



NUMERO 6 - NOVEMBRE 2023

PACKAGING SCIENCE

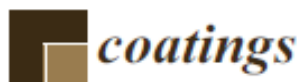
*E' la Rassegna Scientifica Internazionale della **Fondazione Carta Etica del Packaging**.*

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.*

Quantificazione del Ciclo-di-BADGE (CdB) e identificazione di diversi derivati del BADGE in campioni di alimenti in scatola

La maggior parte delle lattine destinate a venire a contatto con gli alimenti richiede l'applicazione di un rivestimento interno a base di polimeri sintetici. Il tipo di rivestimento più utilizzato sono le resine epossidiche a base di bisfenolo A diglicidil etere (BADGE). È stato scoperto che alcuni componenti come il CdB e altri derivati del BADGE possono migrare negli alimenti. Il CdB è costituito da bisfenolo A (BPA, CAS 80-05-7) e bisfenolo A diglicidil etere (BADGE, CAS 1675-54-3). Il CdB è una sostanza aggiunta non intenzionalmente (NIAS) che si forma come sottoprodotto durante la produzione di resina epossidica che viene utilizzata nei rivestimenti delle lattine per alimenti. In questo studio, il rivestimento polimerico di quarantotto lattine è stato valutato utilizzando uno spettrometro a infrarossi con riflettanza totale attenuata.



Article

Quantification of Cyclo-di-BADGE and Identification of Several BADGE Derivatives in Canned Food Samples

Juana Bustos ¹, Antía Lestido-Cardama ², M^a Isabel Santillana ¹, Raquel Sendón ², Perfecto Paseiro Losada ² and Ana Rodríguez Bernaldo de Quirós ^{2,*}

¹ National Food Centre, Spanish Agency for Food Safety and Nutrition, 28220 Majadahonda, Spain; jbastos@aesan.gob.es (J.B.); maribelsantillana@gmail.com (M.I.S.)

² Department of Analytical Chemistry, Nutrition and Food Science, Faculty of Pharmacy, University of Santiago de Compostela, 15782 Santiago de Compostela, Spain; antia.lestido@usc.es (A.L.-C.); raquel.sendon@usc.es (R.S.); perfecto.paseiro@usc.es (P.P.L.)

* Correspondence: ana.rodriguez.bernaldo@usc.es; Tel.: +34-881814965

Abstract: Most cans intended to come into contact with food require the application of an internal coating made from synthetic polymers. The most widely used type of coating are epoxy resins based on bisphenol A diglycidyl ether (BADGE). It has been found that some components like cyclo-di-BADGE (CdB) and other BADGE derivatives can migrate into food. In this study, the polymeric coating of forty-eight cans was assessed using an infrared spectrometer with attenuated total reflectance. The food samples were extracted, and a targeted analysis was carried out to quantify CdB using liquid chromatography with fluorescence detection (HPLC-FLD). The first estimation of the exposure of the adult population was estimated by combining the concentration of CdB in the samples and the Spanish consumption data. In addition, a non-targeted screening by LC-MS was performed in the food sample extracts for the identification of other BADGE derivatives. Twenty samples were positive for the presence of CdB reaching concentrations of 2623 µg/kg. However, the tolerable daily intake of 1.5 µg/kg bw/day recommended for chemical compounds with high toxicological risk was not exceeded. A total of 18 epoxy oligomers could be tentatively identified in the food extracts being BADGE.H₂O.BuEtOH the derivative with the highest incidence.



Citation: Bustos, J.; Lestido-Cardama,

Coatings 2023, 13, 792. <https://doi.org/10.3390/coatings13040792>

<https://www.mdpi.com/journal/coatings>

<https://www.mdpi.com/2079-6412/13/4/792>

Tintura potenziata del polipropilene utilizzando miscele di gas fluoro-ossigeno

Fluorurazione superficiale con F₂ puro il gas può facilmente rendere idrofobica la superficie del PP (polipropilene) e provoca una tingibilità limitata, come riportato in un articolo precedente. In questo studio, per produrre una superficie più idrofila, è stata eseguita la fluorurazione superficiale del PP a 25 °C, pressione totale del gas di 13,3 kPa e tempo di reazione di 1 ora utilizzando F₂ e O₂ miscele con diverse proporzioni di F₂ gas. La rugosità superficiale dei campioni di PP fluorurato era circa 1,5 volte superiore a quella del campione non trattato (5 nm).



