목록

Study on heat-shrinkable poly(butylene adipate-co-terephthalate)/poly(propylene carbonate) blend film

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Abstract

This research addresses the urgent environmental issue of global plastic usage by focusing on the development of sustainable materials for shrink films, which are widely used in the retail sector and contribute significantly to waste. The study proposes an innovative solution that leverages the eco-friendly properties of biodegradable polymers, specifically PBAT and PPC, to create environmentally conscious shrink films. PBAT, a petroleum-based material, is chosen for its compostability, flexibility, and tunable strength, making it suitable for film applications. PPC, synthesized from carbon dioxide and propylene, not only reduces carbon footprint but also offers biodegradability. However, its limited strength and heat sensitivity pose challenges. This study suggests combining the advantageous properties of PBAT with PPC to produce a shrink film that is not only eco-friendly but also high-performing. By doing so, it contributes to the reduction of single-use plastics and supports the development of sustainable shrink films that align with environmental preservation efforts, highlighting a significant step towards mitigating plastic waste problems.

Key words: Poly(butylene adipate-co-terephthalate), Poly(propylene carbonate), Heat-shrinkable film, Bioplastic, Biodegradable plastic

Acknowledgement

Enhancing the oxygen removal rate for its application in food packaging through the impregnation of porous materials with the non-metallic oxygen scavenger sodium metabisulfite

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Abstract

The addition of oxygen scavengers to food products helps to reduce oxygen exposure, thereby mitigating deterioration, including changes in taste, odor, and color, as well as inhibiting microbial growth. Despite the advantages of the existing non-metallic oxygen removal materials in terms of safety for the human body and suitability for use in microwave ovens, their utilization has been limited due to their slow reaction initiation speed. Therefore, in the current study, sodium metabisulfite was impregnated into various porous media, including halloysite nanoclay, activated carbon, montmorillonite, and silica gel (SG). The oxygen scavenger, (SM/SG), produced by impregnating silica gel with sodium metabisulfite, demonstrated a 425% improvement in the initial oxygen removal rate compared to pure sodium metabisulfite. Additionally, sachets containing an oxygen-removing composition with an enhanced oxygen removal rate effectively decreased the oxygen concentration to less than 0.5% on the third day of storage in apple packaging, without elevating carbon dioxide levels. Moreover, it proved effective in preventing the browning of the apple surface. Therefore, the SM/SG oxygen-removal composition can be effectively applied to active food packaging by controlling the oxygen concentration within the packaging.

Key words: Food packaging, Active packaging, Non-metallic oxygen scavenger, Sodium metabisulfite, Porous material

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Development of an LSTM Model for Dynamic Forecasting of Quality Changes in Agricultural Products Based on Storage Environment History

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Abstract

Quality management in post-harvest handling is imperative, especially to minimize quality detriments during long-term storage. Property alterations resulting from environmental factors, microbial spoilage, and mechanical injuries significantly downgrade the quality of long-stored produce like onions. As such, there's a rising interest in predicting the quality changes of stored produce in real-time. Earlier studies mainly concentrated on static models for prediction, but dynamic predictive models reflecting the real-time changes in storage conditions are scarce. This study introduces an LSTM-based model designed to dynamically forecast the quality changes in long-term stored onions by utilizing the history of storage conditions. The LSTM model's proficiency in modelling time-series data demonstrates an effective pattern recognition even in complex scenarios. Data from different storage conditions were gathered and analyzed to establish the most accurate models for quality prediction. These models reliably predicted quality changes with about 5-6% error, up to three weeks ahead, reflecting environmental shifts during storage. Developed for the agricultural sector, this prediction model aims to enhance the sustainable management and optimization of storage environments, extending its applicability beyond agricultural products to other foods requiring long-term preservation.

Key words: onions, cold storage, physical property, recurrent neural network

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Development of Cold Chain Simulation Software for Temperature-Sensitive Products

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Abstract

Temperature management is essential to ensure the safety and quality of products in the food and pharmaceutical industry. Currently, cold chain simulation software users use products produced abroad. For foreign softwares, the results and actual measurements may differ because they do not take into account the distribution environment conditions of Korea.

In this study, domestic distribution and logistics environment data were collected to build a database. It derives a cold chain simulation function based on the database. we developed a software that can predict the expected temperature during transportation in consideration of various distribution environmental conditions considering distribution temperature in Korea. Since the cold chain simulation software was developed based on domestic distribution and logistics environment data, it can obtain results that are most similar to the actual value. This software can be used as an important tool for temperature management of the product to ensuring the safety and quality of the product.

Key words: Temperature controlled Logistics, Temperature sensitive packaging, Cold chain, Simulation software

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Carbon quantum dots-loaded metal-organic frameworks as a hybrid fluorescence turn-on/off sensor to detect hazardous materials

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Abstract

In this study, a hybrid fluorescence turn-on/off sensor was developed using citric acid-derived carbon quantum dots-loaded metal-organic frameworks (CD@MOF) for detection of hazardous materials. CD@MOF exhibits excellent fluorescence selectivity for 2-nitrophenol (2-NP), 4-nitrophenol (4-NP), and mercury (Hg^{2+}) among the various hazardous materials tested. In particular, CD@MOF can detect low concentrations of 2-NP, 4-NP, and Hg^{2+} of 1.03, 0.51, and 0.24 μM, respectively, through fluorescence quenching (turn-off). Additionally, ascorbic acid (AA) can be detected by selectively recovering (turn-on) the fluorescence of CD@MOF. The fluorescence stability of CD@MOF remains excellent and unaffected by external environments such as storage time, NaCl concentration, and UV exposure period. Although the degree of fluorescence emission of CD@MOF can vary with pH, sensor response (turn-off) to 2-NP, 4-NP, and Hg^{2+} remains largely constant in the pH range of 1–13. These findings highlight the promising potential of CD@MOF as a versatile and selective sensor platform for environmental monitoring and hazard detection.

