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Safety Polymers for Food Packaging

Shimaa T. Abdelkareem [a], Yasmeen A. Elemama [a], Reham A. Subaih [a], Hager I. Elhefnawy [a], Marwa A. Saada [a], and Ahmed G. Hassabo [b]*

[a] *Benha University, Faculty of Applied Arts, Industrial Design Department, Benha, Egypt*

[b] *National Research Centre (Scopus affiliation ID 60014618), Textile Research and Technology Institute, Pretreatment and Finishing of Cellulose-based Textiles Department, 33 El-Behouth St. (former El-Tahrir str.), Dokki, P.O. 12622, Giza, Egypt*

Abstract

Food is a vital component for survival. There is more food because of globalization, urbanization, and population growth. Food safety and storage now face more difficulties as a result. Consequently, food must be preserved using appropriate packing materials. Food may be preserved and its quality enhanced throughout storage, distribution, and transportation with the use of packaging materials. The food sector has made advancements and innovations in food packaging crucial. Food packaging uses a range of materials, including plastics, paper, metal, and glass. The majority of packaging materials are made of non-biodegradable plastics, which are bad for the environment and people's health. In order to replace non-biodegradable plastics with environmentally friendly biodegradable polymers, the food sector is searching for solutions. On the other hand, there is a lack of systematic literature on the topic, thus a systematic summary of the material that is accessible is required. The topic of polymer packaging materials has been thoroughly examined, with a focus on biodegradable plastics. The functions and uses of many types of biodegradable polymers in food packaging have been compiled. Research has demonstrated that, in comparison to alternative packaging materials, biodegradable polymers are far superior for use in food packaging. Deep understanding is needed, and there are many obstacles to overcome in the commercialization process when it comes to the usage of biodegradable polymers in food packaging and environmental protection. This review paper has covered every one of these topics.

Keywords: Plastic, Bioplastic, Degradable plastic, Food, Packaging.

Introduction

The packaging of an item for consumption is progressively becoming recognized in terms of its marketing value as products sit on shelves next to similar products and compete for attention from potential buyers.When items are arranged on shelves beside one another and vie for the attention of prospective customers, the packaging of a consumable is increasingly being seen as having marketing significance. Good design, visuals, and an informational label describing the contents of the package may all contribute to a favorable client experience. The packaging of a bad item can draw in more customers than a healthy product housed in a poorly designed wrapper, even when it is obvious that some goods are not the healthiest. Industries nowadays really utilize packaging as a means of advertising and communicating their brand to consumers, in addition to using it to cover and protect items.

Petroleum plastics, or synthetic polymers, are one of the most widely used materials in the food business for packaging. Polyethylene terephthalate (PET), polypropylene (PP), polyvinyl chloride (PVC), low- and high-density polyethylene (LDPE and HDPE, respectively), and polystyrene (PS) are examples of these polymers [1].

Naturally, sustainability is another issue that has attracted the attention of several scientists, researchers, and environmentalists. Biopolymer materials are an environmentally friendly alternative to synthetic polymers in the polymer industry. This is because they use renewable basic materials, biodegrade readily, and are made from agro-industrial waste (biomass). Their cost-effectiveness and avail-

* Corresponding author: Ahmed G. Hassabo, E-mail: aga.hassabo@hotmail.com, Tel. 00201102255513
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ability make them popular as well. Additionally, biopolymer materials can be made edible and perhaps infused with active antibacterial and/or antioxidant compounds. To improve their qualities, these biopolymer materials can also be laminated and molded into composites [2].

It is crucial to acknowledge the significance of health and safety when considering the various materials used in food packaging, while also keeping in mind the primary goal of food packaging, which is to maintain the quality of food items. This is a serious problem as there's a chance that food might get contaminated if elements from packaging migrate into it. Additives (such plasticizers, stabilizers, and antioxidants) and monomers are examples of potential contamination; nevertheless, unidentified chemicals may also inadvertently transfer. Gra´ın˴o et al. [3] discovered a number of migratory compounds in paper-based candy wrappers and plastics, including acetyl tributyl citrate, N-alkanes, tributyl aconitate, phthalates, butylated hydroxytoluene, bis(2-ethylhexyl) adipate, etc. Many of the chemicals found in plastic sample samples are prohibited from ingestion by health and safety agencies. As conventional synthetic polymers made from oil derivatives are gradually being replaced by biopolymers [4], there is an obvious risk of bioplastics migrating into food and becoming a potential cause of contamination. However, because natural components do not constitute a serious hazard to food and consumer safety, the risk of contamination resulting from the usage of these bioplastics is significantly decreased.

