrusion, using 0.5 and 1.0 wt% NPs concentrations. The resulting nanocomposites were characterized for structural, morphological, thermal, and mechanical properties. Silver ink adhesion was tested on PLA/PET substrates to explore printed electronics applications. Additionally, PLA cast film samples based on NPs were also produced.

Acknowledgements

Funded by the European Union under the GA no 101070556. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or RIA. Neither the European Union nor the granting authority can be held

responsible for them.

Furanoate polyesters: New biobased alternative substrates for printed electronics

Authors:
Dimitrios Bikiaris, Aristotle University of Thessaloniki

Abstract ID: 22
Submitted: May 11, 2025
Event: SPE2025

Presenter Name: Dimitrios Bikiaris
Presenter Preference: Oral Presentation
Status: Accepted

Enter description here.

Typical plastic film materials used in printed and hybrid electronics solutions are fossil-based, such as poly(ethylene terephthalate) (PET), poly(imide) (PI), poly(ether sulphone) (PES), etc. PET is widely used in low-cost flexible solutions as in thin-film photovoltaic, where maximum use temperature is below 150°C. Nowadays, there is a growing interest in the preparation of new chemicals and materials based on renewable resources, as biomass-derived fuel and chemicals are a promising alternative to fossil based materials. The idea for polymers from renewable resources is not new, however their relatively high cost when compared with their petrochemical homologues was always a major drawback. The biorefinery concept seems to be answer to the problem. Chemicals from vegetable feedstocks like sugars, vegetable oils, organic acids, glycerol and others have been proposed as monomers for polymer production. 2,5-furandicarboxylic acid (FDCA) is such a biobased monomer with many similarities to that of terephthalic acid. Novel approaches to the preparation of hydroxymethylfurfural open the way to the large-scale production of FDCA which is used for the production of poly(ethylene-2,5-furandicarboxylate) (PEF). PEF has much better thermal and mechanical properties and can be used as alternative biobased substrate for printed electronics. In this work synthesis and properties of PEF and other furanoate polyesters will be provided.

Carbon Nanofiber-Polylactic Acid LTO Composite filaments for the fabrication of 3D Printed Lithium ion Battery

Authors:

Muhammad Saqlain Iqbal, Department of Electrical and Information Engineering, Polytechnic University of Bari, 70125, Bari, (Italy) 2Interdisciplinary Additive Manufacturing Lab, Polytechnic University of Bari, 74100, Taranto, (Italy)

Alejandro Varez, Materials Science and Engineering Department. Carlos III University of Madrid, Leganés 28911, Madrid, Spain

Gianluca Percoco, Department of Mechanics, Mathematics and Management (DMMM), Polytechnic University of Bari, Bari, Italy

Abstract ID: 12
Submitted: March 20, 2025
Event: SPE2025

Presenter Name: Muhammad Saqlain Iqbal
Presenter Preference: Oral Presentation
Status: Accepted

The application of additive manufacturing (3D printing) in the field of lithium-ion batteries has the potential to reshape energy storage by providing more efficient, customizable, and cost-effective solutions. This research focuses on the development of 3D-printed electrodes made from a composite filament containing carbon nanofibers (CNF), polylactic acid (PLA), lithium titanate (LTO), and plasticizer. Initially, the composition was optimized based on viscosity measurements to obtain a feedstock suitable to be extruded. Using a custom made material extrusion 3D printer, this filament was then used to fabricate electrodes in disk shape and tested in half-cell facing to lithium metal and charge/discharge cycles were recorded. Preliminary results demonstrate good columbic efficiency and relatively good rate capability, using a feedstock to filament approach for 3D printing in battery applications. This work contributes to the ongoing efforts to reduce manufacturing costs, enhance battery design flexibility, and support the development of more sustainable energy storage technologies.

exelisis | ARISTOTLE UNIVERSITY OF THESSALONIKI | DANISH TECHNOLOGICAL INSTITUTE | SUSTAIN A PRINT | AXIA INNOVATION

SUSTAINABLE PRINTED ELECTRONICS 2025

BOOK OF ABSTRACTS POSTERS

TUESDAY 23RD TO THURSDAY 25TH OF SEPTEMBER 2025

KEDEA BUILDING,
ARISTOTLE UNIVERSITY OF THESSALONIKI, GREECE

www.exelisis-events.gr

Fabrication and Electrochemical Evaluation of MWCNTs-Lignin based Hybrid Modified Glassy Carbon Electrodes

Authors:
Stefania Koutsourea, Creative Nano

Abstract ID: 82
Submitted: September 1, 2025
Event: SPE2025
Topic:
Presenter Name: Stefania Koutsourea
Presenter Preference: Poster
Status: Pending

The development of sustainable and high-performance materials for electrochemical sensing is essential for advancing green technologies. Lignin (L), a renewable phenolic biopolymer, and multi-walled carbon nanotubes (MWCNTs), known for their exceptional electrical conductivity and surface area, offer complementary properties for creating hybrid electrode materials. Previous research has primarily focused on lignin and CNTs individually, leaving the synergistic potential of their combination for efficient, low-cost, and sustainable sensors underexplored...

AIEgens Methacrylate Copolymers for Transparent Luminescent Solar Concentrators

Authors:
Elisavet Tatsi, Department of Chemistry, Materials and Chemical Engineering "Giulio Natta", Politecnico di Milano, Piazza Leonardo da Vinci 32, 20133 Milano (Italy), Department of Chemistry, University of Pavia, Via Taramelli 10, 27100 Pavia (Italy), Institute of Sciences and Chemical Technologies "Giulio Natta" (SCITEC) of CNR, via A. Corti 12, 20133 Milano (Italy)

Abstract ID: 81
Submitted: July 30, 2025
Event: SPE2025
Topic: Devices and Applications
Presenter Name: Elisavet Tatsi
Presenter Preference: Poster
Status: Accepted

Luminescent Solar Concentrators (LSCs) are promising components for transparent photovoltaic (PV) technologies due to their ability to harvest diffuse light while maintaining aesthetic integration.[1] However, their performance is limited by waveguide losses from reabsorption and aggregation-caused quenching (ACQ) in traditional fluorophores.[2] To overcome these challenges, we developed advanced polymeric materials incorporating aggregation-induced emission (AIE) luminogens [3] using scalable and precise synthetic methods.

The AIE-active monomer TPEMA was copolymerized with methyl methacrylate (MMA) via Free Radical Polymerization (FRP) and Reversible Addition-Fragmentation Chain Transfer (RAFT) polymerization.[4] RAFT enabled fine control over molecular weight and composition, allowing systematic tuning of the materials' optical and thermal properties. The resulting copolymers were processed into uniform luminescent films by spin-coating (~1 µm thick) on 6 mm-thick glass substrates. Commercial silicon PV cells were attached to the glass edges for light harvesting.

Photoluminescence intensity increased with the TPEMA content, peaking at a 50:50 molar ratio. LSCs fabricated with RAFT-derived polymers exhibited external photon efficiencies (η_{ext}) up to 1.64%, internal efficiencies (~33%), and average visible transmittance (AVT) of ~90%, preserving transparency. The highest device efficiency (η_{dev}) of 0.29% was obtained with RAFT copolymers, significantly outperforming FRP-based counterparts.

These results demonstrate how controlled polymer architecture using RAFT can enhance the optical and photovoltaic performance of LSCs. The materials are compatible with solution processing and support scalable fabrication of transparent, energy-harvesting layers for use in printed photovoltaic devices.

Low power wearable device for sweat collection in clinical diagnosis

Authors:

Dimuthu Pathiraja, 1Sensor Systems Division, Silicon Austria Labs GmbH, Europastraße 12, 9524 Villach, Austria

Abstract ID: 79
Submitted: July 16, 2025
Event: SPE2025
Topic: Devices and Applications
Presenter Name: Dimuthu Pathiraja
Presenter Preference: Poster
Status: Accepted

Sweat-based diagnostics are rapidly gaining attention as a non-invasive, painless alternative to blood sampling for monitoring biomarkers including electrolytes, metabolites, and disease biomarkers in clinical settings. Despite their potential, practical deployment has been limited by bulky instrumentation and inconsistent stimulation protocols. To address these challenges, we present a low-power, miniaturized, and wearable iontophoresis device to controllably induce and collect sweat to support clinical diagnosis and point-of-care monitoring applications without the need for physical activity.

The system integrates a voltage-controlled current source and an instrumentation amplifier to deliver precise transdermal stimulation while maintaining safe operating limits. It is developed using an Arduino-based microcontroller to achieve significant reductions in power consumption, circuit size, and overall complexity. A wireless version incorporating a smaller microcontroller enables Bluetooth communication and real-time visualization through a Python-based interface, enhancing usability, portability, and remote operation capability.

The device is powered by compact rechargeable batteries and has two operation modes, direct current (DC) and pulsed current (PC), to produce sweat via transdermal drug delivery. Validation was conducted using an artificial skin model with a fluorescent agent to quantify penetration depth and evaluate performance across different operating conditions. This was followed by in-vivo sweat collection tests with healthy volunteers via the use of a cholinergic hydrogels and a printed microfluidic device. Results confirmed that DC iontophoresis at 3.3 V achieves faster sweat onset and higher collection volumes (>50uL) compared to pulsed current, while maintaining currents safely below 1 mA.