Key words: carbon quantum dots; metal-organic frameworks; hybrid fluorescence turn-on/off sensor; hazardous materials

Acknowledgement

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Red pepper waste-derived carbon dots embedded sodium alginate/gelatin composite films for bioactive fruit preservation

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Abstract

Designing cost-efficient and eco-friendly packaging films with multifunctional features such as antimicrobial, antioxidant, and UV protection is an important factor in food science and engineering fields. Red pepper waste-derived carbon dots (RC-CDs) have been used as reinforcements and active components in fabricating advanced packaging materials. The synthesized spherical RC-CDs (average diameter: 2.5 nm), containing abundant active groups (-NH2, -OH, etc.), exhibited significant UV absorption, antioxidant, and antimicrobial activities. A simple solution casting method was used to load 1, 2, and 3 wt% of RC-CDs into a sodium alginate/gelatin (SA/Gel) polymer matrix. Good compatibility and probable hydrogen bonding between RC-CDs and matrix were confirmed by SEM images and FT-IR & XPS analyses. UV barrier, ABTS radical scavenging, and *L. monocytogenes* bactericidal properties of the composite films were increased by 99.1 %, 80.7 %, and 95.1 %, respectively, with the addition of a 3 wt% RC-CDs. Fruit preservation results showed that the prepared SA/Gel/RC-CD$^{3\%}$ composite film maintained the physiological qualities of grapes post-harvest and extended their storage life. Overall, the manufactured SA/Gel/RC-CD composite films can be recommended to develop innovative active food packaging.

Key words:

Carbon dots, Red pepper waste, Antimicrobial, Fruit preservation.

Acknowledgement

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단일, 복합 또는 첨가제가 함유된 혼합 생분해성 수지의 재질 동등성 확인을 위한 시험방법 표준화 연구

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Abstract

급증하는 플라스틱 폐기물에 의한 환경오염 문제가 발생함에 따라 환경오염 문제를 개선할 수 있는 생분해성 수지에 대한 사회적 관심 및 사용이 증가하고 있는 추세이다. 생분해성 수지의 시장 규모와 경쟁력은 증가하고 있으나, 물리화학적 특성을 충족시키기 위해 2종 이상의 생분해성 수지를 혼합한 복합수지로 제조하는 경우가 많아 각각의 수지 재질에 대한 생분해성 시험을 실시하여 구성 재질이 생분해성 수지임을 확인할 경우 과도한 비용과 시간이 소요되고 있다. 이에 본 연구에서는 2종 이상의 생분해성 수지로 이루어진 복합 재질을 보다 편리하게 확인할 수 있는 시험방법을 표준화하고자 하였다. 생분해성 수지 원료로는 PLA, PBAT, PBS, PCL 및 TPS를 선정하였다. 이는 시장 유통량을 확인하였을 때 PBAT(48.1 %), PLA(46.9 %), PBS(3.7 %) 및 PCL(1.2 %) 순으로 사용 비중이 높았으며, 열가소성 전분 수지인 TPS를 추가하였다. 시험방법으로는 FTIR 및 DSC를 이용해 1차적으로 생분해성 수지 재질을 확인하고, Py-GC-MS를 이용해 2차 확인을 하였다. FTIR 분석에 따르면, PLA 수지는 C-H, C=O, CH_2, C-OH 피크가 관찰되었으며, PBAT 수지는 C-H, C=O, C-O, C-H phenyl 피크가 관찰되었다. DSC 분석에 따른 열전이온도는 각각 PLA 수지는 약 152.7℃, PBAT 수지는 약 123.7℃, PBS 수지는 약 116.7℃, PCL 수지는 약 67.9℃로 나타났으며, TPS는 어떠한 열적 특정도 나타나지 않아 PLA, PBAT, PBS, PCL 4종의 수지에 대해 상대표준편차(RSD)는 (0.4~1.4) % 범위로 나타났다. 이러한 단계적 시험방법을 표준화함으로써 생분해성 수지 재질만을 사용했는지 판단하기 어려울 수 있는 문제를 극복할 가능성을 보였다. 더불어, 기존 생분해도 시험(KS M ISO 14855-1)은 시간과 비용이 많이 소요되지만, 이 방법을 통해 저비용으로 단기간에 기존 생분해성 수지와 동등한 재질인지를 입증하는 방법으로 활용될 것으로 전망된다.

Key words:

생분해성 수지, 생분해성 플라스틱, 포장재, 친환경 포장

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Characterization of poly(butylene adipate-co-terephthalate)/thermoplastic starch/ascorbic acid-derived carbon quantum dots composite films

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Abstract

Ascorbic acid-derived carbon quantum dots (A-CQDs) were synthesized by hydrothermal method. A-CQDs were characterized by Fourier-transform infrared (FT-IR) spectroscope, UV-visible spectroscope, and Photoluminescence Spectroscopy (PL). FT-IR graph shows the disappearance of the functional C=O group at 1750 cm^{-1} and the O-H stretching group at 3000-3600 cm^{-1}. A-CQDs exhibited intense blue luminescence under UV excitation at 365 nm. In addition, A-CQDs were added to provide multifunctional properties such as antioxidant and antibacterial properties. The synthesized A-CQDs showed excellent antioxidant activity with radical scavenging rates of 72.34% and 94.71% for ABTS and DPPH assays at 25 μg/mL. A-CQDs also showed strong antimicrobial activity against Gram-positive *Staphylococcus aureus* and Gram-negative *Salmonella enterica*. Poly(butylene adipate-co-terephthalate) (PBAT) and thermoplastic starch (TPS) were blended to prepare composite films using a twin-crew extruder. Different concentrations of A-CQDs were incorporated into the PBAT/TPS blends and their mechanical, optical, and functional properties were investigated.

Key words:

Ascorbic acid, Carbon quantum dots, Antioxidant, Antimicrobial, PBAT/TPS blend

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Poly (vinyl alcohol)/gelatin-based functional films incorporated with natural triphala carbon dots for food packaging applications

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Abstract

In the present work, the natural carbon dots (CDs) were prepared using triphala powder precursors by a simple one-step hydrothermal method. The prepared CDs was characterized by UV-visible spectroscopy, fluorescence spectroscopy, Fourier-transform infrared (FT-IR) spectroscopy, high-resolution transmission electron microscopy (HR-TEM), and X-ray photoelectron spectroscopy (XPS). HR-TEM analysis showed that CDs are spherical shape with an average size of ~ 5.5 nm. CDs exhibited excellent photophysical property and photostability at different physiological conditions. CDs showed bright blue fluorescence at 434 nm upon excitation at 360 nm. Poly (vinyl alcohol)/gelatin (PVA/Gel)-based functional films were prepared by incorporation of CDs and applied as a packaging film to extend shelf life of chicken. The antibacterial activity of CDs against *Listeria monocytogenes* and *Staphylococcus aureus* was evaluated by measuring the growth curve and cell viability after exposure of bacteria. The chicken meat packaged with PVA/Gel/CDs composite films showed less bacterial growth and maintained the color of the meat. PVA/Gel/CDs composite films also showed excellent functional properties such as antioxidant, antimicrobial and UV-barrier properties and extend the shelf life of chicken meat. Therefore, PVA/Gel/CDs composite films showed a great potential as an active food packaging for extending shelf life and preserving the visual quality of packaged meat.