colorants



Article

Enhanced Dyeing of Polypropylene Using Fluorine–Oxygen Gas Mixtures

Masanari Namie ^{1,2}, Jae-Ho Kim ^{1,*} and Susumu Yonezawa ³

¹ Department of Materials Science and Engineering, Faculty of Engineering, University of Fukui, 3-9-1 Bunkyo, Fukui 910-8507, Japan; namie.masanari@jaea.go.jp

² JAEA Tsuruga Comprehensive Research and Development Center, 1 Shiraki, Fukui 919-1279, Japan

³ Cooperative Research Center, University of Fukui, 3-9-1 Bunkyo, Fukui 910-8507, Japan; yonezawa@matse.u-fukui.ac.jp

* Correspondence: kim@matse.u-fukui.ac.jp

Abstract: Surface fluorination with pure F₂ gas can easily make the surface on PP (polypropylene) hydrophobic, and it causes limited dyeability, as reported in a previous paper. In this study, to produce a more hydrophilic surface, surface fluorination of PP was performed at 25 °C, total gas pressure of 13.3 kPa, and reaction time of 1 h using F₂ and O₂ mixtures with different proportions of F₂ gas. The surface roughness of the fluorinated PP samples was about 1.5 times higher than that of the untreated sample (5 nm). Fourier-transform infrared spectroscopy and X-ray photoelectron spectroscopy (XPS) results showed that the PP-derived bonds (–C–C– and –CH₃) decreased because they were converted into polar groups (–C–O, –CHF, and –CF₃), which increased the surface electronegativity of the PP. The variation in the F₂ gas proportion in the gas mixture significantly affected the hydrophilicity and surface composition of the PP. At F₂ gas proportions of <70%, the hydrophilicity of the fluorinated PP samples was increased. Notably, the hydrophilic and negatively charged PP surface enhanced the dyeing of the polymer with basic methylene blue (MB). In contrast, at F₂ gas proportions of >90%, the PP surface became hydrophobic owing to increased numbers of hydrophobic –CF₃ bonds. Thus, enhanced PP dyeing can be controlled based on the composition of the F₂ and O₂ gas mixture.

Keywords: polypropylene; surface fluorination; dyeing; zeta potential



Citation: Namie, M.; Kim, J.-H.;

Colorants 2023, 2, 552–564. <https://doi.org/10.3390/colorants2030027>

<https://www.mdpi.com/journal/colorants>

<https://www.mdpi.com/2079-6447/2/3/27>

Verso un packaging cosmetico a colori sostenibili

Nonostante i significativi progressi verso la cosmesi sostenibile, il packaging sostenibile prodotto in serie si è rivelato una sfida. La complessità delle considerazioni ambientali, economiche, sociali, tecnologiche e politiche, in combinazione con i diversi comportamenti dei consumatori e gli obiettivi aziendali, può rendere difficile la selezione di una strategia ottimale tra componenti eterogenei della catena di approvvigionamento sparsi in tutto il mondo, e il costo e lo sforzo di sviluppare, testare e convalidare strategie alternative scoraggia l'esplorazione empirica di potenziali alternative. Viene delineata una strategia di ricerca verso lo sviluppo di imballaggi sostenibili che, con un adeguato supporto politico, potrebbero ridurre al minimo le esternalità e fornire imballaggi prodotti in serie accettabili sia per i consumatori che per i produttori.



Review

Towards Sustainable Color Cosmetics Packaging

Manu Dube ^{1,*} and Sema Dube ²

¹ Faculty of Computer and Information Sciences, Yeditepe University, 34755 Istanbul, Turkey

² Faculty of Economics and Administrative Sciences, Yeditepe University, 34755 Istanbul, Turkey; sema.dube@yeditepe.edu.tr