PLA/PBS Nanocomposites with Enhanced Mechanical and Thermal Properties for Potential Substrates in Printed Electronics

Authors:

Georgia Lathira, Laboratory of Chemistry and Technology of Polymers and Colors, Department of Chemistry, Aristotle University of Thessaloniki, Thessaloniki, Greece
Eleftheria Xanthopoulou, Laboratory of Chemistry and Technology of Polymers and Colors, Department of Chemistry, Aristotle University of Thessaloniki, Thessaloniki, Greece
Panagiotis Klonos, Dielectrics Group, Department of Physics, National Technical University of Athens, Athens, Greece
Zoi Terzopoulou, Laboratory of Industrial Chemistry, Department of Chemistry, University of Ioannina, Ioannina, Greece
Miguel Ángel Valera Gómez, AIMPLAS, Asociación de Investigación de Materiales Plásticos y Conexas, Paterna, Spain
Pilar Albaladejo Sánchez, Packaging, Transport & Logistics Research Center (ITENE), Paterna, Spain
Rafael Sánchez, Packaging, Transport & Logistics Research Center (ITENE), Paterna, Spain
Dimitrios N. Bikiaris, Laboratory of Chemistry and Technology of Polymers and Colors, Department of Chemistry, Aristotle University of Thessaloniki, Thessaloniki, Greece

Abstract ID: 77
Submitted: July 15, 2025
Event: SPE2025
Topic: Advanced Materials for Printed Electronics
Presenter Name: Georgia Lathira
Presenter Preference: Poster
Status: Accepted

Enter description here.

rGO/ZnO nanocomposite materials for photocatalytic applications

Authors:
Periklis Parthenidis, Department of Chemistry, Aristotle University of Thessaloniki, GR-54124 Thessaloniki, Greece
Konstantinos N. Maroulas, Hephaestus Laboratory, School of Chemistry, Faculty of Sciences, Democritus of Thrace, GR-65404 Kavala, Greece
Eleni Evgenidou, Department of Chemistry, Aristotle University of Thessaloniki, GR-54124 Thessaloniki, Greece
George Z. Kyzas, Hephaestus Laboratory, School of Chemistry, Faculty of Sciences, Democritus of Thrace, GR-65404 Kavala, Greece
Dimitra A. Lambropoulou, Department of Chemistry, Aristotle University of Thessaloniki, GR-54124 Thessaloniki, Greece

Abstract ID: 74
Submitted: June 30, 2025
Event: SPE2025
Topic: Advanced Materials for Printed Electronics
Presenter Name: Periklis Parthenidis
Presenter Preference: Poster
Status: Accepted

The occurrence of organic pollutants in the aquatic environment is a particularly alarming issue, since some of them can cause severe adverse effects on the aquatic organisms. Among these pollutants, prilocaine is of particular importance because it is a commonly used local anesthetic that has been detected in various wastewater samples from different countries. The inefficiency of the conventional treatment processes utilized in WWTP facilities to completely remove a significant number of pharmaceuticals necessitates the development of robust and highly effective techniques. Among the latter, heterogenous photocatalysis stands out due to its numerous strong points like operational simplicity, high reaction rates and low energy consumption. Nevertheless, conventional photocatalysts like ZnO exhibit disadvantages that limit their application in real life. Today, however, there is a growing interest in applying new photocatalytic materials that limit some of these disadvantages. One such group of materials is semiconductor composites that are based on the utilization of the “wonder material” of the 21st century, graphene. In this context, the scope of this study was the synthesis, characterization and application of rGO/ZnO for the decomposition of pollutant prilocaine. Regarding the photocatalytic activity, the degradation experiments proved that rGO/ZnO was quite effective against prilocaine, achieving 97.5% removal at catalyst dosage of 100 mg/L and treatment time of 30 minutes. Additionally, tests revealed that the addition of higher quantities of the catalyst had a positive impact on the photocatalytic performance of the process, causing a total destruction of the compound within a few minutes

"Sustainable Alginate-Based Hydrogels Incorporating Melatonin for Biofunctional Agricultural Coatings: A Safe-by-Design Thermal Characterization Approach"

Authors:

Kyriakos Athanasiou, Department of Mechanical and Manufacturing Engineering, University of Cyprus, Nicosia, Cyprus

Evangelia Tarani, School of Physics, Aristotle University of Thessaloniki, Thessaloniki, Greece

Lazaros C. Karagiannidis, School of Physics, Aristotle University of Thessaloniki, Thessaloniki, Greece

Andreas Ioannou, Department of Agricultural Sciences, Biotechnology & Food Science, Cyprus University of Technology, Cyprus

Egli C. Georgiadou, Department of Agricultural Sciences, Biotechnology & Food Science, Cyprus University of Technology, Cyprus

Vasileios Fotopoulos, Department of Agricultural Sciences, Biotechnology & Food Science, Cyprus University of Technology, Cyprus

Theodora Krasia-Christoforou, Department of Mechanical and Manufacturing Engineering, University of Cyprus, Nicosia, Cyprus

Konstantinos Chrysafis, School of Physics, Aristotle University of Thessaloniki, Thessaloniki, Greece

Abstract ID: 73
Submitted: June 30, 2025
Event: SPE2025
Topic: Sustainability Circularity, SSbD and market
Presenter Name: Lazaros Karagiannidis
Presenter Preference: Poster
Status: Accepted

The ability to absorb and retain large amounts of water without dissolving makes hydrogels an extremely interesting field of study for the scientific community. In this study, biopolymer-based hydrogels were synthesized, using sodium alginate as a matrix with different concentrations of calcium chloride ($CaCl_2$) which was used as a green, ionic crosslinker. These polymer networks were investigated thermally in order to develop biofunctional printable or sprayable seed coatings to enhance crop resilience under abiotic stress. Melatonin (N-acetyl-5-methoxytryptamine), a bioactive molecule known for its antioxidant, anti-inflammatory, and plant growth-regulating functions, was physically incorporated into selected hydrogel formulations. The assessment of thermal decomposition and physical interactions within the hydrogels studied by carrying out experiments of thermogravimetric analysis (TGA), differential scanning calorimetry (DSC) and temperature-modulated DSC (TMDSC). TGA results exhibited decreased water retention at higher $CaCl_2$ concentrations, indicating denser crosslinked hydrogel networks. DSC and TMDSC analysis revealed additional insights into matrix stability and melatonin–polymer interactions. Melatonin loading altered thermal transitions. The separation of non-reversible from reversible processes demonstrated through TMDSC, highlighting overlapping dehydration and matrix-related thermal events, which supports partial structural reorganization when melatonin is incorporated. The typical melting peak of melatonin for some samples was not

evident which suggests possible amorphous dispersion of melatonin inside a polymeric network. The findings underscore the relevance of alginate-based hydrogels in the development of sustainable, functional materials for printed agricultural systems.

Biobased and biodegradable microplastics as carriers of pharmaceutical compounds in the environment

Authors:
Dimitrios Kalaronis, Aristotle University of Thessaloniki, Department of Chemistry, GR-541 24 Thessaloniki, Greece
Eleni Evgenidou, Aristotle University of Thessaloniki, Department of Chemistry, GR-541 24 Thessaloniki, Greece
George Z. Kyzas, School of Chemistry, Faculty of Sciences, Democritus of Thrace, GR-65404 Kavala, Greece
Dimitrios N. Bikiaris, Aristotle University of Thessaloniki, Department of Chemistry, GR-541 24 Thessaloniki, Greece
Dimitra A. Lambropoulou, Aristotle University of Thessaloniki, Department of Chemistry, GR-541 24 Thessaloniki, Greece

Abstract ID: 72
Submitted: June 30, 2025
Event: SPE2025
Topic: Advanced Materials for Printed Electronics
Presenter Name: Dimitrios Kalaronis
Presenter Preference: Poster
Status: Accepted

Microplastics (MPs) are considered potential carriers of various contaminants, due to their considerable adsorption capacity, acting as a means of long-range transportation for contaminants into the environment. Therefore, the main scope of this research was to study the adsorption capacity of poly(lactic acid) (PLA) MPs in a complex mixture of drugs for the removal of these compounds from wastewater matrices. Three commonly used pharmaceuticals were selected as target compounds: diclofenac, ketoprofen, and valsartan. The selection of PLA MPs was based on their sustainable nature, as they can be used as a substrate for the development of materials for monitoring various pollutants in the aquatic environment. The experimental procedure was designed to: (i) examine the effect of contact time, (ii) investigate isotherm curves, (iii) study the effect of pH, (iv) evaluate the influence of the aqueous matrix, and (v) assess the desorption of the drugs using different solvents. The results showed that PLA MPs can adsorb the selected compounds under realistic conditions. Specifically, the kinetic and isotherm studies revealed possible interactions between the polymers and the drugs. Among the studied pharmaceuticals, diclofenac showed the highest uptake, likely due to its hydrophobic nature. The presence of real wastewater matrices affected the adsorption capacity of the MPs, with high concentrations of organic matter reducing their adsorption efficiency compared to results obtained in distilled water. Desorption studies were also conducted using both aqueous and organic solvents as eluents. In conclusion, PLA MPs can serve as a substrate for creating green materials to monitor pollutants.