Keywords: Carbon dots; antibacterial; antioxidant; active packaging

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Detection of External Defects on Apple Fruits Based on Semantic Segmentation Deep Learning Models

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Abstract

External defects on apple fruits such as bruises and wounds are major factors that compromise the quality and storability of apples. Because of this, accurately identifying the external defects is critical in the postharvest sorting process of apples. However, these external defects are being sorted manually in most of current agricultural products processing centers (APCs), which has limitations in terms of accuracy and efficiency. In this study, an automatic sorting technology based on RGB images of apples with a deep learning method was developed. An RGB image dataset of Fuji apples was constructed with four types of representative external defects which are cracks, bruises, diseases, and scars. With the dataset constructed, four types of deep learning semantic segmentation models were trained and evaluated to identify the defect regions on apples. As a result, not only the presence of defects but also the type and severity were identified. By identifying the type and severity of each defect, a method to sort defective apples based on multiple levels of severity criteria was suggested.

Key words: Apple, Defect, Sorting, Deep learning, Semantic segmentation

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양파 수출시 포장 방법별 적재 방법 개선

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Abstract

양파 수출 시 적재 방법을 관행의 가대기 작업에서 팔렛트 작업으로 개선함으로써 유통 효율화 방안을 제시하고자 하였다. 양파 수출을 위한 적재는 리퍼컨테이너에 인력으로 가대기 작업이 이루어지고 있는데, 인력작업은 시간이 많이 소요되고 작업과정에서 압상의 우려가 있어, 개선이 요구되고 있다.

본 연구에서 효과적인 팔렛팅 작업을 위하여, 양파 포장법(망 포장과 종이 박스 포장)에 대한 적재 방법을 검토하였다. 망 포장은 파렛트 위에 양파를 인력으로 쌓으면 적재 폭이 불균일하고 적재된 양파망의 폭이 넓어 리퍼컨테이너에 안에 끼어 전혀 싣지 못하게 된다. 또한 상차시 양파간의 협착으로 부딪히거나 쓸림으로 인한 압상이 발생하였다. 따라서 양파 망포장의 효율적 팔렛트 적재를 위해서, 팔렛트의 폭을 줄이고, 지게차 작업 방향의 유도 방법을 강구하였다.

본 연구에서 망 포장의 활용 방법은 양파를 적재 시 제작한 팔렛트 틀을 이용하고, 적재 폭을 좁히기 위해 옆면에 골판지나 판넬들을 덧대어 양파 망이 쌓이는 폭을 줄였다. 이러한 적재 방법은 좌우 폭은 좁힐 수 있으나 앞면이 튀어 나와 적재 방향을 혼동 할 우려가 있다. 이러한 지게차가 적재 시 실수를 예방하기 위해서 적재된 망 앞에 커다란 라벨지 등을 부착하여 지게차의 포크가 들어오는 작업 방향을 표시하였다.

종이 상자에 양파를 포장하여 적재 시에는 하중으로 인해 박스 아래 부분이 붕괴되면서 내부에 압상 발생 우려가 있다. 종이박스 포장에 의한 적재방법 개선은 상자 적재 시 각대를 네 모서리에 덧대어 균형적인 적재가 되도록 함으로써 상자의 하부 파손을 방지 할 수 있었다.

본 방법을 싱가포르에 양파 수출시 적용하였는데, 기존의 수출 방법은 압상 등으로 인한 손실이 5~7% 정도 발생하였으나, 개선 방법을 적용하여 수출 한 결과 압상 피해가 전무하였으며, 판매 시 호평을 받았다. 제시한 포장별 적재 방법의 개발 기술을 활용하여, 양파 수출 시 물류 효율화를 꾀할 수 있었으며, 상품성 향상으로 한국 농산물의 이미지 상승과 수출에 기여할 수 있을 것으로 나타났다.

Key words: 양파, 적재, 포장방법, 망, 종이박스

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Utilizing Microwave Synthesized Carbon Quantum Dots for Enhancing the Properties of PET

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Abstract

Carbon Quantum Dots (CQDs) has garnered significant interest in recent years due to their unique properties, including high UV-blocking capabilities and low toxicity. This makes them a promising candidate for the use in packaging applications. For packaging applications, the incorporation of CQDs into non-aqueous polymers such as polypropylene (PP) and polyethylene terephthalate (PET) are being explored. We have synthesised CQDs using citric acid in acetone, and then incorporated into PET using a spray coating method wit various concentrations (0%, 0.1%, 0.3%, 0.5%, and 0.7%) to improve dispersibility. The CQDs/PET composite films were prepared using a hot-press process. The synthesised CQDs was evaluated using UV-visible spectroscopy, PL and TEM while CQDs/PET composite film was analysed using FTIR, DSC, UV-Vis, OTR, and XRD measurements to understand their chemical, thermal, and UV-blocking properties. We observed that the UV-blocking properties of the PET film containing 0.7% CQDs were significantly enhanced, with a 50% reduction over pure PET. Furthermore, an improvement in the gas barrier characteristics was noted, as demonstrated by the lower OTR value of 20 g/mm²·day at 0.1% CQDs as opposed to 41 g/mm²·day for pure PET. These results demonstrate how CQDs/PET composite films can be used in packaging, particularly in sectors where improved UV-blocking qualities are crucial.

Key words: CQDs, PET, UV-blocking, Citric Acid, Microwave

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Effect of Sebacate Content on Soil Degradation of Poly(butylene sebacate-co-terephthalate)

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Abstract

In this study, poly(butylene sebacate-co-terephthalate) (PBSeT) copolyesters were synthesized through a two-step process of esterification and polycondensation using 1,4-butanediol (BDO) and sebacic acid (Se) derived from natural resources, along with dimethyl terephthalate (DMT). The aim of this study is to evaluate the soil degradation of PBSeT according to sebacic acid content. The mechanical and thermal properties, and water contact angle were measured, and visual inspection and remaining weight analysis were conducted to assess soil degradation behavior. A series of PBSeT copolyesters was synthesized with Se content ranging from 40 to 55 % relative to the total diacid. As the Se content increased, the tensile strength decreased from 37.1 to 23.2 MPa, while the elongation at break increased from 680 to 866 %. Both the Tg and Tm of PBSeT decreased linearly with increasing Se content, as the influence of the benzene ring in DMT decreased, resulting in increased molecular mobility within the polymer. Under soil degradation conditions, it was observed that a PBSeT copolyester containing 55 mol% Se underwent degradation through microbial action and hydrolysis, resulting in the formation of holes and exhibiting a weight loss of 17.7 % over a period of 20 weeks. The increase in DMT content leads to linear enhancements in both mechanical and thermal properties of PBSeT copolyesters due to the incorporation of the benzene ring, while the delay in soil degradation is attributed to the increased water contact angle and crystallinity, as well as the bulky and rigid structure of the aromatic chain, hindering the attack on the ester groups near the terephthalic acid. In conclusion, PBSeT copolyesters need to contain approximately 55 mol% of Se content to exhibit significant changes in soil degradation, anticipating their potential as eco-friendly flexible packaging applications.