Classical plastics used in packaging

Properties of Plastics for Packaging Applications.

Primary and secondary functions can be used to roughly categorize the key roles that packaging plays. Strong, leak-proof packaging is necessary for primary tasks such product protection, storage, loading, and transportation. It also has to be able to endure any external circumstances imposed by the storage or transit environment. The package may need to be transparent or have a shiny exterior in order to draw customers' attention for secondary purposes like boosting product sales. Packaging materials must be printed in order to include information on product ingredients, nutrition information (for food products), and usage instructions. Furthermore, a key factor in deciding a polymer's potential as a packaging material, particularly for volume applications, is its recyclability. This chapter covers the general features of plastics for use in packaging applications, with a focus on the qualities of the most popular packaging polymers and what makes them desirable materials for packaging. There is also a brief discussion of novel packaging technologies including modified environment packaging and active packaging.

Overall Plastics Properties

The appropriateness of polymers for packaging applications is determined by a number of factors. These characteristics rely on the kind and composition of the polymer. (Figure 1)displays a list of typical polymers used as packaging materials. Morphology, barrier, mechanical, thermal, and optical characteristics are the five main categories into which the polymer attributes most pertinent to packing applications may be divided. These characteristics have a significant impact on a number of crucial aspects of the final packing material, including strength, transparency, and the capacity to keep out oxygen and water vapor:

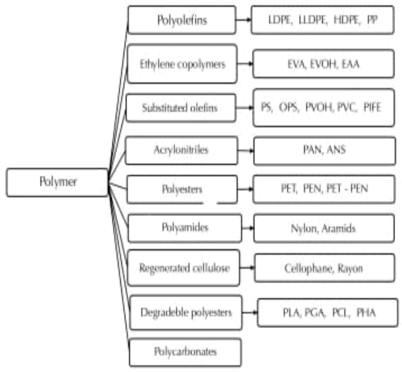


Figure 1 common polymers for packaging applications.

Power Polymer Techniques

The orientation, conformation, and spatial arrangement of polymer chains are referred to as the morphology of polymers. A polymer's degree of crystallinity is one of its most significant morphological characteristics. Most synthetic polymers have domains of both crystalline and amorphous areas, making them semi-crystalline. The following is a quick overview of crystallinity and discusses how different plastic properties are affected by different crystallinity levels.

Regions of parallel, aligned chains that are well-ordered are indicative of polymer crystallinity. The regular configuration might be flat, zigzag, or helical. Amorphous patches in the polymer matrix are caused by disordered or misaligned polymer chains. Numerous man-made polymers possess both amorphous and crystalline areas, making them semi-crystalline. Growing branching results in uneven molecular packing at the branch sites, which reduces crystallinity. In a similar vein, copolymerization reduces the degree of crystallinity by introducing asymmetry in the polymer structure. Additionally, pendant group presence and tactility are important chain features that can significantly impact crystallinity. In polymers, tacticity plays a crucial role in determining the degree of crystallization; atactic polymers tend to be amorphous, whereas isotactic and syndiotactic polymers typically crystallize.

Polymer Morphology's Importance For Packaging Applications

The degree of crystallinity in polymers determines a number of significant features. The impact of increasing crystallinity on several mechanical, optical, and barrier characteristics of polymers is listed in Table 1. The tensile strength and transparency of polymer films are influenced by the crystallinity of polymers, and these properties are crucial for certain packaging applications (Shanks, 2003). Transparency of polymer films diminishes as their tensile strength and crystallinity rise. High crystallinity polymers often have effective chain packing, low diffusion coefficients, and advantageous barrier qualities. Some polymers, like PE, have a high gas transfer rate even if their crystallinity is quite high.