Development of MXene electrodes

Authors:
Alexander Felix Tiniakos, CreativeNano
Michalis Kartsinis, CreativeNano

Abstract ID: 70
Submitted: June 30, 2025
Event: SPE2025
Topic: Advanced Materials for Printed Electronics
Presenter Name: Michalis Kartsinis
Presenter Preference: Poster
Status: Accepted

In 2011 Dresden University discovered a new group of compounds with enhanced electronic properties, namely MXenes. Since then, many research groups around the world have endeavored in their research to advance their scope, ultimately bringing them to market applications. Herein, MXenes synthesised either by High Frequency Acoustic Excitation (HFAE) or by molten salt method were fabricated on to Glassy Carbon Electrodes (GCE) to study their electrochemical properties. Additionally, to enhance MXene's electrochemical properties further, MXenes were also modified with polymers and/or metallic nanoparticles and subsequently drop-casted on to GCE prior to electrochemical investigation. More specifically, Current-Voltage (CV), Chronoamperometry and electrochemical impedance spectroscopy (EIS) were studied. It was found that the redox peaks in the CV plots indicate pseudo-capacitive behavior for most of the GCE/MXene electrodes whereas others showed low charge transfer resistance indicating ideal capacitance behavior. Based on these results, GCE/MXene show the potential to be used in broad range of applications such as conductive inks, small molecule sensing applications, supercapacitors, EMI shielding and anode materials for Li-ion batteries.

Conversion of succinic acid to value added diols

Authors:
K. Rekos, Department of Chemistry, Aristotle University of Thessaloniki, Thessaloniki, Greece; Center for Interdisciplinary Research and Innovation (CIRI), Balkan Center, Thessaloniki, Greece
A. Margellou, Department of Chemistry, Aristotle University of Thessaloniki, Thessaloniki, Greece; Center for Interdisciplinary Research and Innovation (CIRI), Balkan Center, Thessaloniki, Greece
K. Triantafyllidis, Chemistry Department, King Fahd University of Petroleum and Minerals, Dhahran 31261, Saudi Arabia; Interdisciplinary Research Center for Refining and Advanced Chemicals, King Fahd University of Petroleum & Minerals, Dhahran 31261, Saudi Arabia

Abstract ID: 56
Submitted: June 13, 2025
Event: SPE2025
Topic: Advanced Materials for Printed Electronics
Presenter Name: K. Rekos
Presenter Preference: Poster
Status: Accepted

Diols are important chemicals serving as monomers to a wide variety of (biobased) polyesters/plastics. 1,4-butanediol is currently being produced via biocatalytic transformation of succinic acid while the chemo-catalytic hydrogenation of succinic acid to 1,4-BDO is still a challenge. 1,4-BDO can be used in combination with the succinic acid to produce (biobased)-polybutylene succinate polyester resin that can be used in a wide variety of applications in agriculture, packaging, electronics and others. The chemo-catalytic hydrogenation reaction of succinic acid was performed on a 100 mL HT/HP autoclave stirred batch reactor, using different metal catalysts (Ru, Pt, Re, etc.) supported on micro/mesoporous activated carbons (AC). SA hydrogenated with the use of 5%Ru/AC at 250°C, 12h reaction time and catalyst to feed ratio of 0.4, a yield (mol carbon based) of 15% 1,3-PDO, 10% 1,4-BDO, 13% g-GBL and 3% n-Propanol was achieved (at 70% wt. conversion), while at 220°C and 12h the corresponding yields were 10% 1,3-PDO, 8% 1,4-BDO, 9% g-GBL, 4% n-Propanol and 2% THF (at 68% wt. conversion).

Acknowledgement

This project is carried out within the framework of the National Recovery and Resilience Plan Greece 2.0 funded by the European Union NextGenerationEU, under the "SUB1.1 Research Excellence Partnerships-REP" action "Strategy for Excellence in Universities & Innovation" of the the SUB 1 of the initiative "Promoting Quality, Innovation, and Internationalization in Universities". Project code: "Circlandfil: ΥΠ3ΤΑ-0559411".

Design and fabrication of surface dielectric barrier discharge non-thermal plasma actuators printed via aerosol jet technology

Authors:
Tsekourakis Damianos, Center for Research & Technology Hellas (CERTH), Thessaloniki, Greece
Karani Maria, Center for Research & Technology Hellas (CERTH), Thessaloniki, Greece
Kourtzanidis Konstantinos, Center for Research & Technology Hellas (CERTH), Thessaloniki, Greece
Dimitrakellis Panagiotis, Center for Research & Technology Hellas (CERTH), Thessaloniki, Greece
Vlachos Nickolas, Center for Research & Technology Hellas (CERTH), Thessaloniki, Greece
Karagiannakis George, Center for Research & Technology Hellas (CERTH), Thessaloniki, Greece

Abstract ID: 52
Submitted: June 10, 2025
Event: SPE2025
Topic: Devices and Applications
Presenter Name: Tsekourakis Damianos
Presenter Preference: Poster
Status: Accepted

Aerosol Jet Printing (AJP) is a high-precision, direct printing, additive manufacturing process that allows deposition of functional inks onto substrates from a distance of approximately 5mm. CERTH’s AJP produces aerosol droplets with two atomization methods: pneumatic and ultrasonic, with pneumatic allowing material viscosity up to 1000cP. This AJP system can use interchangeable nozzles: fine nozzles for tracewidth up to 20 um, and wide nozzles for large area coverage. AJP technology generates minimal waste, while using aqueous silver nanoparticle ink in this study further enhances its potential as a sustainable approach for fabrication of conductive coatings.

Surface Dielectric Barrier Discharges (SDBDs) are non-thermal, atmospheric-pressure plasma discharges generated along the surface of a dielectric material, using alternating high voltage to produce stable, surface-confined plasma1. In this work, three types of SDBDs were designed and printed: a linear, an annular and a ‘special featured’, all including a top and ground electrode aligned with micrometer precision. The designs were completed in Autodesk AutoCAD 2022 and printed with AJP using the ultrasonic atomization technique. The ink was employed onto 3 mm plexiglass substrates, selected based on compatibility with printed electronics and transparency.

The study’s practical objective was to develop and deposit fully functional electrode structures able to withstand atmospheric non-thermal plasma without structural or conductive failure. Though detailed plasma characterization was beyond scope, all devices performed successfully. The repeatability and micrometer-level precision of fabrication confirmed AJP’s suitability for producing high-precision, micro-scale, customized electrode architectures.

Catalytic hydrogenolysis of polyolefins based plastic wastes towards valuable hydrocarbon fractions

Authors:

Eleftherios Tosounidis, Department of Chemistry, Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece

Antigoni Margellou, Department of Chemistry, Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece

Konstantinos Triantafyllidis, Department of Chemistry, King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia; Interdisciplinary Research Center for Refining and Advanced Chemicals, King Fahd University of Petroleum & Minerals, Dhahran, Saudi Arabia; Department of Chemistry, Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece

Abstract ID: 51
Submitted: June 10, 2025
Event: SPE2025
Topic: Recycling of Printed Electronics
Presenter Name: Eleftherios Tosounidis
Presenter Preference: Poster
Status: Accepted

The ever-increasing use of plastic products and their inadequate management has led to substantial accumulation of plastic waste which causes immense ecological problems. Catalytic hydrogenolysis constitutes an innovative approach in tackling this issue. This thermochemical method aims to convert plastic waste to liquid n-alkanes using heterogeneous metal catalysts under mild reaction conditions, in terms of temperature and hydrogen pressure. In this study, thorough research of pure polyolefin polymers (LDPE and HDPE) and the respective plastic waste was conducted in a batch autoclave reactor. An optimization study was conducted using pure polymers to study the effect of temperature, hydrogen pressure, time, etc. Indicatively, under low temperature (180°C, 3 h), the conversion of LDPE was very low (7 wt.%), whereas at higher temperatures the conversion reached 100 wt.% towards 70-80 wt.% liquid oil yield. Additionally, the gradual increase of reaction temperature led to a decrease of the average molecular weight of the obtained products. Under the optimized conditions, the conversion of real plastic led to 90 wt.% liquid alkanes within the naphtha, kerosene, diesel, lubricant and heavy fractions, which is significantly influenced by the additives (inorganic compounds) content and feedstock's Mw. Based on the results, catalytic hydrogenolysis could be used for the chemical upcycling of polyolefins wastes towards the production of hydrocarbons which can be used to produce fuels or monomers (via steam cracking) and lubricants.

This project is carried out within the framework of the National Recovery and Resilience Plan Greece 2.0, funded by the European Union NextGenerationEU (Implementation Body HFRI).

