NUMERO 4 - LUGLIO 2025

PACKAGING SCIENCE

E' la Rassegna Scientifica Internazionale della ***Fondazione Carta Etica del Packaging.***

Pubblicazione bimestrale in cui sono presentati 7 articoli multidisciplinari, afferenti al packaging, selezionati da diverse riviste del mondo scientifico digitale.

Packaging Science attraverso le tematiche sempre attuali ed aggiornate dei suoi articoli in diverse discipline, concorre ampiamente alla promozione e all'evoluzione della corretta cultura del packaging e dei ***10 Valori della Carta Etica*** *per accompagnare il packaging verso un futuro più consapevole.*

FONDAZIONE™
CARTA
ETICA
del Packaging

Carta patinata ad alte prestazioni da residui di cellulosa batterica e polpa di eucalipto: maggiore resistenza meccanica, resistenza all'acqua e proprietà di barriera all'aria

I prodotti cartacei a base di cellulosa derivati da scarti agroindustriali hanno suscitato notevole interesse per il loro potenziale nello sviluppo di materiali sostenibili. In questo studio, residui di cellulosa batterica (BC) provenienti dall'industria alimentare e delle bevande sono stati impiegati come agente rinforzante per realizzare compositi di carta ad alte prestazioni, miscelandoli con polpa di eucalipto (EP) in diversi rapporti e grammature.

coatings

MDPI

Article

Coated High-Performance Paper from Bacterial Cellulose Residue and Eucalyptus Pulp: Enhanced Mechanical Strength, Water Resistance, and Air Barrier Properties

Preeyanuch Srichola [1,2], Kunat Kongsin [1,2], Thanyachol Apipatpapha [1], Jirachaya Boonyarit [1], Peeraya Ounu [1] and Rungsima Chollakup [1,*]

[1] Kasetsart Agricultural and Agro-Industrial Product Improvement Institute (KAPI), Kasetsart University, Chatuchak, Bangkok 10900, Thailand; aappua@ku.ac.th (P.S.); mew.kunat@gmail.com (K.K.); thanyachol.ap@ku.th (T.A.); aapjab@ku.ac.th (J.B.); peerayaounu721@gmail.com (P.O.)
[2] Cellulose for Future Materials and Technologies Special Research Unit, Department of Biotechnology, Faculty of Agro-Industry, Kasetsart University, Chatuchak, Bangkok 10900, Thailand
* Correspondence: aaprmc@ku.ac.th; Tel.: +66-91-717-4010

Abstract: Cellulose-based paper products derived from agro-industrial waste have attracted considerable interest due to their potential in sustainable material development. In this study, bacterial cellulose (BC) residue from the food and beverage industry was employed as a reinforcing agent to fabricate high-performance paper composites by blending with eucalyptus pulp (EP) at various ratios and basis weights. These papers were coated with a cationic modified starch solution (MS) using a rod coater, followed by hot pressing. Mechanical strengths (TAPPI Standard), water resistance (Cobb test and water contact angle), and air permeability (ASTM D737) were evaluated to assess material performance. The results showed that incorporating 50 wt% BC produced paper with outstanding mechanical performance, characterized by a high tensile index and excellent tear resistance. The application of the MS coating significantly boosted water resistance and air barrier performance, underscoring the effectiveness of this approach in creating high-performance paper materials. The resulting coated composites demonstrated excellent mechanical strength and barrier properties, positioning them as promising candidates for filtration applications such as personal protective face mask membranes.

check for updates

Academic Editor: Sensen Han

Received: 25 April 2025

https://www.mdpi.com/2079-6412/15/6/720

Verso l'uso razionale degli imballaggi in plastica per ridurre l'inquinamento da microplastiche: una breve rassegna

Le microplastiche (MP) nell'ambiente naturale si formano quando i polimeri sintetici vengono frammentati e micronizzati fino a una dimensione ≤ 5 mm. Le MP sono un problema ambientale globale, in particolare all'interno degli ecosistemi acquatici, a causa della loro persistenza, accumulo ed effetti incerti a lungo termine. Questa revisione esamina i percorsi di degradazione dei polimeri che determinano la formulazione di MP, il loro tasso e distribuzione negli ecosistemi e il loro potenziale ingresso nei sistemi alimentari. Le sfide principali includono la mancanza di metodi di rilevamento standardizzati, in particolare per le nanoparticelle; prove limitate di tossicità a lungo termine; e l'inefficienza degli attuali quadri di gestione dei rifiuti.

