NUMERO 2 - MARZO 2022

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.*

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Progettazione ottimale di imballaggi in cartone ondulato a doppia parete

Progettare imballaggi in cartone ondulato è una vera sfida, soprattutto quando il materiale di imballaggio proviene da più ricicli. Il riciclo stesso è un processo pro-ecologico e assolutamente necessario, ma le proprietà meccaniche dei materiali che vengono lavorati molte volte si deteriorano con il numero di cicli. I produttori stanno cercando di utilizzare metodi di progettazione senza precedenti per preservare la capacità portante dell'imballaggio, anche quando il materiale stesso è di qualità deteriorata. Un ulteriore ostacolo nel processo di progettazione della struttura degli imballaggi in carta è la progressiva riduzione sistematica della grammatura (il cosiddetto processo leggero) del cartone ondulato. Pertanto, questa ricerca presenta uno sguardo critico sul processo di selezione ottimale del cartone ondulato per le strutture di imballaggio, a seconda della carta utilizzata.

materials

MDPI

Article

Optimal Design of Double-Walled Corrugated Board Packaging

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Abstract: Designing corrugated board packaging is a real challenge, especially when the packaging material comes from multiple recycling. Recycling itself is a pro-ecological and absolutely necessary process, but the mechanical properties of materials that are processed many times deteriorate with the number of cycles. Manufacturers are trying to use unprecedented design methods to preserve the load-bearing capacity of packaging, even when the material itself is of deteriorating quality. An additional obstacle in the process of designing the structure of paper packaging is the progressive systematic reduction of the grammage (the so-called lightweight process) of corrugated cardboard. Therefore, this research presents a critical look at the process of optimal selection of corrugated cardboard for packaging structures, depending on the paper used. The study utilizes analytical, simplified formulas to estimate the strength of cardboard itself as well as the strength of packaging, which are then analyzed to determine their sensitivity to changes in cardboard components, such as the types of paper of individual layers. In the performed sensitivity analysis, numerical homogenization was used, and the influence of initial imperfections on the packaging mechanics was determined. The paper presents a simple algorithm for the optimal selection of the composition of corrugated cardboard depending on the material used and the geometry of the packaging, which allows for a more conscious production of corrugated cardboard from materials derived, e.g., from multiple recycling.

Keywords: non-local sensitivity analysis; numerical homogenization; optimal packaging; box compressive strength; critical load; orthotropic plate; edge crush resistance; bending stiffness; corrugated cardboard

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Citation: Mrówczyński, D.; Knitter-Piątkowska, A.; Garbowski, T. Optimal Design of Double-Walled Corrugated Board Packaging. *Materials* **2022**, *15*, 2149. https://doi.org/10.3390/ma15062149

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Fabbricazione e caratterizzazione di pellicole composite di cellulosa/polietilene trasparenti e uniformi da bicchieri di carta usa e getta usati con il "metodo One-Pot"

I bicchieri di carta usa e getta sono solitamente composti da cartone di alta qualità e rivestimenti interni in polietilene e sono ampiamente utilizzati nella vita quotidiana. Tuttavia, la maggior parte dei bicchieri di carta usa e getta vengono utilizzati solo per un breve periodo e poi inceneriti o accumulati in discarica alla fine del loro servizio a causa della difficoltà di separare i componenti, portando a una seria minaccia per il nostro ecosistema. Pertanto, lo sviluppo di un metodo facile e verde per riciclare e riutilizzare i bicchieri di carta usa e getta è vitale.

polymers

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Article

Fabrication and Characterization of Transparent and Uniform Cellulose/Polyethylene Composite Films from Used Disposable Paper Cups by the "One-Pot Method"