Biopolymer–Graphene Aerogels for Eco-Friendly β-Blocker Detection: Toward Sustainable Microdevices

Authors:
Androniki Rapti, Aristotle Univeristy of Thessaloniki
Konstantinos Maroulas, Democritus University of Thrace
Eleni Evgenidou, Aristotle University of Thessaloniki
Vasileios Alampanos, Aristotle university of Thessaloniki
George Kyzas, Democritus University of Thrace
Dimitrios Bikiaris, Aristotle university of Thessaloniki
Dimitra Lambropoulou, Aristotle University of Thessaloniki

Abstract ID: 49
Submitted: June 3, 2025
Event: SPE2025
Topic: Devices and Applications
Presenter Name: Androniki Rapti
Presenter Preference: Poster
Status: Accepted

Biopolymer-based hybrid materials are gaining increasing attention as sustainable sorbents in environmental analysis. In this study, a novel dispersive solid-phase extraction (d-SPE) method was developed for the determination of six β-blockers in environmental water samples, employing an aerogel composed of chitosan (CS), polyvinyl alcohol (PVA), and reduced graphene oxide (rGO). Among four synthesized aerogels with varying GO/rGO content, the rGO5% formulation exhibited superior extraction performance, supported by extensive characterization (FTIR, SEM, BET). Key parameters such as sorbent amount, sample pH, and extraction time were optimized to achieve high recovery and selectivity. Coupled with LC–MS/MS, the method delivered excellent analytical performance across various water matrices including river, lake, marine, and wastewater samples. The material's high surface area and functional moieties enabled hydrogen bonding and π–π interactions, enhancing adsorption efficiency. The method was evaluated through the ComplexMoGAPI tool (score: 75), along with the BAGI and VIGI indices, confirming its green and innovative character. Due to its simplicity, low material footprint, and performance, this bio-based aerogel platform represents a promising step toward miniaturized, portable analytical devices for monitoring pharmaceutical residues. Its modular design renders it adaptable for future integration in printed or portable sensing technologies.

Upscaling sustainable polymer nanocomposites in Europe: the role of the BIOMAC OITB

Authors:
Zoi Terzopoulou, University of Ioannina

Abstract ID: 47
Submitted: May 30, 2025
Event: SPE2025
Topic: Advanced Materials for Printed Electronics
Presenter Name: Zoi Terzopoulou
Presenter Preference: Poster
Status: Accepted

BIOMAC is an Open Innovation Test Bed (OITB) Ecosystem capable of upscaling the market-readiness and production of Nano structured bio-based materials (NBM). The core ambition of BIOMAC is to foster sustainable innovation in the European bioeconomy by accelerating the development and commercialization of advanced nanotechnologies. By reducing time-to-market, costs, and associated risks, BIOMAC supports businesses in bringing breakthrough materials and products closer to industrial deployment.

BIOMAC offers tailored service packages for companies—including SMEs and other stakeholders—interested in upgrading existing or developing new solutions within the lignocellulosic value chains of nanomaterials and polymers. The services are targeted at projects starting from Technology Readiness Level (TRL) 4–5, supporting their journey toward market readiness.

Clients can benefit from access to BIOMAC's comprehensive open innovation environment, which brings together pilot lines, advanced characterization tools, and specialized expertise to accelerate innovation and product development.

BIOMAC has demonstrated its capabilities through the implementation of 11 test cases, developing upscaling products for a variety of markets; agriculture, automotive, food packaging and printed electronics include. Starting from biomass and covering the whole value chain, the Pilot Lines of BIOMAC, supported by complementary services such as market analysis, sustainability assessment and advanced characterizations.

This work has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No. 952941.

Thermal Decomposition Analysis of PLA-b-PEAz Copolyesters for Printed Electronics: Recycling Insights via Pyrolysis-GC/MS

Authors:
Nina Maria Ainali, Laboratory of Polymer and Colors, Chemistry and Technology, Department of Chemistry, Aristotle University of Thessaloniki, GR-541 24, Thessaloniki, Greece
Rafail O. Ioannidis, Laboratory of Polymer and Colors, Chemistry and Technology, Department of Chemistry, Aristotle University of Thessaloniki, GR-541 24, Thessaloniki, Greece
Nikolaos F. Nikolaidis, Laboratory of Polymer and Colors, Chemistry and Technology, Department of Chemistry, Aristotle University of Thessaloniki, GR-541 24, Thessaloniki, Greece
Dimitrios N. Bikiaris, Laboratory of Polymer and Colors, Chemistry and Technology, Department of Chemistry, Aristotle University of Thessaloniki, GR-541 24, Thessaloniki, Greece

Abstract ID: 46
Submitted: May 30, 2025
Event: SPE2025
Topic: Recycling of Printed Electronics
Presenter Name: Nina Maria Ainali
Presenter Preference: Poster
Status: Accepted

Abstract

The increasing use of polymeric materials in printed electronics necessitates a better understanding of their thermal decomposition to support sustainable end-of-life strategies. This study investigates the pyrolytic degradation of blocky copolyesters, poly(lactic acid)-b-poly(ethylene azelate) (PLA-b-PEAz), considered for flexible electronic applications. These bio-based copolymers, synthesized in four block ratios, were evaluated for recycling potential using pyrolysis–gas chromatography/mass spectrometry (Py-GC/MS).

Degradation experiments were conducted at two pyrolysis temperatures (350 °C and 500 °C), corresponding to the initial and final decomposition stages identified by thermogravimetric analysis (TGA). This dual-temperature approach enabled detailed analysis of volatile degradation products at early and advanced thermal breakdown stages. Py-GC/MS revealed distinct decomposition profiles for each copolymer composition. At 350 °C, low-molecular-weight esters and lactide-related fragments dominated, indicating selective scission of PLA segments. At 500 °C, more complex mixtures including azelate-derived hydrocarbons, olefins, and aromatics were detected, suggesting full breakdown of both blocks. Monomer ratio variations influenced both the quantity and identity of degradation products, impacting chemical recycling efficiency.

These results provide molecular-level insight into the thermal recyclability of PLA-b-PEAz copolyesters and show how Py-GC/MS can guide material selection for sustainable printed electronics. The study supports integrating bio-based, recyclable polymers into circular

design frameworks, reducing waste and environmental impact in electronic manufacturing.

Acknowledgements

Funded by the European Union under the GA no 101070556. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or RIA. Neither the European Union nor the granting authority can be held responsible for them.

Bisguaiacol-based Epoxy Resins: A lignin-derived and sustainable BPA alternative

Authors:
Christina P. Pappa, Department of Chemistry, Aristotle University of Thessaloniki, GR 54124 Thessaloniki, Greece
Konstantinos S. Triantafyllidis, Department of Chemistry, King Fahd University of Petroleum and Minerals, Dhahran 31261, Saudi Arabia; Interdisciplinary Research Center for Refining and Advanced Chemicals, King Fahd University of Petroleum & Minerals, Dhahran 31261, Saudi Arabia; Department of Chemistry, Aristotle University of Thessaloniki, GR 54124 Thessaloniki, Greece

Abstract ID: 45
Submitted: May 29, 2025
Event: SPE2025
Topic: Advanced Materials for Printed Electronics
Presenter Name: Christina P. Pappa
Presenter Preference: Poster
Status: Accepted

Nowadays, most high-performance materials are petroleum-derived. Sustainable manufacturing and circular economy models are gaining popularity as industries aim to reduce environmental impact and adopt bio-based products. Epoxy resins, a widely used thermosetting polymer in electronics, construction, and automobiles, offer durability and protection from moisture, abrasion, and UV degradation. However, they are typically produced from Bisphenol-A (BPA), a known hormone disruptor—specifically of estrogen—highlighting the need for its replacement in epoxy resin production.

Lignin, the second most abundant natural aromatic/phenolic polymer, can be isolated from forest/agricultural biomass or be produced as a side product in the paper/pulp industry. Lignin and its derived-chemicals have huge potential to serve as raw materials for the development of industrially relevant platform chemicals such as BPA-bisphenol analogues and polymers.

In our approach, guaiacol and vanillyl alcohol, both lignin-derived phenolic compounds, were utilized as renewable and bio-sourced chemicals to synthesize guaiacol-based BPA (bisguaiacol, BGF). The chemical structure and Mw of BGF were characterized. Then, the BGF was glycidylized with epoxy groups with epichlorohydrin and NaOH, to obtain bisguaiacol-based epoxy resin monomer/prepolymer (DGEBGF). DGEBGF's structure and EEW were evaluated by ^{1}H-NMR. Epoxy polymers were prepared from the obtained DGEBGF epoxy resin using amine hardener (Jeffamine-D230) and their thermo-mechanical and thermal properties were evaluated. The resulting polymers offer durability and strength, rendering them as highly relevant bio-based substrates in printed electronics applications.

Acknowledgement: To European Union's Horizon 2020 research and innovation programme and internal ELKE-AUTH funds. KST also would like to acknowledge the support from KFUPM, Deanship of Research via project CUP24201.

Recycling of Lignin-Epoxy Composites: A Circular Approach to BPA Recovery via Fast Pyrolysis

Authors:

Christina P. Pappa, Department of Chemistry, Aristotle University of Thessaloniki, GR 54124 Thessaloniki, Greece

Petros Soldatos, Department of Chemistry, Aristotle University of Thessaloniki, GR 54124 Thessaloniki, Greece

Konstantinos S. Triantafyllidis, Chemistry Dept., King Fahd University of Petroleum and Minerals, Dhahran 31261, Saudi Arabia; Interdisciplinary Research Center for Refining and Advanced Chemicals, King Fahd University of Petroleum & Minerals, Dhahran 31261, Saudi Arabia; Department of Chemistry, Aristotle University of Thessaloniki, GR 54124 Thessaloniki, Greece.