* Correspondence: manu.dube@yeditepe.edu.tr

Abstract: In spite of the significant progress towards sustainable cosmetics, mass-produced sustainable packaging has proven to be a challenge. The complexity of environmental, economic, social, technological, and policy considerations in conjunction with varying consumer behaviors and corporate goals can make it difficult to select an optimal strategy across heterogeneous supply chain components spread over the globe, and the cost and effort of developing, testing, and validating alternative strategies discourages empirical exploration of potential alternatives. This review discusses the challenges that can be expected in the context of broader sustainability efforts, as well as the experience gained in related fields, such as sustainable cosmetics and sustainable packaging, to identify potential pitfalls as well as promising trends towards the development of sustainable color cosmetics packaging. The findings suggest there may be little to be gained from attempting to induce customers to change their behavior, waiting for a significant increase in global recycling infrastructure, or expecting regulatory constraints to substitute for the lack of technological and business solutions. A research strategy is delineated towards the development of sustainable packaging that, with appropriate policy support, could minimize externalities and provide mass-produced packaging that is acceptable to both consumers and producers.

Keywords: sustainable cosmetics; sustainable packaging; sustainability strategies; consumer behavior; corporate social responsibility; technological developments

Cosmetics **2023**, *10*, 139. <https://doi.org/10.3390/cosmetics10050139>

<https://www.mdpi.com/journal/cosmetics>

<https://www.mdpi.com/2079-9284/10/5/139>

Le microplastiche sono un problema macro? Un'analisi sulle fonti di contaminazione, le sfide analitiche e l'impatto sulla salute umana delle microplastiche negli alimenti

Negli ultimi anni, l'esposizione delle popolazioni umane alle microplastiche attraverso gli alimenti sta diventando un argomento di preoccupazione. Sebbene le microplastiche siano state definite come "contaminanti emergenti", la loro presenza nell'ambiente e negli alimenti è piuttosto datata. Questa revisione sistematica ha lo scopo di indagare le discrepanze che stanno caratterizzando la ricerca nel campo delle microplastiche negli alimenti, con particolare riguardo alle preparazioni dei campioni, alle concentrazioni di microplastiche e al loro effetto sull'uomo. Questa revisione ha chiaramente sottolineato la necessità di standardizzare gli approcci di laboratorio per ottenere risultati utili per una migliore gestione della sicurezza alimentare.



Review

Are Microplastics a Macro Issue? A Review on the Sources of Contamination, Analytical Challenges and Impact on Human Health of Microplastics in Food

Cristina Di Fiore ^{1,*}, Fabiana Carriera ^{1,2}, Mario Vincenzo Russo ¹  and Pasquale Avino ^{1,3} 

¹ Department of Agricultural, Environmental and Food Sciences (DiAAA), University of Molise, 86100 Campobasso, Italy; fabiana.carriera@unicas.it (F.C.); mv.russo@unimol.it (M.V.R.); avino@unimol.it (P.A.)

² Department of Civil and Mechanical Engineering, University of Cassino and Southern Lazio, 03043 Cassino, Italy

³ Institute of Atmospheric Pollution Research, Division of Rome, c/o Ministry of Environment and Energy Security, 00147 Rome, Italy

* Correspondence: c.difiore@studenti.unimol.it

Abstract: In recent years, human populations' exposure to microplastics via foods is becoming a topic of concern. Although microplastics have been defined as "emerging contaminants", their occurrence in the environment and food is quite dated. This systematic review aims to investigate the discrepancies which are characterizing the research in the microplastics field in foods, with particular regard to sample preparations, microplastics' concentrations and their effect on humans. For the selection of papers, the PRISMA methodology was followed. Discrepancies in the methodological approaches emerged and in the expression of the results as well, underlying the urgency in the harmonization of the methodological approaches. Uncertainties are still present regarding the adverse effects of microplastics on the human body. The scientific evidence obtained thus far is, in fact, not sufficient to demonstrate a concrete negative effect. This review has clearly underlined the need to standardise laboratory approaches to obtain useful results for better food safety management.