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Abstract: Disposable paper cups are usually composed of high-grade paper board and an inner polyethylene coatings and are extensively used in daily life. However, most disposable paper cups are only used for a short time and then incinerated or accumulated in landfill at the end of their service due to the difficulty in separating the components, leading to a serious threat to our ecosystem. Therefore, developing a facile and green method to recycle and reuse disposable paper cups is vital. By using ionic liquid 1-allyl-3-methylimidazolium chloride (AmimCl) as a solvent, transparent and homogenous cellulose/polyethylene composite films were successfully prepared from used bamboo-based disposable paper cups through the "one-pot method", without any pre-treatment. It was found that there was a transformation of cellulose I to II after the dissolution and regeneration processes, and the crystallinity degree of the regenerated cellulose-based materials decreased significantly, resulting in a change in thermal properties. Meanwhile, compared to traditional pure cellulose films, the composite films possessed good UV-shielding properties and hydrophobicity. Moreover, they also displayed good mechanical properties. Additionally, the size of the ground PE coatings displayed obvious effects on the structures and properties of the composite films, where the CPE100 (sieved with 100–200 mesh) possessed the most homogeneous texture and the highest tensile strength (82 Mpa), higher than that of commercial polyethylene film (9–12 MPa), showing superiority as packaging or wrapping materials. Consequently, the goals to fabricate uniform cellulose/polyethylene composite films and valorize the solid waste from disposable paper cups were simultaneously achieved by a facile and green "one-pot method".

Keywords: disposable paper cups; recycle; cellulose; polyethylene composite films

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Citation: Wang, L.; Zhou, Q.; Ji, X.; Peng, J.; Nawaz, H.; Xia, G.; Ji, X.; Zhang, J.; Zhang, J. Fabrication and Characterization of Transparent and Uniform Cellulose/Polyethylene Composite Films from Used Disposable Paper Cups by the "One-Pot Method". *Polymers* **2022**, *14*, 1070. https://doi.org/10.3390/polym14061070

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Progressi nei film attivi biodegradabili per l'imballaggio alimentare: effetti dell'incorporazione di nano/microcapsule

Il packaging alimentare svolge un ruolo fondamentale nella moderna industria alimentare come processo principale per preservare la qualità dei prodotti alimentari dalla produzione al consumo. Sono in fase di sviluppo nuove tecnologie di imballaggio alimentare formulate con composti naturali sostituendo agenti antimicrobici e antiossidanti sintetici / chimici per soddisfare le aspettative dei consumatori per un cibo sano. La strategia di incorporare composti antimicrobici naturali nelle strutture di imballaggio alimentare è una tecnologia recente e promettente per raggiungere questo obiettivo. Concetti come ″imballaggi biodegradabili″, ″imballaggi attivi″ e ″imballaggi bioattivi″ attualmente guidano la ricerca e lo sviluppo di imballaggi alimentari.

foods

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Review

Advancements in Biodegradable Active Films for Food Packaging: Effects of Nano/Microcapsule Incorporation

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Abstract: Food packaging plays a fundamental role in the modern food industry as a main process to preserve the quality of food products from manufacture to consumption. New food packaging technologies are being developed that are formulated with natural compounds by substituting synthetic/chemical antimicrobial and antioxidant agents to fulfill consumers' expectations for healthy food. The strategy of incorporating natural antimicrobial compounds into food packaging structures is a recent and promising technology to reach this goal. Concepts such as "biodegradable packaging", "active packaging", and "bioactive packaging" currently guide the research and development of food packaging. However, the use of natural compounds faces some challenges, including weak stability and sensitivity to processing and storage conditions. The nano/microencapsulation of these bioactive compounds enhances their stability and controls their release. In addition, biodegradable packaging materials are gaining great attention in the face of ever-growing environmental concerns about plastic pollution. They are a sustainable, environmentally friendly, and cost-effective alternative to conventional plastic packaging materials. Ultimately, a combined formulation of nano/microencapsulated antimicrobial and antioxidant natural molecules, incorporated into a biodegradable food packaging system, offers many benefits by preventing food spoilage, extending the shelf life of food, reducing plastic and food waste, and preserving the freshness and quality of food. The main objective of this review is to illustrate the latest advances in the principal biodegradable materials used in the development of active antimicrobial and antioxidant packaging systems, as well as the most common nano/microencapsulated active natural agents incorporated into these food-packaging materials.