Abstract ID: 44
Submitted: May 29, 2025
Event: SPE2025
Topic: Recycling of Printed Electronics
Presenter Name: Christina P. Pappa
Presenter Preference: Poster
Status: Accepted

The growing demand for sustainable materials has placed biopolymers at the forefront of advanced research. Epoxy resins are thermosetting polymers, produced from diglycidyl ether of bisphenol-A (DGEBA), that is based on the toxic bisphenol-A (BPA). Lignin, the second most abundant biopolymer and a large-scale industrial byproduct, presents a sustainable alternative to petrochemical-based DGEBA. Its hydroxylated surface is prone towards functionalization via epoxy rings (glycidylation), partially replacing DGEBA, thus resulting in biobased epoxy composites with promising properties. However, the environmental impact of polymer waste is still present, pressing the need to apply circular economy strategies for their recycling. Fast Pyrolysis (FP) represents a promising depolymerization process, which can lead to the recovery of monomers/oligomers, like BPA. In this approach, DGEBA precursors can be obtained, following sustainable manufacturing and circular economy models thus establishing a closed-loop circular and fossil-independent path towards epoxy resin composites.

In this work, the functionalization of kraft lignin via glycidylation was investigated. Glycidylized lignin (GKL) was fully characterized using NMR, GPC, TGA etc., and was used as biobased epoxy prepolymer, achieving up to 50 wt.% replacement of DGEBA. Thermo-mechanical/thermal properties of the biocomposites revealed enhanced properties. Following, the biocomposites were depolymerized via fast-pyrolysis to test the effectiveness of thermochemical recycling towards obtaining valued chemicals. GC-MS and HSQC-NMR analysis testified to the successful depolymerization towards BPA and phenolic compounds.

Acknowledgments: To European Union's Horizon 2020 research and innovation program and internal ELKE-AUTH funds. KST also would like to acknowledge the support from

KFUPM, Deanship of Research via project CUP24201.

Toward Sustainable PFAS Detection: Iron-Based MOF Embedded in Polymeric Monoliths for Miniaturized Analytical Systems

Authors:

Vasilieios Alampanos, Aristotle University of Thessaloniki
Kyriaki Anagnostopoulou, Aristotle University of Thessaloniki
Lydia Sallis Roufou, Aristotle University of Thessaloniki
Katerina Kako, Aristotle University of Thessaloniki
Zoi Terzopoulou, University of Ioannina
Dimitrios N. Bikiaris, Aristotle University of Thessaloniki
Dimitra A. Lambropoulou, Aristotle University of Thessaloniki

Abstract ID: 42
Submitted: May 27, 2025
Event: SPE2025
Topic: Sustainability Circularity, SSbD and market
Presenter Name: Vasileios Alampanos
Presenter Preference: Poster
Status: Accepted

Advanced materials are reshaping the future of environmental analysis, with hybrid sorbents offering both functional versatility and compatibility with miniaturized platforms. In this work, we present a novel composite sorbent comprising an iron-based metal–organic framework (MOF) embedded within a polymeric monolith. The material was integrated into a miniaturized solid-phase extraction setup designed for the green and efficient determination of per- and polyfluoroalkyl substances in complex water matrices. Its enhanced porosity, stability, and tailored surface chemistry enable high extraction efficiency and selectivity. The method was optimized using Central Composite Design, targeting sustainable performance through reduced solvent and material consumption. Green assessment via the ComplexMoGAPI index confirmed its alignment with the principles of Green Analytical Chemistry. Coupled with liquid chromatography–high-resolution mass spectrometry (LC-HRMS), the platform delivered recoveries above 70% and RSDs below 15%. Beyond laboratory application, the MOF–polymer hybrid shows clear potential for integration into modular, low-footprint analytical devices — including printed and wearable sensors — for decentralized monitoring of persistent contaminants such as PFAS. This work represents a step toward sustainable smart configurations in environmental sensing.

Amino-functionalized metal-organic framework NH_2-UiO-66 as sustainable materials for PFAS trapping

Authors:
Dimitra Lambropoulou, Aristotle University of Thessaloniki
Styliani Petromelidou, Aristotle University of Thessaloniki
Vasilios Alampanos, Aristotle University of Thessaloniki
Haj-Yahya, A., Aristotle University of Thessaloniki
Theodoros Lazarides, Aristotle University of Thessaloniki

Abstract ID: 41
Submitted: May 26, 2025
Event: SPE2025
Topic: Advanced Materials for Printed Electronics
Presenter Name: Dimitra Lambropoulou
Presenter Preference: Poster
Status: Accepted

The integration of sustainable materials into smart analytical configurations is a key challenge in the development of next-generation environmental monitoring systems. In this context, we present the application of the amino-functionalized metal-organic framework NH_2-UiO-66 as a green sorbent for the extraction of nine per- and polyfluoroalkyl substances (PFAS) from complex environmental water matrices. Synthesized in accordance with green chemistry principles, this MOF was implemented in a dispersive solid-phase extraction (d-SPE) protocol, offering a low-impact alternative for sample preparation. The method was coupled with high-resolution mass spectrometry for accurate and selective analysis. Key parameters such as pH, eluent volume, and sorbent mass were optimized using design of experiments (DoE), ensuring high extraction efficiency (recoveries >70%) and low detection limits (4–95 ng/L). The environmental sustainability of the method was assessed using the ComplexGAPI tool, confirming its green analytical profile. While this work focuses on offline preconcentration, the use of MOF-based materials opens promising avenues for integration into decentralized, printed, or wearable sensor platforms. This study highlights the potential of hybrid sorbents in shaping greener, smarter monitoring strategies for persistent emerging contaminants like PFAS.

Funding

The research work was supported by the Hellenic Foundation for Research and Innovation (H.F.R.I.) under the “2nd Call for H.F.R.I. Research Projects to support Faculty Members & Researchers” (Project Number: 3616)

Koukoutsi Eco-Material from Olive Waste: A Sustainable Substrate for Printed and Functional Materials

Authors:

Evangelia Tarani, a Laboratory of Advanced Materials and Devices, School of Physics, Aristotle University of Thessaloniki, GR-541 24 Thessaloniki, Greece bSchool of Chemistry, University of Ioannina, P.O. Box 1186, 45110 Ioannina, Greece

George Z. Papageorgiou, School of Chemistry, University of Ioannina, P.O. Box 1186, 45110 Ioannina, Greece

Konstantinos Chrissafis, Laboratory of Advanced Materials and Devices, School of Physics, Aristotle University of Thessaloniki, GR-541 24 Thessaloniki, Greece

Abstract ID: 40
Submitted: May 26, 2025
Event: SPE2025
Topic: Sustainability Circularity, SSbD and market
Presenter Name: Evangelia Tarani
Presenter Preference: Poster
Status: Accepted

This study presents the development and comprehensive characterization of “Koukoutsi,” an innovative eco-material produced from the solid waste generated during olive oil production. The material is composed of olive pips and olive cores collected from Lesvos Island, Greece, and is combined with a high bio-content epoxy resin to fabricate decorative composite boards.

The resulting boards were thoroughly investigated in terms of structural, thermal, mechanical, and surface properties. Thermal behavior was examined using thermogravimetric analysis and differential scanning calorimetry, while mechanical performance was assessed through impact resistance tests. Scanning electron microscopy provided insight into the morphology and resin distribution, and Fourier-transform infrared spectroscopy and X-ray diffraction confirmed the presence of both epoxy and cellulose-based phases. Additionally, contact angle measurements and antioxidant activity tests were conducted to evaluate the material's surface hydrophilicity and free radical scavenging capacity.

Boards derived from olive cores showed higher thermal stability, lower water absorption, and greater antioxidant activity, whereas those made from olive pips exhibited superior impact strength due to their dense structure. With surface properties indicating moderate to high hydrophobicity, these boards offer strong potential for integration into sustainable device packaging, smart labels, or flexible printed platforms. So, these features suggest that the Koukoutsi eco-material may serve as a viable bio-based substrate in the development of environmentally friendly printed or functional materials. The use of agricultural by-products in this work demonstrates a circular economy approach that transforms agro-industrial waste into valuable materials for interior and possibly electronic applications.

The role of biaxial stretching toward improving the durability of PLA and PLA-based copolyester cast film sheets for printed electronics

Authors:

Rafail O. Ioannidis, Laboratory of Polymer and Colors, Chemistry and Technology, Department of Chemistry, Aristotle University of Thessaloniki, GR-541 24 Thessaloniki, Greece

Nikolaos D. Bikiaris, Laboratory of Polymer and Colors, Chemistry and Technology, Department of Chemistry, Aristotle University of Thessaloniki, GR-541 24 Thessaloniki, Greece

Kyriazis Rekos, Laboratory of Chemical and Environmental Technology, Department of Chemistry, Aristotle University of Thessaloniki, GR-541 24, Thessaloniki, Greece

Zoe Terzopoulou, University of Ioannina, Department of Chemistry, Ioannina

Dimitrios N. Bikiaris, Laboratory of Polymer and Colors, Chemistry and Technology, Department of Chemistry, Aristotle University of Thessaloniki, GR-541 24 Thessaloniki, Greece

Abstract ID: 38
Submitted: May 23, 2025
Event: SPE2025
Topic: Advanced Materials for Printed Electronics
Presenter Name: Rafail O. Ioannidis
Presenter Preference: Poster
Status: Accepted

The increasing demand for sustainable materials in the field of printed electronics has driven significant research efforts toward the development of biobased polymer substrates that offer environmental benefits and enhanced performance. Among these, poly(lactic acid) (PLA) has emerged as a particularly promising candidate. As a renewable, compostable, and non-toxic thermoplastic, PLA offers several advantages over conventional fossil-derived polymers, including high tensile strength, good stiffness, and reduced environmental impact. However, its application in PE remains limited due to inherent drawbacks such as brittleness, low elongation at break, and reduced durability during thermal and mechanical processing.