Table 1 Effect of Increase in Crystallinity on Different Polymer Properties

S/N	Polymer	(°C)
1	PS	240
2	PVA	228
3	PET	265
4	PP (isotactic)	185
5	PP (atactic)	——
6	PVDC	195–205
7	PE	105–115 (LDPE) 120–145 (HDPE)

Properties of Barriers

It is advantageous for the packaging material to have a high resistance to gas transfer in a number of applications, including the packaging of food goods that are sensitive to oxygen (such as oxygen and water vapor). Excellent barrier qualities of plastics are necessary to achieve the desired attributes in these kinds of packaging materials. But packaging for foods that require respiration, like fruits and vegetables, has to be able to let in carbon dioxide and oxygen, therefore it needs to be permeable to these gases. Permeability and barrier property are negatively correlated; a lower permeability value indicates a greater barrier property. The solubility and diffusion coefficients of a penetrant determine its permeability inside a polymer.

The quantity of penetrant absorbed by the polymer from a contacting phase is measured by the solubility coefficient. It shows the sorption ability of a polymer towards a certain sorbate. In contrast, the diffusion coefficient quantifies the penetrants' movement inside the polymer. In polymers, the gas diffusion rate in the crystalline zone is often much less than that in the amorphous region. Numerous variables, including the size of the penetrant, interactions between polymers and solubility, polymer shape, glass transition temperature, and others, affect the values of solubility and diffusion coefficients.Temperature-dependent solubility and diffusion coefficient usually show an Arrhenius-type dependency.The mechanical behavior of polymers is influenced by their thermal characteristics, such as the glass transition and heat deflection distortion temperatures, which are crucial in determining the viability of polymers for certain packaging applications. The glass transition temperature is a critical factor to consider while storing packed material in a cold environment. In these situations, it is important to make sure that the packing material's glass transition temperature is lower than the freezer temperature. If not, the packing material can split and become brittle. Another thermal characteristic that is crucial in choosing the packing material is heat of fusion. The Apple polymer structure may alter and the packaging may fail if the heat absorbed from an external source or environment is greater than the heat of fusion.

Importance of optical properties in packaging applications

Glossy packages enhance the aesthetic appeal of the product making it more likely to attract customer attention. Polymers with high transparency are used as an alternative to glass in packaging applications as they provide the added advantage of easier processabilty and lower brittleness.

Interaction Phenomena Between Packaging and Product

An overview of the phenomena that interact with polymer packaging and packaged goods is given in this chapter. Numerous outcomes might result from the sorption of the product in the polymer and the movement of species from primary packaging to confined product. The packaged product's quality, shelf life, organoleptic properties, or medicinal efficacy may all be affected by migration. Squeezing, paneling, or stress-cracking of the container might result from sorption. First, a brief overview of the primary thermoplastics and their typical additions is provided. The discussion of experimental techniques set up for the characterisation of interaction phenomena is the focus of the second section.The sorption phenomena of amylacetate in polypropylene packing is then thoroughly described using gravimetric and FTIR techniques. Sorption kinetics is used to investigate the effects of amyl acetate concentration and interaction temperature. We demonstrate the sigmoidal-type sorption kinetics, emphasizing the sorption kinetics' asymptotic tendency at the polymer surface. Together with the diffusion coefficient D, the surface mass transfer coefficient H is introduced as a result of the mathematical modeling of this mass transfer event. These values are derived from the sorption curves, which demonstrate that as the temperature of the solution and the concentration of amyl acetate increase, the surface mass transfer coefficient H increases while the diffusion coefficient D stays constant.

Every industry sector, including food, cosmetics, health and care, chemicals, transportation, distribution, industrial and agricultural products, and so on, uses polymer packaging extensively. Ensuring the protection of the goods it contains is one of packaging's main functions.The product's quality is preserved and external contamination is avoided thanks to the packing. However, chemicals migrate from the thermoplastic material to the product (migration) or from the product to the material (sorption) when they come into contact. Several research have been conducted on the mass transfer between items and their packaging.