Foods 2023, 12, 3915. <https://doi.org/10.3390/foods12213915>

<https://www.mdpi.com/journal/foods>

<https://www.mdpi.com/2304-8158/12/21/3915>

La caratterizzazione di film biodegradabili e imballaggi alimentari

Ogni anno, circa 300 milioni di tonnellate di plastica a base di petrolio vengono prodotte in tutto il mondo e queste plastiche causano notevoli problemi ambientali a causa della loro natura non biodegradabile e dell'emissione di gas tossici al momento dell'incenerimento. Di conseguenza, c'è un urgente bisogno di sviluppare nuovi materiali di imballaggio che siano interamente biodegradabili e provenienti da sostanze rinnovabili. I ricercatori si stanno concentrando sempre più sulla creazione di film e rivestimenti utilizzando polimeri biodegradabili derivati da risorse rinnovabili, come lipidi, proteine, polisaccaridi, poliesteri microbici e poliuretani. Questi materiali hanno attirato sempre più attenzione in quanto possono essere facilmente personalizzati, il che può conferire loro proprietà antimicrobiche o antiossidanti, rendendoli così particolarmente adatti per applicazioni legate agli alimenti.



membranes



Editorial

The Characterization of Biodegradable Films and Food Packaging

Ismael Marcet

Department of Chemical and Environmental Engineering, Research Group TBR, University of Oviedo, 33006 Oviedo, Spain; ismael.marcet@gmail.com

Every year, approximately 300 million tons of petroleum-based plastics is manufactured worldwide, and these plastics cause significant environmental issues due to their non-biodegradable nature and emission of toxic gases upon incineration. Consequently, there is an urgent need to develop new packaging materials that are entirely biodegradable and sourced from renewable substances. Researchers are increasingly focusing on the creation of films and coatings using biodegradable polymers derived from renewable resources, such as lipids, proteins, polysaccharides, microbial polyesters, and polyurethanes. These materials have attracted increasing attention since they can be easily customized, which may provide them with antimicrobial or antioxidant properties, thus making them particularly suitable for food-related applications.

Therefore, the primary objective of this Special Issue was to collate the most significant contributions to the field of biodegradable films for packaging, specifically emphasizing materials with tailored properties designed for specific applications in the food industry.

Thirteen research papers and two reviews were published in this Special Issue. Two research papers focus on the preparation of novel antimicrobial compounds suitable for incorporation into biodegradable food packaging materials. One of these is the article of Valdés et al. [1], which describes the microwave-assisted ethanolic/aqueous extraction of polyphenolic compounds from almond shell residues. The other is a study by Marchianò et al. [2], focusing on the development of a new method for preparing nanovesicles loaded with vanillin, which is a natural compound with antioxidant and antimicrobial properties.



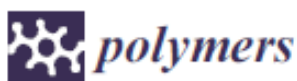
Membranes 2023, 13, 826. <https://doi.org/10.3390/membranes13100826>

<https://www.mdpi.com/journal/membranes>

<https://www.mdpi.com/2077-0375/13/10/826>

Poliidrossibutirrato-co-idrossivalerato (PHBV) con acidi fenolici per imballaggi alimentari attivi

I film PHBV che incorporano il 3, 6 e 9% di acido ferulico (FA) o acido p-cumarico (PCA) sono stati ottenuti mediante fusione e stampaggio a compressione. Sono state analizzate le microstrutture e i comportamenti termici dei film, nonché le loro proprietà meccaniche, ottiche e di barriera. È stata inoltre caratterizzata la migrazione globale e specifica dei materiali in diversi simulanti alimentari. La FA è stata miscelata in modo omogeneo con il polimero, mentre la PCA è stata principalmente dispersa sotto forma di particelle fini nelle matrici PHBV a causa del suo punto di fusione più elevato. Queste caratteristiche strutturali hanno promosso differenze nelle proprietà fisiche dei film a seconda della concentrazione del composto.



Article

Polyhydroxybutyrate-co-hydroxyvalerate (PHBV) with Phenolic Acids for Active Food Packaging

Eva Moll * and Amparo Chiralt

Instituto Universitario de Ingeniería de Alimentos (FoodUPV), Universitat Politècnica de València, Camí de Vera s/n, 46022 València, Spain; dchiralt@tal.upv.es