Keywords: biodegradable packaging; active packaging; antimicrobial agent; antioxidant agent; nano/microencapsulation; biopolymers

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Citation: Baghi, F.; Gharsallaoui, A.; Dumas, E.; Ghnimi, S. Advancements in Biodegradable Active Films for Food Packaging: Effects of Nano/Microcapsule Incorporation. *Foods* **2022**, *11*, 760. https://doi.org/10.3390/foods11050760

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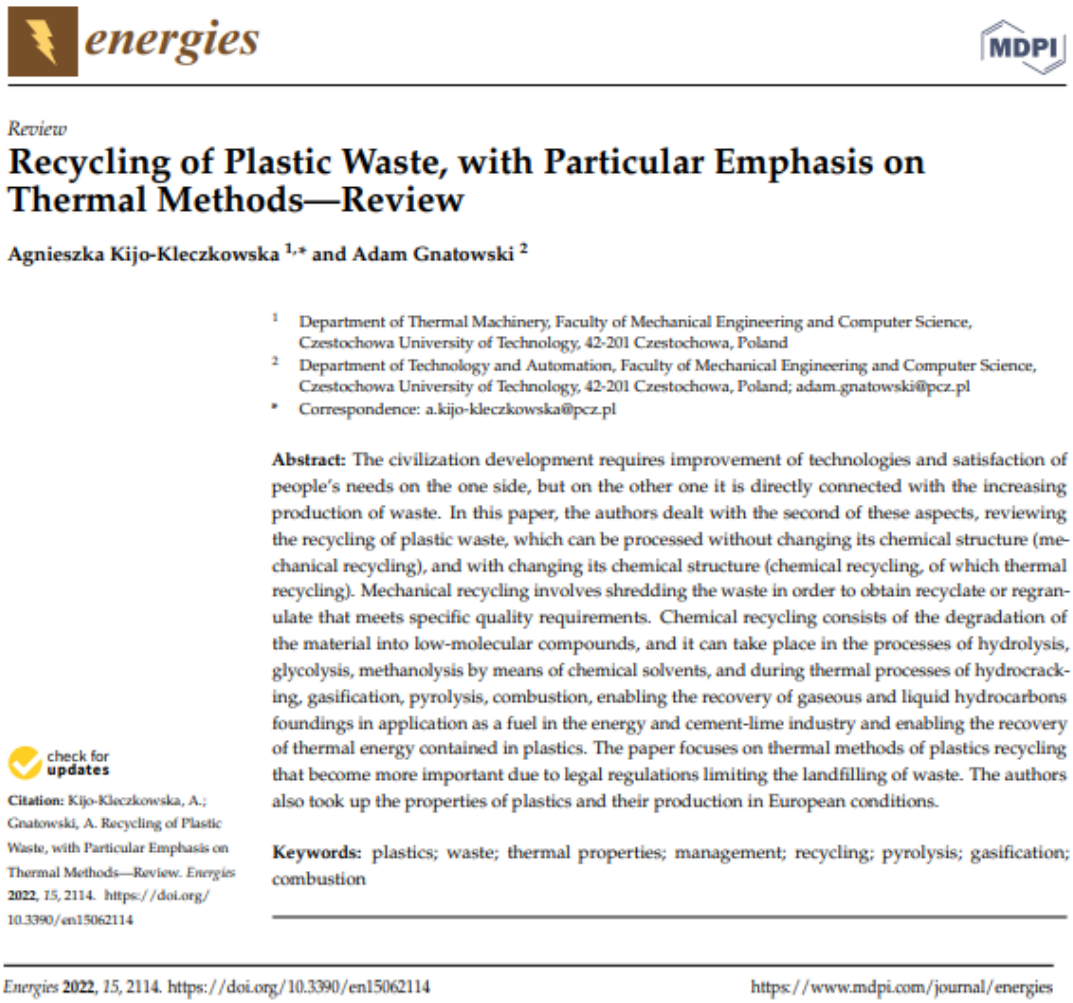
Riciclo dei rifiuti di plastica, con particolare attenzione ai metodi termici: revisione.