Simultaneously, the rapid expansion of the PE industry has intensified the need for high-performance materials while raising concerns about the accumulation of electronic waste, particularly from substrates made of non-recyclable, petroleum-based polymers. To address these challenges, this study explores the fabrication of PLA-based copolyester cast film sheets, alongside neat PLA films, and their subsequent biaxial stretching over induced strain crystallization. This processing approach aims to enhance the mechanical robustness, dimensional stability, and durability of the resulting films. The integration of biobased copolymers with mechanical orientation offers a promising and scalable route for producing eco-friendly, high-performance substrates tailored for next generation printed electronic devices.

Acknowledgements

Funded by the European Union under the GA no 101070556. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or RIA. Neither the European Union nor the granting authority can be held responsible for them.

PHOTOCATALYTIC UPCYCLING OF BIO-BASED PLASTICS INTO VALUE ADDED CHEMICALS

Authors:

Athanasia Kotsaridou1, 1Aristotle University of Thessaloniki, Department of Chemistry, Thessaloniki, Greece

Dimitrios A. Giannakoudakis1,2, 1Aristotle University of Thessaloniki, Department of Chemistry, Thessaloniki, Greece__2Department of Theoretical Chemistry, Institute of Chemical Sciences, Faculty of Chemistry, Maria Curie-Sklodowska University, 20-031 Lublin, Poland

Konstantinos Triantafyllidis3,4,1, 3Department of Chemistry, King Fahd University of Petroleum and Minerals, Dhahran 31261, Saudi Arabia__4Interdisciplinary Research Center for Refining and Advanced Chemicals, King Fahd University of Petroleum & Minerals, Dhahran 31261, Saudi Arabia__1Aristotle University of Thessaloniki, Department of Chemistry, Thessaloniki, Greece

Abstract ID: 36
Submitted: May 22, 2025
Event: SPE2025
Topic: Recycling of Printed Electronics
Presenter Name: Athanasia Kotsaridou
Presenter Preference: Poster
Status: Accepted

PLA is one of the most commonly used plastics in 3D printing applications. However, 3D printing generates a large amount of plastic waste. Although PLA is assumed as a promising alternative to traditional petroleum-based plastics, its degradation remains significantly slower than desired. Therefore, to assure the sustainability of 3D printing, it is necessary to propose methods to manage the increasing amount of plastic waste generated. Our approach targets to the development of sustainable method for PLA upcycling with the smallest environmental footprint, through additive-free heterogeneous photocatalysis. Herein, we present a novel titanate (hydroxy)oxide photocatalyst. Our developed material, demonstrated a 34% higher PLA conversion, a 58% higher yield of 2,3-butanediol, a 67% higher yield of ethanol, and a 76% higher yield of acetic acid compared to P25. This material has a surface area above 400 m^2/g and the pores volume exceed 0.5 cm^3/g. In addition, it possesses a significant volume of micropores (~0.08 cm^3/g). The rough external “sponge-like” surface of the NPs has a high density of SFGs, predominately acidic, with the surface pH to be found equal to 3.0. The acid surface environment is anticipated to play a key role on interacting with the PLA particles and acting as a “bridge” for the transfer of the photo-induced charges (e^-/h^+), initiating polymer’s C-C cleavage without the need any acidic additive.

Acknowledgements: This project is carried out within the framework of the National Recovery and Resilience Plan Greece 2.0, funded by the European Union – NextGenerationEU (Implementation body: HFRI, Project No.: 015949)

Development of 3D Printing Filaments from Recycled Low Density Polyethylene (rLDPE) and High Density Polyethylene (rHDPE) Composites Reinforced with Lignin Additive

Authors:
Nikolaos Pardalis, Aristotle University of Thessaloniki

Abstract ID: 35
Submitted: May 20, 2025
Event: SPE2025
Topic: Advanced Materials for Printed Electronics
Presenter Name: Nikolaos Pardalis
Presenter Preference: Poster
Status: Accepted

This study explores the development of sustainable nanocomposite materials using recycled low-density polyethylene (LDPE) and high-density polyethylene (HDPE) in an 80/20 weight ratio, integrating kraft nanolignin as a bio-based filler and polyethylene-graft-maleic anhydride (PE-g-MA) as a compatibilizer. Melt mixing was employed to fabricate composites with varying lignin loadings (1, 3, 5, and 10 wt%). The primary objective was to create an eco-efficient polymer blend with enhanced properties suitable for advanced manufacturing applications. The structural, thermal, mechanical, and flow properties of the resulting materials were systematically investigated through Differential Scanning Calorimetry (DSC), Infrared Spectroscopy (FTIR), X-Ray Diffraction (XRD), Thermogravimetric Analysis (TGA), tensile testing, Melt Flow Index (MFI), and Scanning Electron Microscopy (SEM). The incorporation of lignin exhibited minimal disruption to the polymeric thermal transitions, while enhancing thermal stability as confirmed by TGA. Mechanical analysis revealed that the 1 wt% lignin composite delivered the most favorable balance of strength and ductility. Flow index measurements further supported the processability of this formulation. Filaments derived from the optimal nanocomposite were successfully extruded for 3D printing, indicating potential applications in the field of Advanced Materials for Printed Electronics. This work underscores the synergy of bio-based fillers and recycled polymers in engineering high-performance materials, promoting circular economy principles and reduced environmental footprint through upcycling waste streams into functional, value-added products.

PLA nanocomposites based on conductive hybrid lignin-CNTs nanomaterial: Thermomechanical investigation and preliminary adhesion properties for printed electronics

Authors:
Andreas-Chrysovalantis Pitsavas, Laboratory of Polymer and Colors, Chemistry and Technology, Department of Chemistry, Aristotle University of Thessaloniki, GR-541 24 Thessaloniki, Greece
Rafail O. Ioannidis, Laboratory of Polymer and Colors, Chemistry and Technology, Department of Chemistry, Aristotle University of Thessaloniki, GR-541 24 Thessaloniki, Greece
Panagiotis A. Klonos, Laboratory of Polymer and Colors, Chemistry and Technology, Department of Chemistry, Aristotle University of Thessaloniki, GR-541 24 Thessaloniki, Greece; Department of Physics, National Technical University of Athens, Zografou Campus, GR-15780, Athens, Greece
Nikolaos D. Bikiaris, Laboratory of Polymer and Colors, Chemistry and Technology, Department of Chemistry, Aristotle University of Thessaloniki, GR-541 24 Thessaloniki, Greece
Sofia P. Makri, Creative Nano PC, 43 Tatoiou, Metamorfosi, 14451 Athens, Greece
Stefania Koutsourea, Creative Nano PC, 43 Tatoiou, Metamorfosi, 14451 Athens, Greece
Alexios Grigoropoulos, Creative Nano PC, 43 Tatoiou, Metamorfosi, 14451 Athens, Greece
Alexandros Zoikis-Karathanasis, Creative Nano PC, 43 Tatoiou, Metamorfosi, 14451 Athens, Greece
Ioanna Deligkiozi, AXIA Innovation GmbH, Fritz-Hommel-Weg 4, 80805 München, Germany
Apostolos Kyritsis, Department of Physics, National Technical University of Athens, Zografou Campus, GR-15780, Athens, Greece
Dimitrios N. Bikiaris, Laboratory of Polymer and Colors, Chemistry and Technology, Department of Chemistry, Aristotle University of Thessaloniki, GR-541 24 Thessaloniki, Greece

Abstract ID: 34
Submitted: May 19, 2025
Event: SPE2025
Topic: Advanced Materials for Printed Electronics
Presenter Name: Andreas-Chrysovalantis Pitsavas
Presenter Preference: Poster
Status: Accepted

Poly(lactic acid) (PLA) is a biobased aliphatic polyester, known for its sustainability, compostability and semicrystalline character. Recent investigations were focused on the enhancement of its electrical conductivity for its utilization to printed electronic applications. In order to achieve it, a plethora of conductive fillers are added to the polymer matrix like metal particles, graphene and carbon nanotubes (CNTs). CNTs demonstrate huge interest, mainly due to high electrical behavior. Lignin is a natural biopolymer and a wood component. Owing to its wide range of functional groups, is considered an appropriate bio-additive for PLA. Thus, novel PLA nanocomposites were investigated by incorporating hybrid nanoparticles based on MWCNTs and lignin.

Herein, PLA-based (nano)-composites have been prepared via the melt mixing, adding lignin/MWCNTs hybrids, in amounts from 0,5 to 30%. Simultaneously, PLA/lignin composites were prepared by this method in concentrations from 0,5% to 2,5% lignin. Tensile and 3-point bending tests proved the impact of the hybrid to the mechanical

properties of PLA nanocomposites. Finally, the conductivity properties of composites were measured by BDS technique. Adhesion tests with silver-based inks were performed, by curing them onto PLA-based samples and PET substrates to explore alternative materials for printed electronics.

Acknowledgements

Funded by the European Union under the GA no 101070556. Views and opinions exprsessed are however those of the author(s) only and do not necessarily reflect those of the European Union or RIA. Neither the European Union nor the granting authority can be held responsible for them.