* Correspondence: evmolmon@upvnet.upv.es

Abstract: PHBV films incorporating 3, 6 and 9% ferulic acid (FA) or p-coumaric acid (PCA) were obtained by melt blending and compression moulding. The films' microstructures and thermal behaviours were analysed as well as their mechanical, optical and barrier properties. The overall and specific migration of the materials in different food simulants was also characterised. FA was homogeneously mixed with the polymer, whereas PCA was mainly dispersed as fine particles in the PHBV matrices due to its higher melting point. These structural features promoted differences in the physical properties of the films depending on the compound concentration. As the concentration of both compounds rose, the barrier capacity of the films to oxygen, and to a lesser extent water vapour, was enhanced. While FA promoted the extensibility of the films, 9% PCA enhanced their brittleness. Both compounds affected the crystallisation pattern of the polymer, promoting smaller crystalline formations and a slight decrease in crystallinity. Although the overall migration of every film formulation was lower than the overall migration limit (OML), the release of active compounds was dependent on the food simulant; almost total release was noted in ethanol containing simulants but was more limited in aqueous systems. Therefore, these films could be used as food contact materials, contributing to extending the food's shelf life.



Citation: Moll, E.; Chiralt, A.
DOI: <https://doi.org/10.3390/polym15214222>

Keywords: ferulic acid; p-coumaric acid; phenolic acids; PHBV; overall migration; specific migration; crystallinity; active food packaging

Polymers 2023, 15, 4222. <https://doi.org/10.3390/polym15214222>

<https://www.mdpi.com/journal/polymers>

<https://www.mdpi.com/2073-4360/15/21/4222>

Quantità di residui del prodotto di riempimento negli imballaggi di plastica destinati al riciclo

Riempire i residui di prodotto negli imballaggi equivale a perdite di prodotto. Vengono lavati dopo la cernita e prima di iniziare i processi di riciclo. Non sono stati pubblicati molti dati sulla quantità di prodotto di riempimento ancora presente negli imballaggi dedicati al riciclo. I risultati provengono spesso da studi di laboratorio. Pertanto, sono state analizzate diverse centinaia di imballaggi provenienti da un impianto di smistamento di un sistema doppio in Germania per determinare la quantità di residui del prodotto di riempimento.



waste



Article

Amount of Fill Product Residues in Plastic Packagings for Recycling

Konstantin Schinkel¹, Bastian Küppers², Sven Reichenbach³, Teresa Rohrmeier^{1,2}, Kajetan Müller^{4,5}, Tanja Fell⁵ and Sven Sänglerlaub^{1,5,*} 

¹ Department for Technical Systems, Processes and Communication, Munich University of Applied Sciences HM, Lothstraße 38, 80335 Munich, Germany

² STADLER® Anlagenbau GmbH, 88361 Altshausen, Germany

³ PreZero Recycling Süd GmbH, 75248 Öttronn-Dürrn, Germany

⁴ Faculty of Mechanical Engineering, University of Applied Science Kempten, Bahnhofstraße 61, 87435 Kempten, Germany

⁵ Fraunhofer Institute for Process Engineering and Packaging IVV, Giggenhauser Straße 35, 85354 Freising, Germany

* Correspondence: sven.sanglerlaub@hm.edu; Tel.: +49-89-1265-1539

Abstract: Fill product residues in packagings are equivalent to product losses. They are washed out after sorting and before commencing recycling processes. Not much data have been published about how much fill product is still present in packagings dedicated for recycling. Results are often from laboratory trials. Therefore, several hundred packagings from a sorting plant of a dual system in Germany were analysed to determine the amount of fill product residues. Approximately 10 wt. % of highly viscous fill products in tubes were lost as residue. In the case of packagings that were easy to empty, such as cups, and in the case of low-viscosity fill products, such as water, less than 1 wt. % of the fill products remained in the packagings. The mean amount of residue in relation to clean packaging was 0.9 g residue in 1 g of packaging material (without residue) in tubes and 0.07 g in PET bottles. These values were significantly lower for low-viscosity fill products compared to high-viscosity fill products, as expected.



Citation: Schinkel, K.; Küppers, B.; Reichenbach, S.; Rohrmeier, T.; Müller, K.; Fell, T.; Sänglerlaub, S.

Keywords: recycling; emptying behaviour; food residue; fill good residue; packaging waste

Waste 2023, 1, 901–918. <https://doi.org/10.3390/waste1040052>

<https://www.mdpi.com/journal/waste>

<https://www.mdpi.com/2813-0391/1/4/52>



Via Cosimo Del Fante 10 - 20122 Milano - Tel. +39 02 58319624

C.F: 97870780158

segreteria@fondazionepackaging.org - www.fondazionecartaeticapackaging.org