In questo articolo, gli autori hanno affrontato il riciclo dei rifiuti di plastica. Il riciclo meccanico prevede la triturazione dei rifiuti al fine di ottenere un riciclo o un rigranulato che soddisfi specifici requisiti di qualità. Il riciclo chimico consiste nella degradazione del materiale in composti a basso peso molecolare, e può avvenire nei processi di idrolisi, glicolisi, metanolosi per mezzo di solventi chimici, e durante processi termici di idrocracking, gassificazione, pirolisi, combustione, consentendo il recupero di idrocarburi gassosi e liquidi fondando in applicazione come combustibile nell'industria energetica e cementizia-calce e consentendo il recupero di energia termica contenuta nelle materie plastiche. Il documento si concentra sui metodi termici di riciclaggio della plastica che diventano più importanti a causa delle normative legali che limitano il collocamento in discarica dei rifiuti.



energies

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Review

Recycling of Plastic Waste, with Particular Emphasis on Thermal Methods—Review

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Abstract: The civilization development requires improvement of technologies and satisfaction of people's needs on the one side, but on the other one it is directly connected with the increasing production of waste. In this paper, the authors dealt with the second of these aspects, reviewing the recycling of plastic waste, which can be processed without changing its chemical structure (mechanical recycling), and with changing its chemical structure (chemical recycling, of which thermal recycling). Mechanical recycling involves shredding the waste in order to obtain recyclate or regranulate that meets specific quality requirements. Chemical recycling consists of the degradation of the material into low-molecular compounds, and it can take place in the processes of hydrolysis, glycolysis, methanolysis by means of chemical solvents, and during thermal processes of hydrocracking, gasification, pyrolysis, combustion, enabling the recovery of gaseous and liquid hydrocarbons foundings in application as a fuel in the energy and cement-lime industry and enabling the recovery of thermal energy contained in plastics. The paper focuses on thermal methods of plastics recycling that become more important due to legal regulations limiting the landfilling of waste. The authors also took up the properties of plastics and their production in European conditions.

Keywords: plastics; waste; thermal properties; management; recycling; pyrolysis; gasification; combustion

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Citation: Kijo-Kleczkowska, A.; Gnatowski, A. Recycling of Plastic Waste, with Particular Emphasis on Thermal Methods—Review. *Energies* **2022**, *15*, 2114. https://doi.org/10.3390/en15062114