Key words: Biodegradable polyester, Soil degradation, Water contact angle

Synthesis of calcium oxide (CaO) and calcium peroxide (CaO_2) from eggshell wastes and their applicability to antimicrobial packaging

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Abstract

When calcium peroxide (CaO_2) reacts with water, it produces calcium hydroxide ($Ca(OH)_2$) and releases hydrogen peroxide (H_2O_2), and oxygen (O_2). CaO_2, a relatively stable solid form, has been attracting attention as a potential substitute for liquid H_2O_2. To produce CaO_2 more effectively and eco-friendly, several approaches have been tested and implemented over time. These methods aim to optimize the synthesis process and improve the overall efficiency of CaO_2 production. In this study, we have prepared an eco-friendly antimicrobial agent (CaO and CaO_2) from eggshell wastes using a simple process and assessed its suitability for antimicrobial packaging. CaO and CaO_2 were characterized using FT-IR, XRD, TGA, and SEM, and the H_2O_2 release behavior was also investigated. The antimicrobial activity was comparatively evaluated using the disk diffusion method. The inhibition zone of CaO_2 was approximately 1.5 to 2 times higher than CaO, which is known as a potent antimicrobial agent. Additionally, significant inactivation of microbial growth was observed in EVOH/CaO_2 films compared with EVOH/CaO. Overall, the findings of the study have significant implications for the potential use of eggshell waste in producing high-value materials and for developing novel antimicrobial agents for various applications. It also suggests that CaO_2 can be used as an antimicrobial agent for packaging materials to prevent the growth of harmful bacteria.

Key words:

Eggshells; Calcium peroxide (CaO_2); Calcium oxide (CaO); Antimicrobial packaging agent

Acknowledgement

This work is supported by Korea Institute of Planning and Evaluation for Technology in Food, Agriculture, Forestry and Fisheries (IPET) through (High Value-added Food Technology Development Program), funded by Ministry of Agriculture, Food and Rural Affairs (MAFRA) (grant number 321048043HD030).

Development of the edible coating system for Korean Ginseng to maintain its quality

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Abstract

The global ginseng market for Korean ginseng (*Panax ginseng*) is growing significantly due to its pharmacological effects from ginsenoside (ginseng saponin), which is effective in the central nervous system, immune system, etc. However, the exportation of ginseng has been faced up to an issue owing to the moisture loss during the storage. Moisture loss during storage is the main factor that reduces its marketability because ginseng is sold by weight. To prevent the moisture loss from storage while exportation, cold-chain system usually selected. However, cold-chain systems require a lot of energy and increase the cost, which has created challenges for low price competitiveness for decades. To overcome these issues, edible coating system applied in this study. Edible coating system can form a physical barrier on the surface of food product to reduce the moisture loss against external environmental factors. In this study, Ginseng was coated with a composite edible coating emulsion consisting of beeswax (BW), which gives moisture barrier properties to the solutions, and cellulose nanocrystals (CNC), which improve the stability of the emulsion and the mechanical properties of the coating layer. The weight loss rate of non-coated and coated samples during the storage was measured to check the moisture barrier properties of the coating. As a result, it was confirmed that the storage properties at room temperature (RT: 25°C, 60% RH) could be compared with the refrigerated temperature (CT: 4°C, RH uncontrolled) for 4 weeks. Moreover,

the CNC/BW composite edible coating emulsion shows about 1.9 times lower moisture loss rate under both storage conditions. Notably, comparing the moisture loss rate between the coating samples stored at RT (7.05%) and the control samples stored at CT (5.89%) shows that the coating can provide about the same level of moisture evaporation prevention as refrigerated storage at room temperature. Therefore, the suggested edible coating system has the potential to reduce energy and costs required to maintain the cold-chain and contribute to upcycling of food by-products and food waste reduction.

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Key words:
Edible coating, cellulose nanocrystal, beeswax, ginseng, quality

Antibacterial coating system on stainless steel with *N*-halamine structures using sesame oil meal protein

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Abstract

Microbial cross-contamination is a significant challenge in processing fresh produce. An antibacterial coating system has been identified as a potent strategy to mitigate this issue. Our research team selected an *N*-halamine structure to create a robust antimicrobial coating on food contact surfaces. To formulate this coating, we utilized sesame meal to produce protein materials that supply the *N*-halamine structure. We extracted Sesame meal-based Protein Isolate (SPI) via an acid-alkali precipitation method from sesame meal, achieving approximately a 10% (w/w) yield and over 90% purity. Employing SPI and sodium hypochlorite (NaOCl), we developed an antimicrobial coating for stainless steel, which was applied via spraying. Fourier Transform Infrared Spectroscopy (FT-IR) analysis confirmed the successful formation of the *N*-halamine structure. Moreover, 4.92 μmol/cm^2 of free chlorine was detected following chlorination with 2% NaOCl. *Escherichia coli* O6 (ATCC 25922) was utilized to assess the antimicrobial activity. We found that this activity was directly proportional to the free chlorine content. After a 30-minute contact with the coated surface, we observed a 4-log reduction in 6 log CFU/mL. Overall, the antimicrobial coating developed in this study exhibits potential as a sustainable solution with significant antimicrobial properties, aiming to reduce the risk of microbial cross-contamination in fresh food processing.