Journal of Marine Science and Engineering

MDPI

Review

Towards the Rational Use of Plastic Packaging to Reduce Microplastic Pollution: A Mini Review

Evmorfia Athanasopoulou [1], Deborah M. Power [2], Emmanouil Flemetakis [3] and Theofania Tsironi [1,*]

1 Laboratory of Food Process Engineering, Department of Food Science and Human Nutrition, Agricultural University of Athens, Iera Odos 75, 11855 Athens, Greece; efiatha@aua.gr
2 Centro de Ciencias do Mar, Universidade do Algarve, Campus de Gambelas, 8000-117 Faro, Portugal; dpower@ualg.pt
3 Laboratory of Environmental Biotechnology, Department of Biotechnology, Agricultural University of Athens, Iera Odos 75, 11855 Athens, Greece; mflem@aua.gr
* Correspondence: ftsironi@aua.gr

Abstract

Plastic pollution has been recognized as an emerging risk for the aquatic environment. Shifting from the prevailing linear "take-make-dispose" model to a "circular" economy framework is essential for mitigating the environmental impact of plastics. Microplastics (MPs) in the natural environment are formed when synthetic polymers are fragmented and micronized to a size ≤ 5 mm. MPs are a global environmental problem, particularly within aquatic ecosystems, due to their persistence, accumulation, and uncertain long-term effects. This review examines the degradation pathways of polymers that result in MP formulation, their rate and distribution across ecosystems, and their potential entry into food systems. Key challenges include a lack of standardized detection methods, specifically for nanoparticles; limited evidence of long-term toxicity; and the inefficiency of current waste management frameworks. Emphasis is placed on the cradle-to-grave lifecycle of plastic materials, highlighting how poor design, excessive packaging, and inadequate post-consumer treatment contribute to MP release. The transition from Directive 94/62/EC to the new Regulation (EU) 2025/40 marks a significant policy shift towards stronger preventive

J. Mar. Sci. Eng. **2025**, *13*, 1245 https://doi.org/10.3390/jmse13071245

https://www.mdpi.com/2077-1312/13/7/1245

Rivestimento idro-oleorepellente sostenibile a base di chitosano altamente deacetilato per pasti in scatole monouso

In risposta alle preoccupazioni ambientali e sanitarie associate ai contenitori per alimenti in plastica a base petrolchimica e agli agenti idrorepellenti e oleorepellenti fluorurati, questo studio propone una tecnologia di rivestimento sostenibile e priva di fluoro a base di chitosano per migliorare la resistenza all'acqua e all'olio dei contenitori per alimenti in polpa di carta stampata. Regolando il grado di deacetilazione e la concentrazione della soluzione di chitosano, i contenitori per alimenti rivestiti sono stati realizzati mediante un metodo di spruzzatura.

materials

MDPI

Article

Sustainable Water- and Oil-Repellent Coating for Disposable Meal Boxes Based on Highly Deacetylated Chitosan

Zhiwei Shen †, Yihan Yang †, Shufeng Hu and Weiqing Kong *

State Key Laboratory of Advanced Fiber Materials, College of Materials Science and Engineering, Donghua University, Shanghai 201620, China; szw709133136@163.com (Z.S.); 221100317@mail.dhu.edu.cn (Y.Y.); shufengbeyond@yeah.net (S.H.)

* Correspondence: kongweiqing@dhu.edu.cn

† These authors contributed equally to this work.

Abstract: To mitigate the serious environmental impact caused by the persistent accumulation of plastics, replacing conventional plastics with paper-based alternatives has emerged as a promising trend. In response to the environmental and health concerns associated with petrochemical-based plastic meal boxes and fluorinated water- and oil-repellent agents, this study proposes a sustainable, fluorine-free coating technology based on chitosan to enhance the water and oil resistance of molded-paper pulp meal boxes. By adjusting the degree of deacetylation and the solution concentration of chitosan, coated meal boxes were fabricated via a spraying method. The results demonstrate that coatings prepared with highly deacetylated (>95%) and concentrated (4% *w*/*v*) chitosan significantly improve barrier properties, achieving a water contact angle of 114.9° ± 3°, the highest oil-resistance rating (12/12) according to TAPPI standards, and stable resistance to 95 °C hot oil for up to 30 min without leakage. In addition, the coated samples exhibit enhanced mechanical strength (21.26 MPa) and excellent biodegradability. This work provides a cost-efficient and eco-friendly disposable food packaging solution, facilitating the sustainable substitution of petrochemical-based plastics.