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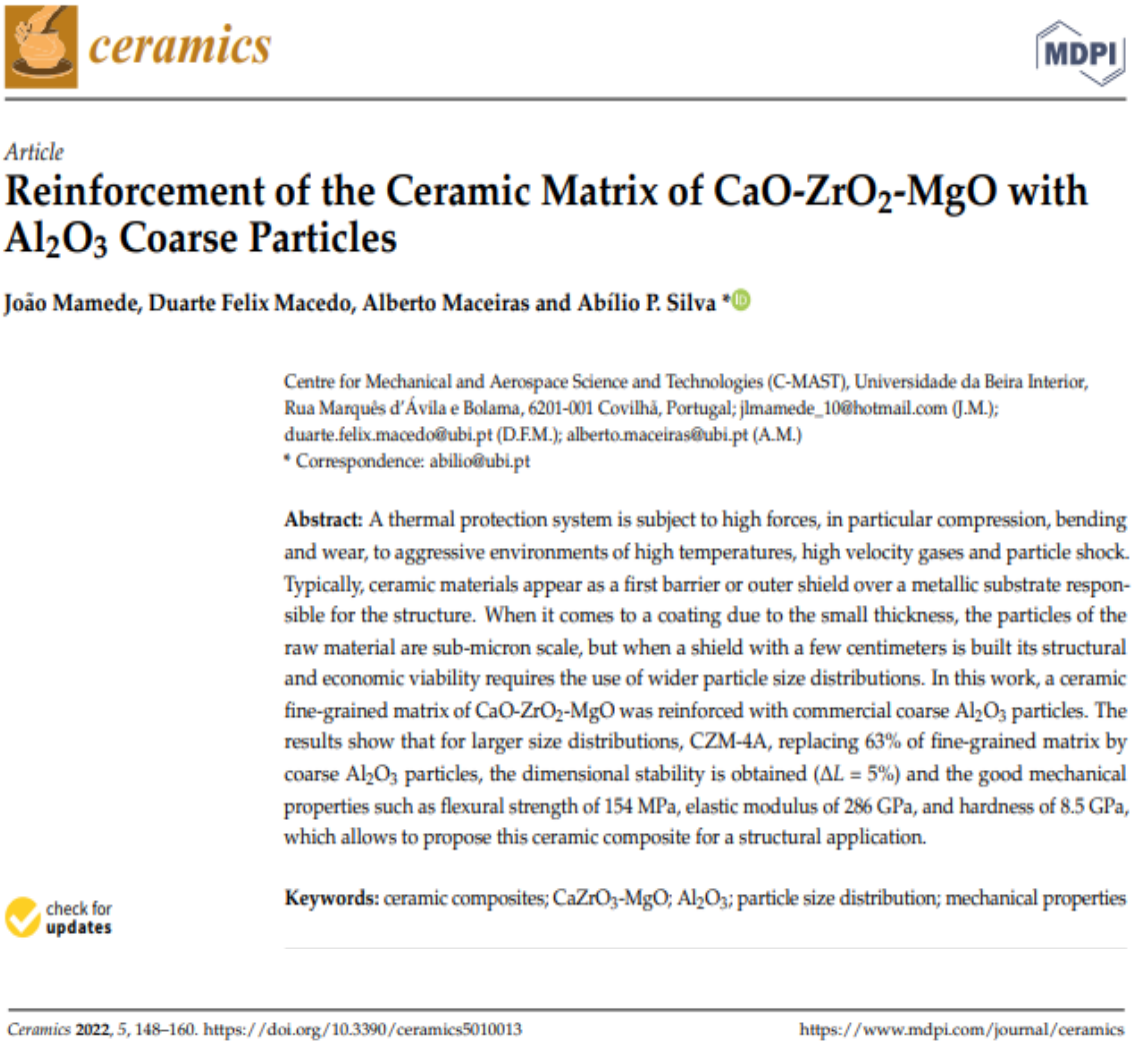
Rinforzo della matrice ceramica di CaO-ZrO2-MgO con particelle grossolane di Al_2O_3.

Un sistema di protezione termica è soggetto a forze elevate, in particolare compressione, flessione e usura, ad ambienti aggressivi di alte temperature, gas ad alta velocità e shock particellari. Tipicamente, i materiali ceramici appaiono come una prima barriera o scudo esterno su un substrato metallico responsabile della struttura. Quando si tratta di un rivestimento a causa del piccolo spessore, le particelle della materia prima sono di scala sub-micron, ma quando viene costruito uno scudo con pochi centimetri la sua fattibilità strutturale ed economica richiede l'uso di distribuzioni granulometriche più ampie. In questo lavoro, una matrice ceramica a grana fine di CaO-ZrO2-MgO è stata rinforzata con particelle di Al_2O_3 grossolane commerciali.



ceramics

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Article

Reinforcement of the Ceramic Matrix of CaO-ZrO_2-MgO with Al_2O_3 Coarse Particles

João Mamede, Duarte Felix Macedo, Alberto Maceiras and Abílio P. Silva *

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Abstract: A thermal protection system is subject to high forces, in particular compression, bending and wear, to aggressive environments of high temperatures, high velocity gases and particle shock. Typically, ceramic materials appear as a first barrier or outer shield over a metallic substrate responsible for the structure. When it comes to a coating due to the small thickness, the particles of the raw material are sub-micron scale, but when a shield with a few centimeters is built its structural and economic viability requires the use of wider particle size distributions. In this work, a ceramic fine-grained matrix of CaO-ZrO_2-MgO was reinforced with commercial coarse Al_2O_3 particles. The results show that for larger size distributions, CZM-4A, replacing 63% of fine-grained matrix by coarse Al_2O_3 particles, the dimensional stability is obtained (ΔL = 5%) and the good mechanical properties such as flexural strength of 154 MPa, elastic modulus of 286 GPa, and hardness of 8.5 GPa, which allows to propose this ceramic composite for a structural application.