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Key words:

Antimicrobial activity, cross-contamination, fresh product processing, sesame meal-based protein isolate

Mechanical and Thermal Properties of Recycled Polyethylene Reinforced with Polyolefin Elastomers and Antioxidants

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Abstract

Polyolefins are extensively utilized polymers, yet their recycling is hindered by degradation occurring during reprocessing. In this study, to enhance the properties of recycled polyethylene (rPE), varying amounts of polyolefin elastomers (POE) and antioxidants were introduced, followed by an investigation into their mechanical and thermal properties. As a result, the incorporation of POE and antioxidants led to improvements in impact strength, elongation at break, and melt index, and some rPE/POE/antioxidants composites exhibited properties surpassing virgin materials. Subsequently, the recycling stability of the rPE/POE/antioxidants composites was confirmed through 5 cycles of simulated mechanical recycling via extrusion. The results indicated that the introduction of POE and antioxidants reduced the degradation of PE properties during repeated extrusion cycles, a crucial aspect for closed-loop recycling.

Key words: Plastic recycling, Recycled polyethylene, Simulated mechanical recycling, Closed-loop

Acknowledgement

This study was supported by the project 'Development of plastic recycling materials for carbon neutrality and development of ultra-light foldable multi-use containers for logistics' of the Korea Institute of Industrial Technology, grant number JB240006.

Impact of cellulose dimensions on the properties of thermoplastic starch composites

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Abstract

Thermoplastic starch (TPS) is increasingly recognized as a promising solution for sustainable and biodegradable materials in various applications. In this study, we investigate the impact of filler dimensions on inducing crystalline types during the gelatinization and retrogradation processes of TPS. Through systematic variation of cellulose dimensions by acid hydrolysis while maintaining other formulation parameters constant, the change in the ratio of two types of TPS crystalline structures induced by the cellulose dimensions was confirmed through X-ray diffraction (XRD) analysis. Differential scanning calorimetry (DSC) results revealed the melting temperature for each sample, reflecting the type of chains constituting the derived crystalline structures. Controlled adjustment of cellulose dimensions led to improvements in the toughness of TPS composites and enhanced resistance to moisture. Analysis of the induced crystalline types according to filler dimensions and their associated properties enables precise tailoring of TPS composite properties that meet various application requirements.

Key words: Thermoplastic starch, Cellulose, Green composites, Crystalline structure

Nanoclay Composite Coating Materials with Different Size for High Oxygen Barrier Properties

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Abstract

The design and fabrication of oxygen barrier films is important for both fundamental and industrial applications. One approach to improve the barrier properties of thin films is to apply a coating layer containing two-dimensional nanosheets, thereby creating a tortuous path for molecular transport and reducing diffusion through the film. Nanoclay, which is widely used as a nano-filler for film coating, is a layered alumina-silicate clay minerals. It consists of two silica tetrahedral sheets fused to an edge-sharing octahedral sided sheet of aluminum hydroxide, with a layer thickness of 0.96 nm and lateral dimensions in the range of 100-1000 nm.

For enhancing oxygen barrier property of the LDPE films, the nanoclay composite coating materials composed of montmorillonite (MMT) and laponite (LN), a typical low cost inorganic clay, with the MMT/LN weight ratios of 3/1, 4/1, 5/1, 10/1 and 20/1 were applied on the substrate. The films with MMT/LN = 5/1 sample exhibited high oxygen barrier property reached 2.275 cm^3/m^2.day.atm, which was caused by forming more complex tortuous path with different size clay composite materials.

Key words: Nanoclay, Coating, Different size, Oxygen barrier

Acknowledgement

Different crosslinking effects of salt ions in thermoplastic starch and TEMPO-oxidized cellulose nanofiber nanocomposites films

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Abstract

Thermoplastic starch (TPS) and TEMPO-oxidized cellulose nanofiber (TOCNF) exhibit excellent compatibility due to their similar chemical structures, leading to extensive research in developing new composites films by combining them. In this study, with high compatibility of TPS and TOCNF, we used various salt ions of the carboxyl group of TOCNF as crosslinking agents to induce interactions between the two materials. The content of TOCNF was fixed at 3 wt%, and the TPS/TOCNF composites were produced by varying the type of ions added in the melt blending process. The addition of TOCNF increased the viscosity of the matrix, indicating an enhanced crosslinking effect due to salt ions, as confirmed by torque data. The quantity of charge associated with each ion influences the structural density of the TPS/TOCNF composite network, thereby affecting the mechanical properties of the TPS/CNF composites.

Key words: Thermoplastic starch, Cellulose nanofiber, salt ions, crosslinking agent

리싸이클러블 고차단성 폴리올레핀 UNI 소재 기반 포장재의 레토르트 식품 적용성 평가

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한국식품연구원

Abstract

레토르트 식품 포장재는 식품을 장기 저장하는 동안 품질이 유지될 수 있도록 각 기능의 여러 필름을 적층하여 고차단성 및 내열성 등의 우수한 특성을 갖추고 있어야 한다. 그러나, 이종의 필름으로 적층이 된 다층포장재는 포장재질간의 분리가 쉽지 않아 재활용이 어려운 실정이다. 이에 따라 본 연구에서는 본 연구팀이 개발한 재활용이 가능한 폴리올레핀 UNI 소재 기반 포장재가 식품 포장재로 적용 가능한지 확인하였다. 개발된 UNI 포장재(Uni)의 레토르트 적합성을 확인하기 위하여 시판되고 있는 레토르트용 PET 포장재(PET), Al 증착 포장재(Al)와 비교하여 파손률을 측정하였다. 레토르트 조건인 121℃, 15분에서 UNI는 PET, Al과 같이 파손율이 0%로 나타나 레토르트 포장재로서 적합함을 확인하였다. 포장재 내부에서 식품의 품질변화는 대상 식품을 유부로 선정하여, 저장온도와 저장기간별로 과산화물가, 산가 등을 측정하여 평가하였다. 20℃에서 저장한 유부의 과산화물가 측정 결과, 레토르트 직후의 UNI는 7.5±0.1 meq/kg oil, PET는 7.3±0.1 meq/kg oil로 유의적인 차이가 없었으나, Al은 6.4±0.1 meq/kg oil로 유의적으로 낮게 나타났다. 저장기간이 길어짐에 따라 UNI는 PET에 비해 낮은 수치를, Al에 비해서는 높은 수치를 나타내었다. 이러한 경향은 저장 온도가 높을수록 두드러지게 나타났다. 산가 측정 결과는 PET 》 UNI ≥ Al 순으로 나타났으며, 이는 과산화물 측정 결과와 같은 경향을 보여주었다. 본 실험 결과, UNI는 Al에 비해서는 다소 낮지만, PET에 비해 식품의 산패 억제 효과 및 우수한 기체 차단 효과를 보여주었다. 이를 통해 개발된 UNI는 레토르트 식품포장재로서 적용 가능함을 확인하였다.