Flexible PLA nanocomposites with MWCNTs for printed electronics: Insights into thermal, mechanical and conductivity properties

Authors:

RIZOS-EVANGELOS BIKIARIS, Hephaestus Laboratory, School of Chemistry, Faculty of Sciences, Democritus University of Thrace, Kavala, Greece

Abstract ID: 33
Submitted: May 19, 2025
Event: SPE2025
Topic: Advanced Materials for Printed Electronics
Presenter Name: RIZOS-EVANGELOS BIKIARIS
Presenter Preference: Poster
Status: Accepted

Printed electronics encompass a broad range of applications, particularly in the fields of sensing and energy storage. At present, the majority of PE substrates are derived from fossil-based polymers, with poly(ethylene terephthalate) (PET) being among the most widely utilized. In contrast, poly(lactic acid) (PLA) presents a more sustainable alternative, offering high tensile strength, non-toxicity and recyclability. Given the escalating levels of electronic waste worldwide, this research focuses on developing next-generation, sustainable substrate materials, such as PLA-based substrates, to replace the fossil-based options like PET. In this context, PE can contribute meaningfully to environmental sustainability by integrating advanced materials that exhibit enhanced adhesion and eco-conscious performance.

Herein, different PLA nanocomposite systems based on MWCNTs, MWCNTs-COOH, at small concentrations (i.e. 0.5, 1.0 and 2.5 wt%), were prepared by solvent casting, followed by melt mixing. The thermal and mechanical properties of the systems were investigated in detail. PPG acted as plasticizer, decreasing the glass transition temperature of the materials, thus increasing the elongation of the samples. For further investigation of the surface properties of the samples, adhesion measurements were conducted using different silver-based inks onto the PLA-based substrates and PET samples to propose alternative substrates for PE applications.

HDPE/Calcium Polymer Nanocomposites with Enhanced Thermal Stability for Applications in Printed Electronics and Sustainable Technologies

Authors:

Dimitra Karavasili, Christina Samiotaki, Dimitrios N. Bikiaris, Aristotle University of Thessaloniki

Abstract ID: 31
Submitted: May 16, 2025
Event: SPE2025
Topic: Advanced Materials for Printed Electronics
Presenter Name: Dimitra Karavasili
Presenter Preference: Poster
Status: Accepted

High-density polyethylene (HDPE) is a widely used polymer, thanks to its flexibility, chemical stability and insulating properties. As a substrate in printed electronics, HDPE demonstrates potential when combined with fillers that improve its thermal and mechanical properties, enhancing the lifetime and recyclability of the final devices.

In this work, the effect of calcium pimelate (CaPim), a functional filler, on HDPE nanocomposites was studied. Initially, CaPim was synthesized by neutralizing pimelic acid from $Ca(OH)_2$, with a final yield of 78%. Then, nanocomposites with 0.1-1 % w/w CaPim were prepared, which were thermoformed on films using a thermopress and characterized by Fourier-Transform Infrared Spectroscopy (FTIR) for structural analysis; Thermogravimetric Analysis (TGA) and Differential Scanning Calorimetry (DSC) for thermal behavior study; X-ray Diffraction (XRD), and Scanning Electron Microscopy (SEM) for their morphological and surface evaluation.

The results showed that the addition of CaPim significantly increases the thermal stability of the materials without altering the basic mechanical properties. This improvement makes these composites suitable candidates for use in printed electronics with high strength and recyclability requirements.

Recycling of printed electronics: Challenges and Future Prospects

Authors:
Papadimitriou Maria, Student

Abstract ID: 30
Submitted: May 15, 2025
Event: SPE2025
Topic: Recycling of Printed Electronics
Presenter Name: Papadimitriou Maria
Presenter Preference: Poster
Status: Accepted

Enter description here.

Bio-Based Copolymers of PLLA and PLGA with PEAd: Synthesis, Structural and Thermal Insights, and Dielectric Properties

Authors:
Evi Christodoulou, Department of Chemistry, Laboratory of Polymer Chemistry and Technology, Aristotle University of Thessaloniki, GR-541 24, Thessaloniki, Greece
Christina Samiotaki, Department of Chemistry, Laboratory of Polymer Chemistry and Technology, Aristotle University of Thessaloniki, GR-541 24, Thessaloniki, Greece
Panagiotis A. Klonos, Dielectrics Research Group, Department of Physics, National Technical University of Athens, Zografou Campus, GR-15780, Athens, Greece
Apostolos Kyritsis, Dielectrics Research Group, Department of Physics, National Technical University of Athens, Zografou Campus, GR-15780, Athens, Greece
Dimitrios N. Bikiaris, Department of Chemistry, Laboratory of Polymer Chemistry and Technology, Aristotle University of Thessaloniki, GR-541 24, Thessaloniki, Greece

Abstract ID: 29
Submitted: May 15, 2025
Event: SPE2025
Topic: Advanced Materials for Printed Electronics
Presenter Name: Evi Christodoulou
Presenter Preference: Poster
Status: Accepted

The advancement of printed electronics relies on the development of flexible, sustainable, and high-performance substrates. Bio-based polymeric materials present a promising alternative to conventional synthetic substrates, offering several environmental advantages including faster degradation and regeneration of raw materials. Various synthetic polymers have been recently explored for their ability to form thin films and composite structures with conductive fillers enabling the fabrication of eco-friendly, biodegradable substrates. Among them, polylactic acid (PLA) and poly(lactic-co-glycolic acid) (PLGA) possess vast potential due to their high performance and processability, consistent quality, and their tunable degradation times and mechanical properties. To further enhance their flexibility and mechanical performance, and thus their applicability, they are often combined with other biodegradable polyesters. This study explores the potential of PLA- and PLGA-co-poly(ethylene adipate) (PEAd) copolymers as substrates for printed electronic applications.

PEAd was synthesized *via* a two-stage melt polycondensation process, and subsequently utilized in the copolymers' preparation with PLLA (PLLA-co-PEAd) and PLGA (PLGA-co-PEAd) in weight ratios of 90/10 and 75/25. The synthesized materials were extensively characterized in terms of structure, molecular weight, crystallinity, and thermal behavior. The presence of PEAd in all materials induced a plasticization effect, evident from the systematic drop in the glass transition temperature, which contributes to enhanced flexibility and processability – essential properties for printed electronics applications. Dielectric spectroscopy provided additional insights into local and segmental molecular

mobility, confirming homogeneity and underlining their potential ability to support uniform electronic conductivity when combined with conductive fillers.

Bio-Based Polyesters Derived from Mandelic Acid for Potential Printed Electronic Applications

Authors:
Despoina Meimaroglou, Aristotle University of Thessaloniki

Abstract ID: 28
Submitted: May 15, 2025
Event: SPE2025
Topic: Advanced Materials for Printed Electronics
Presenter Name: Despoina Meimaroglou
Presenter Preference: Poster
Status: Accepted

The increasing demand for sustainable alternatives to petroleum-based plastics has driven research toward the development of bio-based polymeric materials with tailored properties suitable for advanced applications such as flexible and printed electronics. Aromatic α-hydroxy acids, particularly mandelic acid, present a unique opportunity for designing bio-derived substrates due to their inherent rigidity, chirality, and phenyl-derived functionality. While poly(lactic acid) (PLA) and poly(glycolic acid) (PGA) dominate the landscape of biodegradable polymers, poly(mandelic acid) (PMA) remains underexplored despite its promising characteristics for thermally and mechanically stable substrate applications.

In this study, we present the synthesis of poly(S,R-mandelic acid) via step-growth polymerization using N,N′-diisopropylcarbodiimide (DIC) as a coupling agent and 4-(dimethylamino)pyridinium 4-toluenesulfonate (DPTS) as the nucleophilic catalyst, under mild, water-free conditions. This strategy avoids the use of high temperatures and harsh catalysts, enabling better control over molecular weight and minimizing thermal degradation—factors crucial for thin-film processing and substrate stability.

Thermal and structural characterization was performed using Differential Scanning Calorimetry (DSC), Thermogravimetric Analysis (TGA), Fourier-Transform Infrared Spectroscopy (FTIR), X-Ray Diffraction (XRD), and Gel Permeation Chromatography (GPC). The polymer displayed a distinct glass transition temperature (Tg) of 100 °C and thermal stability up to 280 °C, while XRD confirmed its semicrystalline morphology—attributes desirable for dimensional stability and processability as a printed electronic substrate.These results demonstrate that poly(mandelic acid)s synthesized via DIC/DPTS-mediated Steglich esterification are not only environmentally friendly but also structurally and thermally robust, rendering them suitable candidates for next-generation bio-based substrates in printed electronics.

Synthesis and Characterization of Non-Isocyanate Polyurethanes (NIPUs) for Applications in Flexible Printed Electronics Substrates

Authors:
Evangelia Balla, Aristotle University of Thessaloniki

Abstract ID: 27
Submitted: May 13, 2025
Event: SPE2025
Topic: Devices and Applications
Presenter Name: Evangelia Balla
Presenter Preference: Poster
Status: Accepted

The development of flexible substrates with improved thermal and mechanical properties is a critical challenge for the evolution of printed electronics. Non-isocyanate polyurethanes (NIPUs) are emerging as a new generation of polymers with potential to be applied to flexible electronic devices, due to the combination of flexibility, chemical resistance and synthetic safety.