Keywords: ceramic composites; $CaZrO_3$-MgO; Al_2O_3; particle size distribution; mechanical properties

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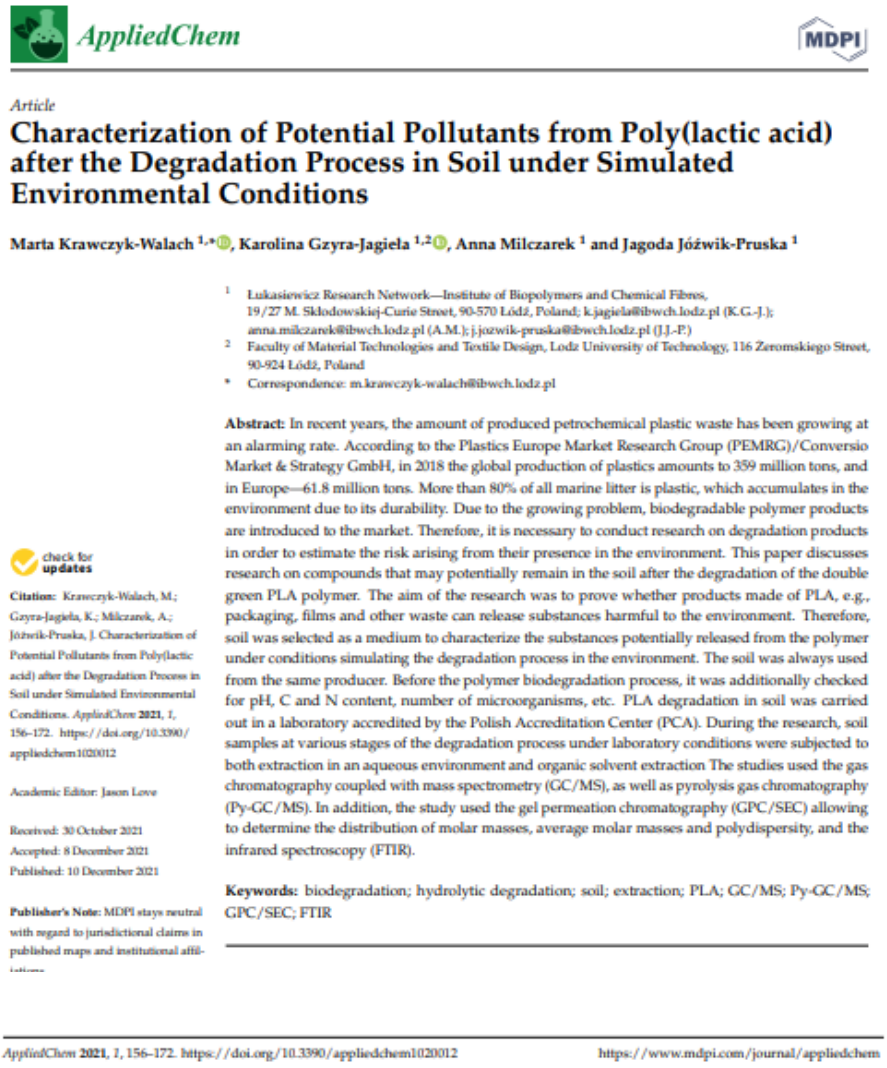
https://www.mdpi.com

Caratterizzazione di potenziali inquinanti da acido poli(lattico) dopo il processo di degradazione nel suolo in condizioni ambientali simulate

Negli ultimi anni, la quantità di rifiuti di plastica petrolchimici prodotti è cresciuta a un ritmo allarmante. Secondo il Plastics Europe Market Research Group (PEMRG)/Conversio Market & Strategy GmbH, nel 2018 la produzione globale di materie plastiche ammonta a 359 milioni di tonnellate e in Europa a 61,8 milioni di tonnellate. Più dell'80% di tutti i rifiuti marini è plastica, che si accumula nell'ambiente grazie alla sua durata. A causa del crescente problema, vengono introdotti sul mercato prodotti polimerici biodegradabili. Pertanto, è necessario condurre ricerche sui prodotti di degradazione al fine di stimare il rischio derivante dalla loro presenza nell'ambiente. Questo documento discute la ricerca su composti che possono potenzialmente rimanere nel terreno dopo la degradazione del doppio polimero PLA verde.