Key words:

리싸이클, 고차단성, 폴리올레핀 Uni 소재, 친환경 포장재, 레토르트 식품 포장재

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The Effect of Hollow Glass Microsphere on Thermal and Mechanical Properties of PBAT-g-MAH/Kenaf Composite

이름

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Abstract

Poly(butylene-adipate-co-terephthalate) (PBAT) is one of widely used biodegradable polymers with high ductility while its high cost and low stiffness limit its application in packaging industry. In our previous study, the composite system with Kenaf fiber in PBAT matrix was found to be a good solution to overcome these drawbacks. The low interfacial adhesion between the hydrophobic polymer matrix and the hydrophilic fiber was improved by modified PBAT with maleic anhydride (MAH). However, the poor dispersion of kenaf fiber in composite resulted in decreased mechanical properties. The good dispersion of fiber is an important factor in determining appropriate properties of composite. In this research, the hollow glass microsphere (HGM) was incorporated into the PBAT/Kenaf fiber composite to enhance Kenaf fiber dispersion by formation of the syntactic foam. The effect of optimal content of HGM on the dispersion state of Kenaf fiber on morphology, thermal and mechanical properties was investigated. The binary filler system with Kenaf fiber and HGM on PBAT-g-MAH was effective to generate an unique performance such as reduced density and improved stiffness, making it be applicable to various industrial fields.

Key words: Poly (butylene adipate-co-terephthalate), Kenaf fiber, Hollow glass microsphere (HGM), Reactive modification

Acknowledgement

This work was supported by the Technology Innovation Program (20015894) funded by the Ministry of Trade, Industry & Energy (MOTIE, Korea)

Biodegradability of poly(butylene-co-isosorbide sebacate) copolyester in compost and agricultural soils

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Abstract

As environmental pollution problems caused by non-degradable plastics become increasingly serious, research on biodegradable plastics has received much attention as an alternative. However, commercial biodegradable plastics such as PLA, PBAT, PBS have faced criticism for their unsatisfactory degradation rates in open environments. In this context, poly(butylene-co-isosorbide sebacate) (PBISe), a new biodegradable polyester synthesized from renewable resources and capable of accelerated degradation, has been developed. PBISe copolyesters with 0-30mol% of isosorbide (IS) have been successfully synthesized and evaluated for their degradation performance under soil and compost conditions. It was observed that the degradation rates under soil and compost conditions increased with the IS content in PBISe copolyesters. In compost conditions, samples with a thickness of 200 μm completely degraded within five weeks due to the low melting point of PBISe (<65.2°C). Notably, when the IS content exceeded 14 mol% under soil conditions, a weight loss of over 50% was observed within eight weeks. A study on the degradation performance of PBISe under soil and compost conditions has been reported for the first time, and it is expected to offer a viable option for biodegradable plastic materials requiring a rapid degradation rate in such environments.

Key words: PBISe, Isosorbide, Bio-based, Degradation, compost, Soil

Analysis of Hazardous Heavy Metals in Metal Camping Cooking Utensils

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Abstract

Recently the camping population has increased due to changes in leisure life by COVID-19. Accordingly, the supply and demand of camping cooking utensils are also increasing but safety verification of camping cooking utensils is insufficient. When camping, campers often drink, talk and eat for a long time, so cooking utensils come into contact with fire for a long period of time. Therefore hazardous substances may migrate from food contact materials into food. In this study, the amounts of migrated heavy metals from pots, kettles, skewers, grills were analyzed by reflecting cooking condition while camping. Migration time varied from 30 minutes to 2 hours. Water, 0.5% citric acid and 4% acetic acid were used as migration simulants. 15 heavy metals including Pb, Cd etc. were analyzed with ICP-OES and Cr6+ was analyzed with UV spectrophotometer. The detection levels did not exceed the standards and specifications for metal utensils, so domestic camping cooking utensils were evaluated as safe to use for cooking.

Key words: Camping cooking utensils, Heavy metal, Usage patterns

Acknowledgement

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Effect of recycled paper pulp on the phase change duration of Water

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Abstract

Phase change materials (PCMs) are substances that can store and release a lot of heat energy while maintaining a certain temperature in cold chain system. To maintain temperatures around 0°C, PCMs can use pure water or water mixed with super absorbent polymers (SAP). However, pure water can't maintain temperature for long enough, and water with SAP may be harmful to the environment. In this paper, we have used recycled paper pulp (1-5% by weight) as an alternative, because it enhance temperature duration while offering environmental benefits. The effect the recycled paper pulp on the thermal and chemical properties of water as a PCM were analyzed using differential scanning calorimetry (DSC), data logger, and Fourier transform infra-red spectroscopy (FT-IR). The results revealed that by adding 3% recycled paper pulp to water, the duration of temperature retention increased by 70 minutes compared to pure water. This suggests that recycled paper pulp has the potential to serve as an effective and environmentally friendly alternative to SAP in PCMs, offering improved temperature stability while addressing concerns about sustainability and environmental impact.

Key words: Thermal energy storage, Phase change materials, Recycled paper pulp, Cold chain system

Acknowledgement

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The Effects of PBO on the Mechanical and Thermal Properties of PGA by chain extension

이름

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소속

계명대학교

Abstract

Polyglycolic acid (PGA) is getting a great attention as a substitute material for some of petroleum based plastics in packaging field due to its excellent barrier properties and high biocompatibility. However, low melt strength of PGA leading to thermal degradation presents challenges for its wide applications in the packaging industry. Recently, various studies have been conducted to improve the melt strength of PGA using a chain extender. 2,2'-(1,3-Phenylene)bis-2-oxazoline (PBO) is commonly used as a chain extender for polymers with carboxyl end groups. This carboxyl groups of PGA could react with PBO indusing a ring-opening reaction and formation of ester amide groups. In this study, PBO was introduced in PGA with various contents to improve the low thermal stability through melt processing using an internal mixer. The effect of PBO as a chain extender and the mechanical and thermal properties of modified PGA were investigated.

Key words: Polyglycolic acid, 2,2'-(1,3-Phenylene)bis-2-oxazoline, Chain extension, Processibility, Oxygen barrier

Acknowledgement

This research was supported by Korea Institute of Marine Science & Technology Promotion (KIMST) funded by the Ministry of Oceans and Fisheries (RS-2021-KS211537)

Monitoring of overall migration and volatile compounds content from food contact rubber

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Abstract

Rubber has been widely used in food containers and utensils because of its various properties such as heat-resistance and flexibility. In Korea, these rubbers in contact with food are regulated by 'Standards and Specifications for Utensils, Containers and Packages' established by MFDS. The overall migration is the key specification which should be under 60 mg/L except rubber nipples. For rubber nipples, the overall migration is regulated under 40 mg/L, and the volatile compounds content should be under 0.5%.