Materials **2025**, *18*, 2741 https://doi.org/10.3390/ma18122741

https://www.mdpi.com/1996-1944/18/12/2741

Attacco e formazione di biofilm di otto diversi sierotipi di Salmonella su tre superfici a contatto con gli alimenti a diverse temperature

Le specie da Salmonella rappresentano un rischio per la sicurezza alimentare nella catena di produzione a causa del loro potenziale di sviluppo di biofilm. Questo studio ha esaminato la formazione di biofilm di otto sierotipi di Salmonella provenienti da diversi focolai di origine alimentare su tre superfici a contatto con gli alimenti, acciaio inossidabile, silicone e nylon, a 10 °C e 37 °C. L'effetto della temperatura è stato osservato in una formazione più lenta del biofilm a 10 °C con circa 5 log (ufc/cm2) dopo 24 ore, in contrasto con 7-log (ufc/cm2) a 37 °C. Il materiale ha anche influenzato la formazione del biofilm, con i biofilm più forti su acciaio inossidabile a 10 °C e silicone a 37 °C.

microorganisms

MDPI

Artide

Attachment and Biofilm Formation of Eight Different *Salmonella* Serotypes on Three Food-Contact Surfaces at Different Temperatures

Katrina L. Counihan [1], Shannon Tilman [1], Joseph Uknalis [2], Sudarsan Mukhopadhyay [1], Brendan A. Niemira [1] and Daniela Bermudez-Aguirre [1,*]

[1] Characterization and Interventions for Foodborne Pathogens Research Unit, United States Department of Agriculture, Agricultural Research Service, Eastern Regional Research Center, 600 East Mermaid Lane, Wyndmoor, PA 19038, USA; katrina.counihan@usda.gov (K.L.C.); shannon.tilman@usda.gov (S.T.); sudarsan.mukhopadhyay@usda.gov (S.M.); brendan.niemira@usda.gov (B.A.N.)

[2] Microbial and Chemical Food Safety Research Unit, United States Department of Agriculture, Agricultural Research Service, Eastern Regional Research Center, 600 East Mermaid Lane, Wyndmoor, PA 19038, USA; joseph.uknalis@usda.gov

* Correspondence: daniela.bermudez@usda.gov

Abstract

Salmonella spp. represent a food safety risk in the production chain because of their potential for biofilm development. This study examined the biofilm formation of eight *Salmonella* serotypes from diverse foodborne outbreaks on three food-contact surfaces, stainless steel, silicone, and nylon, at 10 °C and 37 °C. The effect of temperature was observed in slower biofilm formation at 10 °C with about 5-log (cfu/cm^2) after 24 h, contrasting with 7-log (cfu/cm^2) at 37 °C. The material also influenced biofilm formation, with the strongest biofilms on stainless steel at 10 °C and silicone at 37 °C. The serotypes producing the strongest biofilms were *S.* Enteritidis, *S.* Saint Paul, and *S.* Montevideo. The weakest serotypes were *S.* Senftenberg, *S.* Anatum, and the avirulent *S.* Typhimurium. The production of extra-polymeric substances was evident with *S.* Enteritidis. The biofilm index showed the highest value for low temperature, nylon, and silicone, and for *S.* Montevideo, *S.* Enteritidis, and *S.* Saint Paul. The whole-genome sequencing of each serovar suggested

check for updates

Academic Editor: Giuseppe Comi

Microorganisms **2025**, *13*, 1446 https://doi.org/10.3390/microorganisms13071446

https://www.mdpi.com/2076-2607/13/7/1446

Studio delle proprietà superficiali e dell'attività antibatterica di campioni a base di poliammide 12 stampati in 3D rivestiti da un film sottile amorfo al plasma SiOxCyHz approvato per il contatto alimentare

Questo studio ha valutato l'efficacia di un rivestimento nanometrico SiOxCyHz depositato, approvato per il contatto con gli alimenti, su substrati a disco in poliammide 12 (PA12) stampati in 3D, con l'obiettivo di fornire funzionalità antimicrobica e anti-biofilm a componenti meccanici e materiali di imballaggio nella filiera alimentare. Il rivestimento è stato applicato utilizzando la deposizione chimica da vapore con plasma (PECVD) e caratterizzato tramite spettroscopia infrarossa a trasformata di Fourier (FTIR), spettroscopia Raman, analisi termogravimetrica (TGA), microscopia elettronica a scansione (SEM) e misurazioni dell'angolo di contatto.

polymers

MDPI

Artide

Investigation of Surface Properties and Antibacterial Activity of 3D-Printed Polyamide 12-Based Samples Coated by a Plasma $SiO_xC_yH_z$ Amorphous Thin Film Approved for Food Contact