AppliedChem

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Article

Characterization of Potential Pollutants from Poly(lactic acid) after the Degradation Process in Soil under Simulated Environmental Conditions

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Abstract: In recent years, the amount of produced petrochemical plastic waste has been growing at an alarming rate. According to the Plastics Europe Market Research Group (PEMRG)/Conversio Market & Strategy GmbH, in 2018 the global production of plastics amounts to 359 million tons, and in Europe—61.8 million tons. More than 80% of all marine litter is plastic, which accumulates in the environment due to its durability. Due to the growing problem, biodegradable polymer products are introduced to the market. Therefore, it is necessary to conduct research on degradation products in order to estimate the risk arising from their presence in the environment. This paper discusses research on compounds that may potentially remain in the soil after the degradation of the double green PLA polymer. The aim of the research was to prove whether products made of PLA, e.g., packaging, films and other waste can release substances harmful to the environment. Therefore, soil was selected as a medium to characterize the substances potentially released from the polymer under conditions simulating the degradation process in the environment. The soil was always used from the same producer. Before the polymer biodegradation process, it was additionally checked for pH, C and N content, number of microorganisms, etc. PLA degradation in soil was carried out in a laboratory accredited by the Polish Accreditation Center (PCA). During the research, soil samples at various stages of the degradation process under laboratory conditions were subjected to both extraction in an aqueous environment and organic solvent extraction The studies used the gas chromatography coupled with mass spectrometry (GC/MS), as well as pyrolysis gas chromatography (Py-GC/MS). In addition, the study used the gel permeation chromatography (GPC/SEC) allowing to determine the distribution of molar masses, average molar masses and polydispersity, and the infrared spectroscopy (FTIR).

Keywords: biodegradation; hydrolytic degradation; soil; extraction; PLA; GC/MS; Py-GC/MS; GPC/SEC; FTIR

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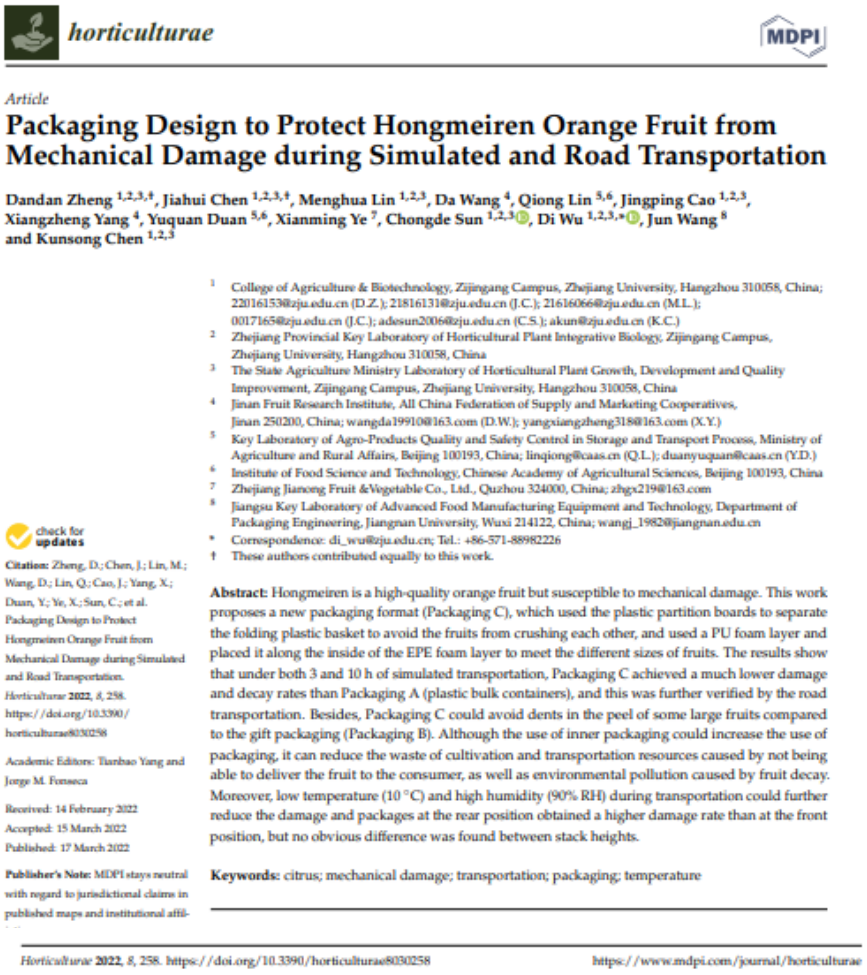
Design dell'imballaggio per proteggere la frutta arancione di Hongmeiren da danni meccanici durante il trasporto simulato e su strada