In this study, the overall migration was analyzed from food utensils made of various types of rubber. A total of 130 samples including 5 natural rubbers(NR), 120 synthetic rubbers(SR), and 5 thermoplastic elastomers(TPE) were collected from local markets.

As a result, the overall migration was ranged from 0.0 to 52.0 mg/L for NR, from 0.0 to 17.0 mg/L for SR, and 0.0 mg/L for TPE. In terms of items, the overall migration was 0.0 to 52.0 mg/L for the rubber products and 0.0 to 4.50 mg/L for the rubber nipples. Additionally, the volatile compounds content of 18 rubber nipples was analyzed 0.14 to 0.46%. Through this study, we confirmed the level of overall migration and volatile compounds content from the rubber utensils in current market are as low as to meet the standards.

Key words: Food contact rubber, Overall migration test, Volatile compound content

Acknowledgement

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CO_2 흡수 하이드로겔 일체형 포장재의 생산기술 개발

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초록

김치 산업은 2010년 8천억 원이었던 시장 규모에서 2022년 1조 5천억 원의 규모로 크게 성장하였고, 그 성장세는 앞으로도 지속될 것으로 예상된다. 이는 김장을 더 이상 하지 않고 포장김치를 사 먹는 세대문화가 정착 및 확대되었기 때문이다. 이러한 시장의 성장 속도에 비해 현재 문제가 되는 포장김치의 유통 중 팽창에 따른 제품의 반품·폐기 및 소비자의 구매 기피 현상은 완전히 해결되지 않고 있다. 이에 본 연구는 김치 포장재의 한쪽 측면 전체를 샌드위치 패널 구조로 설계하여 해당 공간에는 CO_2 흡수 소재를 삽입·도포 하는 새로운 포장재를 개발하여 기존 대비 효과적으로 팽창 방지 기능을 구현하고자 하였다. 특히 이에 대한 대량 생산성을 확보하고자 제대설비에서 샌드위치 패널용 삽입지 투입장치, 횡/종 실링의 전 단계에서 하이드로겔을 투입하는 장치 개발 및 생산기술을 연구하였다.

전체 공정 과정은 투입된 원단과 삽입지를 실링 후 원단과 삽입지 사이 중심부에 액상을 삽입 및 도포하여 하단 스탠드 원단 부착, 파우치형의 봉투로 제작된다.

포장재 시제품에 대해 김치 400g, 10℃ 조건에서 30일 동안 저장실험을 수행한 결과, 팽창된 제품은 관찰되지 않았다.

키워드: 이산화탄소 흡수, 김치, 팽창 방지, 이중구조, 액티브 포장재

감사의 글

이 연구는 김치 플라스틱 포장재 사용 절감을 위한 CO2 흡수 하이드로겔 적용 포장재 개발인 연구 과제명으로 2023년~2024년 농림식품기술기획평가원의 연구비 지원으로 진행되었다. (123001-02 / 연구 과제번호)

Identifying problems and direction in urban logistics standardization

이름

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Abstract

Urban logistics is the key to the efficient transportation and delivery of goods and resources in modern urbanized societies. It mainly refers to the process of organizing and managing the flow of goods and resources within cities to support urban life and promote economic development through efficient transportation, storage, and delivery. In other words, urban logistics is becoming increasingly important due to the growth of urban populations and changes in consumption patterns. As a result, urban logistics is being discussed in terms of efficiency, sustainability, and environmental protection.

As a result, urban logistics is an important element that is central to logistics activities in urbanized societies. However, it faces challenges such as traffic congestion, environmental pollution, and space constraints. Therefore, through the establishment of urban logistics standardization, we aim to improve the efficiency and sustainability of urban logistics by providing solutions such as the introduction of intelligent transportation systems, the expansion of eco-friendly transportation, and the construction of next-generation logistics facilities.

Key words:

Urban Logistics / Transportation / Systems / Delivery / Standardization

Acknowledgement

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Controlled release of staphylococcal phage from pectin-poly(butylene adipate-co-terephthalate) bilayer film in response to bacterial contamination

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Abstract

There is a growing interest in designing novel eco-friendly packaging due to emerging environmental pollution concerns. This study aimed to develop a new antibacterial bilayer packaging using pectin and poly(butylene adipate-co-terephthalate) (PBAT) to gradually release *Staphylococcus aureus* bacteriophage (phage) SAC. The phage SAC showed rapid bactericidal activity within 1 h at a multiplicity of infection of 1 and high stability in various environmental conditions, including temperatures under 60℃ and pH ranging from 5 to 9. Until now, no film has been reported to control the release of phage. So, there is a strong need for related studies that can control phage release as bacterial growth. The pectin can be utilized as a film (1.5%, w/v) and coating (6%, w/v) on extruded PBAT film for its wide range of application. These results demonstrate the potential of pectin as a great eco-friendly edible coating and film material by preserving phage stability and controlling their release.

Keywords: bacteriophage; pectin coating; PBAT film; antibacterial; biodegradable packaging

Implementation and low-power design analysis of an embedded system applying energy-reducing technology in 2.4 GHz band RFID Tags

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Abstract

The ISO/IEC 18000 series standards are the best known of the RFID wireless interface standards. It is used in a variety of frequency bands from 125 kHz to 2.45 GHz, and the reading distance ranges from a few centimeters to tens of meters. In the case of active tags used at relatively long distances, small coin cell batteries are mostly installed inside, and the operating time of the battery is most important for interactive recognition of tag information over a long period of time. For this reason, low-power research is being conducted globally to save tag energy. In this study, a circuit was designed and implemented for the RISK-V 32bit ESP32-C2 MCU, a wireless-based ESP processor designed as an ultra-low-power SOC (system on chip) for 2.4 GHz RFID tags. and then analyzed and conducted experiments on how to save energy by applying firmware software. The experimental method measured battery power consumption in three power modes (ModemSleep mode, DeepSleep mode, and Hibernation mode). Among these, it was found that the lowest power consumption of 10 uA was achieved in Hibernation mode. And ModemSleep mode was excluded because it continues to consume power in the active state of the tag. Therefore, software firmware optimization was performed in the embedded system with two DeepSleep modes and Hibernation mode. When the rechargeable LIR2032 3.6 V 40 mA CoinCell consumes 10 uA of current in Hibernation mode, it can theoretically be used for 4,000 hrs or 166 days. It was analyzed that if the operation cycle is periodically controlled live over a 166-day period, recognition of active tag information will be possible for at least one year. In addition, we analyzed and presented a power saving method in DeepSleep mode and Hibernation mode that can minimize battery power consumption through software in the tag.