Mario Nicotra [1,†], Raphael Palucci Rosa [2,†], Valentina Trovato [2,*], Giuseppe Rosace [2,3,4], Roberto Canton [5], Anna Rita Loschi [1], Stefano Rea [1], Mahmoud Alagawany [6], Carla Sabia [7] and Alessandro Di Cerbo [1,*]

1 School of Biosciences and Veterinary Medicine, University of Camerino, 62024 Matelica, MC, Italy; mario.nicotra@unicam.it (M.N.); annarita.loschi@unicam.it (A.R.L.); stefano.rea@unicam.it (S.R.)
2 Department of Engineering and Applied Sciences, University of Bergamo, 24044 Dalmine, BG, Italy; raphael.rosa@unibg.it (R.P.R.); giuseppe.rosace@unibg.it (G.R.)
3 Local CSGI (Inter-University Center for Colloid and Surface Science) Research Unit, 24044 Dalmine, BG, Italy
4 Local INSTM (National Consortium of Materials Science and Technology) Research Unit, 24044 Dalmine, BG, Italy
5 Moma Nanotech Srl, 24041 Brembate, BG, Italy; canton@nanotech.it
6 Poultry Department, Agriculture Faculty, Zagazig University, Zagazig 44511, Egypt; mmalagwany@zu.edu.eg
7 Department of Life Sciences, University of Modena and Reggio Emilia, 41125 Modena, MO, Italy; carla.sabia@unimore.it
* Correspondence: valentina.trovato@unibg.it (V.T.); alessandro.dicerbo@unicam.it (A.D.C.)
† These authors contributed equally to this work.

Abstract: Microbial contamination and biofilm formation on food contact materials (FCMs) represent critical challenges within the food supply chain, compromising food safety and quality while increasing the risk of foodborne illnesses. Traditional materials often lack sufficient microbial resistance to contamination, creating a high demand for innovative antimicrobial surfaces. This study assessed the effectiveness of a nanosized deposited $SiO_xC_yH_z$ coating approved for food contact on 3D-printed polyamide 12 (PA12) disk

check for updates

Academic Editors: Pedro Aguilar-Zarate, Nuria Elizabeth Rocha-

Polymers **2025**, *17*, 1678 https://doi.org/10.3390/polym17121678

https://www.mdpi.com/2073-4360/17/12/1678

Sviluppo di film di acido poli(L-lattico) contenenti estratto di Curcuma lunga L. per il confezionamento attivo di formaggi

Le soluzioni di imballaggio a base biologica con funzioni attive per diverse categorie alimentari sono oggi un tema molto interessante. Questo imballaggio garantisce un'adeguata conservazione della qualità degli alimenti e prolunga la durata di conservazione dei prodotti confezionati. Inoltre, rappresenta una promettente strada per contrastare l'inquinamento globale, proteggere la salute umana e garantire un migliore benessere planetario. In questo lavoro, una composizione di imballaggio a base di acido polilattico (PLA) con l'aggiunta di estratto di Curcuma longa L. (C), preparata con il metodo di fusione in soluzione, viene promossa come potenziale opzione di imballaggio per il confezionamento alimentare attivo del formaggio.

processes

MDPI

Artide

Development of Poly(L-lactic acid) Films Containing *Curcuma lunga* L. Extract for Active Cheese Packaging

Aleksandra Bužarovska [1,*], Darko Dimitrovski [1] and Anka Trajkovska Petkoska [2,3,*]

[1] Faculty of Technology and Metallurgy, Ss. Cyril and Methodius University, Rudjer Boskovic 16, 1000 Skopje, North Macedonia; dardim@tmf.ukim.edu.mk
[2] Faculty of Technology and Technical Sciences, St. Kliment Ohridski University—Bitola, Dimitar Vlahov, 4000 Veles, North Macedonia
[3] Department of Materials Science and Engineering, Korea University, 145 Anam-ro, Seongbuk-gu, Seoul 02841, Republic of Korea
* Correspondence: abuzar@tmf.ukim.edu.mk (A.B.); anka.trajkovska@uklo.edu.mk or ankatp@korea.ac.kr (A.T.P.)