Hongmeiren è un frutto arancione di alta qualità ma suscettibile di danni meccanici. Questo lavoro propone un nuovo formato di imballaggio (Packaging C), che utilizza i pannelli divisori in plastica per separare il cestello di plastica pieghevole per evitare che i frutti si schiacciassero a vicenda, e utilizza uno strato di schiuma PU e lo posiziona lungo l'interno dello strato di schiuma EPE per soddisfare le diverse dimensioni dei frutti. I risultati mostrano che sotto entrambe le 3 e 10 ore di trasporto simulato, l'imballaggio C ha raggiunto tassi di danno e decadimento molto più bassi rispetto all'imballaggio A (contenitori di plastica alla rinfusa), e questo è stato ulteriormente verificato dal trasporto su strada. Inoltre, packaging C potrebbe evitare ammaccature nella buccia di alcuni frutti di grandi dimensioni rispetto alla confezione regalo (Packaging B).



horticulturae

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Article

Packaging Design to Protect Hongmeiren Orange Fruit from Mechanical Damage during Simulated and Road Transportation

Dandan Zheng [1,2,3,†], Jiahui Chen [1,2,3,†], Menghua Lin [1,2,3], Da Wang [4], Qiong Lin [5,6], Jingping Cao [1,2,3], Xiangzheng Yang [4], Yuquan Duan [5,6], Xianming Ye [7], Chongde Sun [1,2,3], Di Wu [1,2,3,*], Jun Wang [8] and Kunsong Chen [1,2,3]

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Citation: Zheng, D.; Chen, J.; Lin, M.; Wang, D.; Lin, Q.; Cao, J.; Yang, X.; Duan, Y.; Ye, X.; Sun, C.; et al. Packaging Design to Protect Hongmeiren Orange Fruit from Mechanical Damage during Simulated and Road Transportation. *Horticulturae* **2022**, *8*, 258. https://doi.org/10.3390/horticulturae8030258

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Abstract: Hongmeiren is a high-quality orange fruit but susceptible to mechanical damage. This work proposes a new packaging format (Packaging C), which used the plastic partition boards to separate the folding plastic basket to avoid the fruits from crushing each other, and used a PU foam layer and placed it along the inside of the EPE foam layer to meet the different sizes of fruits. The results show that under both 3 and 10 h of simulated transportation, Packaging C achieved a much lower damage and decay rates than Packaging A (plastic bulk containers), and this was further verified by the road transportation. Besides, Packaging C could avoid dents in the peel of some large fruits compared to the gift packaging (Packaging B). Although the use of inner packaging could increase the use of packaging, it can reduce the waste of cultivation and transportation resources caused by not being able to deliver the fruit to the consumer, as well as environmental pollution caused by fruit decay. Moreover, low temperature (10 °C) and high humidity (90% RH) during transportation could further reduce the damage and packages at the rear position obtained a higher damage rate than at the front position, but no obvious difference was found between stack heights.

Keywords: citrus; mechanical damage; transportation; packaging; temperature

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