In the present work, four types of NIPUs were synthesized, through the polyaddition of dicarboxylic acids (electric, adipic, malonic and azelaic) with 1,6-hexamethylenodiamine . The final products were characterized with a number of techniques: Nuclear Magnetic Resonance (NMR) and Fourier-Transform Infrared Spectroscopy (FTIR) for structural analysis; Thermogravimetric Analysis (TGA) and Differential Scanning Calorimetry (DSC) for thermal behavior study; X-ray Diffraction (XRD), Penetration Chromatography Gel Permeation Chromatography (GPC), water contact angle measurement and Scanning Electron Microscopy (SEM) for their morphological and surface evaluation.

The results showed that the produced NIPUs exhibit sufficient thermal stability and surface characteristics suitable for use as flexible substrates or protective coatings in printed electronics, suggesting a safe and adaptable material for future applications.

Evaluation of adipic acid-based non-isocyanate polyurethanes as potential substrate materials for flexible printed electronic applications

Authors:
Maria Angeliki Ntrivala, Aristotle University of Thessaloniki
Evangelia Balla, Aristotle University of Thessaloniki
Dimitrios Bikiaris, Aristotle University of Thessaloniki

Abstract ID: 26
Submitted: May 13, 2025
Event: SPE2025
Topic: Devices and Applications
Presenter Name: Maria Angeliki Ntrivala
Presenter Preference: Poster
Status: Accepted

Printed electronics are an emerging topic of the last decades, due to their favorable characteristics, such as functional versatility, flexible structure, elasticity, sustainability and cost-effective synthesis. Among the essential components of printing systems, the substrate constitutes a fundamental element. Several materials have been applied for this role, among which polyurethanes (PUs) are included. PUs represent a versatile category of synthetic polymers applicable in flexible printed electronics primarily as substrates and adhesives. However, their synthesis relies on toxic isocyanate molecules, soon to be banned in Europe- a factor that has contributed to the development of non-isocyanate polyurethanes (NIPUs). Specifically NIPUs produced through polyaddition are a promising material for multiple applications, displaying decreased synthesis toxicity, greener nature and ability to derive from bio-based compounds, such as adipic acid.

In the present study, NIPUs are evaluated as potential candidates for printed electronics applications (i.e. flexible substrates). In details, their synthesis was performed through polyaddition reaction, utilizing adipic acid, glycerol carbonate and two diamines, 1,6-hexamethylenediamine and 1,2-ethylenediamine. Upon verification of the successful polymer synthesis using Nuclear Magnetic Resonance (NMR) and Fourier Transform Infrared Spectroscopy (FTIR), Differential Scanning Calorimetry (DSC) and Thermogravimetric Analysis (TGA) were employed for the investigation of the materials' thermal behavior. Furthermore, Broad Dielectric Spectroscopy (BDS) was performed. The obtained NIPUs were further emulsified and freeze-dried for the production of foams. The results of the aforementioned characterization techniques were evaluated in terms of potential suitability for NIPUs' application as substrate materials in flexible printed electronics.

Toward Sustainable Polymer Composites: Modified Lignin as a Reinforcing Additive in High-Density Polyethylene (HDPE)

Authors:
Christina Samiotaki, Laboratory of Polymer Chemistry and Technology, Department of Chemistry, Aristotle University of Thessaloniki, Thessaloniki, Greece
Alexandra Zamboulis, Laboratory of Polymer Chemistry and Technology, Department of Chemistry, Aristotle University of Thessaloniki, Thessaloniki, Greece
Evangelia Tarani, Laboratory of Advanced Materials and Devices, School of Physics, Aristotle University of Thessaloniki, GR 54124, Thessaloniki, Greece
Dimitrios Bikiaris, Laboratory of Polymer Chemistry and Technology, Department of Chemistry, Aristotle University of Thessaloniki, Thessaloniki, Greece
Chrissafis Konstantinos, Laboratory of Advanced Materials and Devices, School of Physics, Aristotle University of Thessaloniki, GR 54124, Thessaloniki, Greece

Abstract ID: 25
Submitted: May 12, 2025
Event: SPE2025
Topic: Advanced Materials for Printed Electronics
Presenter Name: Christina Samiotaki
Presenter Preference: Poster
Status: Accepted

In the framework of sustainability and the transition to a circular economy, the utilization of biomass-derived materials offers a promising pathway toward reducing reliance on fossil fuels. Lignin, an abundant and underutilized byproduct of the pulp and paper industry, has gained significant attention due to its renewable origin, aromatic structure, and functional versatility. Incorporating lignin into polymer matrices leads to the development of bio-based composites and the enhancement of the environmental profile of conventional plastics. By combining lignin with various polymers it is possible to tailor material properties while simultaneously improving resource efficiency, enabling innovative, opening up new sustainable options for a range of applications.

In this work, Kraft and phosphorylated lignin were incorporated in the HDPE matrix through melt mixing at filler loadings 1%, 5%, 10%, 20%, and 30%. The resulting composites were thoroughly characterized to evaluate their chemical structure using Fourier-transform infrared spectroscopy (FTIR), their thermal behavior through differential scanning calorimetry (DSC), thermogravimetric analysis (TGA), the flame retardancy and mechanical performance. The incorporation of phosphorylated lignin led to a notable enhancement in thermal stability and flame-retardant properties, highlighting the effectiveness of the chemical modification.

Acknowledgments
This project has received funding from the European Union's Horizon Europe Framework Programme under Grant Agreement No 101058449. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European

Union or HADEA. Neither the European Union nor the granting authority can be held responsible for them.

Poly(lactic acid) Filled with Hybrid Lignin-CNT Particles with Enhanced Electrical Conductivity via Synergistic Effect: Sustainable Polymeric Materials for Printing Inks Applications

Authors:

Panagiotis A. Klonos, Department of Chemistry, Laboratory of Polymer Chemistry and Technology, Aristotle University of Thessaloniki, GR-541 24, Thessaloniki, Greece

Abstract ID: 21
Submitted: May 9, 2025
Event: SPE2025
Topic: Advanced Materials for Printed Electronics
Presenter Name: Department of Chemistry, Laboratory of Polymer Chemistry and Technology, Aristotle University of Thessaloniki, GR-541 24, Thessaloniki, Greece
Presenter Preference: Poster
Status: Accepted

A series of novel poly(lactic acid) (PLA)-based composites filled with Hybrid particles of lignin and multiwalled carbon nanotubes (CNTs) were prepared and studied, employing combinatory. Relatively low CNT loadings, up to 3 wt%, were chosen, aiming at the formation of conductive networks, enhancement of the particle-polymer adhesion and preserving the nanocomposites' sustainable character. The Hybrid-filled PLA composites exhibited electronic conductivity, whereas the PLA/CNTs not (insulators). This was indicative of a synergistic effect between lignin and CNTs, in the sense of facilitating the formation of CNT continuous paths via the lignin entities and, simultaneously, throughout the composites' volume (electrons' percolation). Interestingly, this is compatible with the microscopic view. The data indicated the lowering of the percolation threshold, p_c, to 3 wt%, being almost ideal for sustainable conductive printing inks. With the addition of the Hybrid particles, the glass transition temperature of PLA, at ~60 °C, was slightly decreased, resulting in 'softer composites'. At the same time, the relatively low melting temperature of ~175 °C was unchanged. Both results are wanted for the efficient, green and economic processing. Overall, our findings demonstrate the potential of eco-friendly conductive PLA composites for new generation applications, in particular, as printed electronics.

Acknowledgements: This research was funded by the European Union under the GA no 101070556 (Sustain-a-Print, https://www.sustainaprint.eu/). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or RIA. Neither the European Union nor the granting authority can be held responsible for them.

New generation Sustainable Printed Electronics

Authors:
Ioanna Deligkiozi, AXIA Innovation GmbH

Abstract ID: 13
Submitted: March 23, 2025
Event: SPE2025
Topic: Sustainability Circularity, SSbD and market
Presenter Name: Ioanna Deligkiozi
Presenter Preference: Poster
Status: Accepted

The Sustain A Print (SaP) project, funded by the European Commission under the Horizon Europe program, aims to revolutionize the printed electronics industry by introducing sustainable materials and processes. This initiative addresses the urgent need to replace fossil-based materials with recycled, bio-based, and biodegradable alternatives, aligning with the Circular Economy Action Plan. SaP's methodology integrates Sustainable and Safe by Design (SSbD) principles at every stage of the printed electronics lifecycle, from material selection to end-of-life management.

The project focuses on four key areas: materials, formulations, printing, and circular economy. It involves the development of biodegradable and recyclable substrate materials, environmentally friendly ink formulations, and adhesives optimized for end-of-life. Advanced digital printing methods are employed to create flexible and stretchable electronics, opening new market applications. SaP also explores two alternative lifecycle routes—recycling and biodegradation—to enhance the reuse and recycling of high-value materials from printed electronics products.

Demonstrations of SaP technologies are conducted through industrial applications such as electrochemical biosensors and membrane switch keyboards. By promoting the use of sustainable materials and processes, SaP aims to significantly reduce electronic waste and its environmental impact, contributing to a greener and more circular economy.

This abstract highlights the innovative approach and potential impact of the Sustain A Print project, showcasing its commitment to sustainability and technological advancement in the printed electronics sector.

THANK YOU
FOR ATTENDING OUR EVENT