Key words: Passive Tag, ISO/IEC18000, Energy-reducing Technology, Power Mode, Embedded System, RFID

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A novel strategy utilizing cellulose nanofiber film to contain bacteriophage in the netting structure of muskmelon rind

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Abstract

There is a crucial need for an active food packaging system suitable for curved surfaces, particularly the netting structure found in muskmelon rinds, to mitigate bacterial adhesion. This study aimed to develop an antibacterial film utilizing cellulose nanofiber (CNF) for its high water barrier and strong bacterial attachment properties, incorporating a lytic bacteriophage targeting *Escherichia coli* O157:H7 for application on melon rinds. A phage JY01 exhibited strong antibacterial activity with a multiplicity of infection ranging from 1 to 0.01, persisting for up to 8 h post-infection. Its activities remained stable over a broad temperature range (-18–60°C) and pH conditions (pH 4–10). Furthermore, this study proposes CNF films (1%, w/v) with various plasticizers, demonstrating efficient encapsulation based on their type. The selection of plasticizer was expected to influence phage viability, correlating with the moisture content in the film. Overall, this study highlights the development of optimal films suitable for the netting structure, indicating the importance of polymer/plasticizer combinations in achieving antibacterial efficacy.

Key words: bacteriophage, netting structure, cellulose nanofiber, antibacterial food packaging

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Development of antibacterial bacteriophage powder for moisture regulation in food packaging

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Abstract

Brown blotch disease in mushrooms, caused by *Pseudomonas tolaasii*, decreases quality and leads to economic losses. Packaging has been essential for protecting and maintaining quality, yet water condensation from the rapid respiration of mushrooms in packaging promotes microbial growth and decay. Bacteriophages (phages) possess specificity in lysing target bacteria. So, employing a phage combined with humidity-regulating materials in freeze-drying powder aims to innovate a new antibacterial packaging solution. An MKPT02 phage was newly isolated from white mushrooms (*Agaricus bisporus*) and characterized. The phage only lysed *P. tolaasii* among *Pseudomonas* spp. and remained stable over a wide temperature range from -80 to 50°C. It exhibited prolonged inhibitory activity for over 16 h even at a low multiplicity of infection of 0.01. Therefore, the phage powder is expected to preserve the stable color and texture of mushrooms, thereby serving as an eco-friendly antimicrobial packaging agent.

Key words: Bacteriophages, mushroom, humidity regulation, antibacterial packaging

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Preparation of Chitosan-based Composite Films Enhanced with Lignin-rich Lignocellulose Nanofibers from Rice Husk

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Abstract

Rice husk, an important byproduct in the rice milling process, has limited economic utility. In the present study, rice husk yielded approximately 6 g/L xylose, 32 g/L glucose, and 5 g/L ethanol under the typical pretreatment, enzymatic hydrolysis, and fermentation process. The residual solid fractions after saccharification still hold potential for lignocellulosic nanofibers (LCNFs) production, which can enhance the properties of biomaterials. The variations in lignin contents (ranging from approximately 50.6%–66.8%) among LCNFs considerably influenced optical strengths and mechanical properties. The Inclusion of LCNFs into the chitosan matrix notably enhanced UV blocking ability by approximately a 20-fold increase in opacity, which might be mostly caused by lignin in LCNFs. Also, Young's modulus was approximately 3-fold increased, implying suitable incorporations of LCNFs into the chitosan matrix. In conclusion, the study underscores the promise of lignin-rich biomass fractions for chitosan-LCNF film production, potentially enhancing the economic viability of biomaterial industries.

Key words: Rice husk; Lignocellulose nanofiber; Lignin-based material; Chitosan film; Upcycling

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Alginate-based Edible Film Incorporated with Microfibrillated Cellulose Derived from Grapefruit Peels

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Abstract

This study focused on producing microfibrillated cellulose (MFC) from grapefruit peels treated with deep eutectic solvent (lactic acid and betaine at a molar ratio of 2:1) for various temperatures (60 – 90°C) and times (1 – 60 min). The produced MFC had superior dispersibility (a H_s/H_o ratio of 0.91) and specific particle size (average 85.9 μm) under treatment at 90°C for 30 min. Afterward, MFC was incorporated into alginate-based film with different content (0 – 20%), exhibiting the highest tensile strength (339.0 MPa) and elongation (15.43%) with the addition of 15% MFC. Also, swelling tests and water vapor permeability (WVP) showed significant improvements in water resistance and barrier properties compared to pure alginate, and thermal stability was observed over 600°C by thermo-gravimetric analysis. In conclusion, this study highlights the sustainable potential of MFC addition, offering cost-effectiveness, enhanced peel value, and improved film properties.

Key words: Grapefruits peel; Microfibrillated cellulose; Alginate; Deep eutectic solvent;

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Efficient and Eco-friendly Conversion of Brewer's Spent Grain to Levulinic Acid using Deep Eutectic Solvent (DES)

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Abstract

Levulinic acid (LA), a key platform chemical for its rich ketone carbonyl group and a carboxyl group, can be synthesized from cellulose and xylose under harsh treatment and with a catalyst. In this study, Brewer's spent grains (BSG), a by-product in brewing industry containing considerable amounts of both cellulose and xylose, were efficiently converted into LA. Using deep eutectic solvent (DES), after the careful considerations of conductivity, viscosity, Kamlet-Taft parameters, microwave absorption degree, and the intensity of hydrogen bonds by Fourier-transform infrared spectroscopy, choline chloride:lactic acid with a molar ratio of 1:8 among the 5 different types of DES exhibited the highest hydrogen bond acidity (2.011) and enzymatic digestibility (61.0%). After pretreatment under optimized conditions, 7.51 g/L of LA was produced from hydrolysates with the yield of 41.1% based on glucose and xylose content. Additionally, 7.51 g/L of ethanol was fermented from the solid with a yield of 66.74%.

Key words: Brewer's spent grain; Deep Eutectic Solvent; Levulinic acid; Bioconversion; Biorefinery

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