Abstract: Biobased packaging solutions with active functions for different food categories are a very attractive topic nowadays. This packaging provides suitable preservation of the food quality and extends the shelf life of packed items. In addition, this is a promising pathway to overcome global pollution, to protect human health, as well as to provide a better planetary wellbeing. In this work, a packaging composition based on poly(lactic acid) (PLA) with the addition of *Curcuma longa* L. (C) extract prepared by the solution casting method is promoted as a potential packaging option for the active food packaging of cheese. The dopant levels of the extract were performed at 0.5%, 1%, 2%, 5%, and 10%, while the neat PLA film was used as a control. The obtained results are promising. By a thermal analysis, it is shown that C-extract has a plasticizing and nucleating effect on PLA molecules, as well as improving the barrier and other film properties. Moreover, this

Processes **2025**, *13*, 1881 https://doi.org/10.3390/pr13061881

https://www.mdpi.com/2227-9717/13/6/1881

Tendenze e sfide recenti nell'analisi non mirata e nella valutazione del rischio di sostanze migranti aggiunte non intenzionalmente da materiali plastici a contatto con gli alimenti

I quadri normativi si sono evoluti di pari passo con questi progressi analitici per garantire la sicurezza alimentare. Il Regolamento (UE) n. 10/2011 della Commissione Europea [7], recentemente modificato dal Regolamento (UE) 2025/351 della Commissione [8], ad esempio, stabilisce limiti di migrazione specifici per le sostanze presenti nei materiali per il contatto con gli alimenti (MOCA) in plastica e impone ai produttori di valutare la potenziale migrazione sia di IAS che di NIAS nelle condizioni peggiori, utilizzando simulanti alimentari appropriati. Tali normative richiedono test di migrazione completi, che comportano l'esposizione dei MOCA a simulanti alimentari in condizioni controllate che riproducono scenari reali.

toxics

MDPI

Review

Recent Trends and Challenges on the Non-Targeted Analysis and Risk Assessment of Migrant Non-Intentionally Added Substances from Plastic Food Contact Materials

Pablo Miralles [1,*], Esther Fuentes-Ferragud [1,2], Cristina Socas-Hernández [1,3,4] and Clara Coscollà [1]

[1] Foundation for the Promotion of Health and Biomedical Research of the Valencian Community (FISABIO), FISABIO-Public Health, Av. Catalunya 21, 46020 Valencia, Spain; esther.fuentes@fisabio.es (E.F.-F.); asocashe@ull.edu.es (C.S.-H.); clara.coscolla@fisabio.es (C.C.)
[2] Environmental and Public Health Analytical Chemistry, Research Institute for Pesticides and Water, University Jaume I, Av. Sos Baynat s/n, 12071 Castelló de la Plana, Spain
[3] Departamento de Química, Unidad Departamental de Química Analítica, Facultad de Ciencias, Universidad de La Laguna (ULL), Avda. Astrofísico Fco. Sánchez s/n, 38206 San Cristóbal de La Laguna, Spain
[4] Instituto Universitario de Enfermedades Tropicales y Salud Pública de Canarias, Universidad de La Laguna (ULL), Avda. Astrofísico Fco. Sánchez s/n, 38206 San Cristóbal de La Laguna, Spain
* Correspondence: pablo.miralles@fisabio.es

Abstract

Non-intentionally added substances (NIAS) in plastic food contact materials represent a critical undercharacterized chemical safety concern, caused by their inherent diversity, potential toxicity, and regulatory challenges. This review synthesizes recent advances and persistent gaps in NIAS analysis, with a primary focus on analytical workflows for non-targeted analysis, alongside a consideration of risk assessment and toxicological prioritization frameworks. Conventional plastics (e.g., polyethylene, polypropylene, or polyethylene terephthalate) as well as emerging materials (e.g., bioplastics and recycled polymers) exhibit different NIAS profiles, including oligomers, degradation products, additives, and contaminants, requiring specific approaches for migration testing, extraction, and detection. Advanced techniques, such as ultra-high-performance liquid chromatography or two-dimensional gas chromatography coupled with high-resolution mass spectrometry, have enabled non-targeted analysis approaches. However, the field remains

Academic Editor: Ping Xiang

Received: 21 May 2025
Revised: 17 June 2025
Accepted: 24 June 2025
Published: 28 June 2025

Citation: Miralles, P.; Fuentes-Ferragud, E.; Socas-Hernández, C.; Coscollà, C. Recent Trends and Challenges on

Toxics **2025**, *13*, 543 https://doi.org/10.3390/toxics13070543

https://www.mdpi.com/2305-6304/13/7/543

FONDAZIONE™
CARTA
ETICA
del Packaging

Via Cosimo Del Fante 10 - 20122 Milano - Tel. +39 02 58319624
C.F: 97870780158
segreteria@fondazionepackaging.org - www.fondazionecartaeticapackaging.org