An overview of the primary thermoplastic materials used in packaging

Polyolefin accounts for the majority of packaging demand (74% of all plastic packaging used in Europe), with polyethylene terephthalate (PET), polystyrene (PS), and polyvinyl chloride (PVC) following closely behind. With 40.1% of the demand for plastic in Europe, packaging is by far the largest application market for thermoplastics in general Apple Academic Press. The most common plastics used in packaging are Low-Density Polyethylene (LDPE) and Linear Low-Density Polyethylene (LLDPE), which account for 31% of usage, followed by HDPE (22%), and PP (21%). One of the most adaptable polymers on the market, polypropylene (PP) finds extensive use in packaging. It is possible to make the PP as a copolymer or as a homopolymer. A single monomer, in the case of PP, propylene, is the source of a homopolymer molecule. Alternatively, two or more monomers can be combined to create a copolymer molecule; in the instance of PP, this combination is propylene and ethylene. The strongest and stiffest polymers are homopolymers because they are more crystalline than copolymers. There are two types of copolymers: random and block.

Impact on the packaged good

Food or medication, for example, may absorb ingredients from packing materials (additives and other low molecular weight molecules) during the migration process. The way food interacts with its packaging is an important issue that can impact shelf life, quality, and appearance. Food residues adhering to the container may improve oxidation and off tastes, diminish product acceptance, increase waste, and degrade overall product quality. Foods packaged with plasticized PVC cling films had the highest amounts of packaging materials that may be harmful to human health. Therefore, changes related to container/content interactions may have an effect on the packed product's effectiveness, safety, and quality.

Effects on the polymer

Transport phenomena can cause physical aging of polymers which results in irreversible alteration of its properties. This alteration can affect its chemical structure, its composition or its physical state. Physical aging is reflected in several ways that we will discuss hereafter.

Plasticization occurs when the diffusing molecules penetrate into the macromolecular network. This produces disorders that weaken or even destroy the secondary bonds responsible for the cohesion of the material.

Theoretically, plasticization is reversible. In fact, it induces internal rearrangements and may also facilitate the relaxation of internal stresses. These phenomena are often found when the material has chains of low molecular weight or when it has a low degree of crystallinity. Plasticization is characterized by a change in the mechanical properties of the material, resulting in a decrease of the glass transition temperature (Tg).

Diffusion of solvent in the polymeric material may induce swelling causing changes in its internal structure if there are heterogeneities which induce stresses between more or less swollen areas. These areas may be amorphous (relatively accessible) or crystalline (relatively inaccessible). This swelling can also occur when the kinetics of diffusion of the solvent create concentration gradients. Damage under stress can produce cracks in the material. Crazing concerns the areas constituted of vacuum and highly oriented fi brils in the polymer. These can lead to the formation of a micro-cracks and cracks. Diffusion is the process by which the transfer of the material of one part of the system to another. It results from random movements of molecules in the system. Consider two areas of a system with different concentrations where the molecules move randomly. A large number of molecules will move from high concentration area to low concentration, which leads to smooth out spatially varying concentrations.

Specific Migration of Antioxidants BHT, Irganox and Irgafos into Typical Edible Oils under Microwave Heating Conditions.

The migration of chemicals from plastic packaging materials into food, including plastic additives, monomers, oligomers, and their degradation products, has been extensively studied for many years by researchers from the FDA, EC, and other organizations worldwide. This migration could result in issues with food safety for consumers. Since 2005, the Chinese government has been deeply concerned about a number of issues pertaining to food contact materials migration. These issues have been brought to the attention of the General Administration of Quality Supervision, Inspection, and Quarantine of the People's Republic of China (AQSIQ), which has been involved in the "PVC film affair" and the "PVC gasket phthalate affair" (both of which are related to migration issues).As mandated by AQSIQ (the General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China), plastic and paper products intended for food contact should have obtained QS Certification between 2006 and 2007. began studying the migration issues with materials that come into contact with food, particularly polyolefin films, in early 2004. Chinese consumers were initially introduced to migration testing methods, technologies for analyzing migrants, and migration models by Wang et al. Liu examined the developments in analytical mathematical models for chemical substance migration prediction from plastic packaging materials. She assesses the impact of factors on the effectiveness of analytical migration models using a non-dimensional technique.

Chemical migration from plastic food packaging materials into foods (simulants) and the instability of migrants in foods are numerically simulated. In recent times, an increasing number of microwave ovens have been installed in kitchens due to the popularity of microwave heating as a quick, hygienic, and easy way to heat meals for Chinese families. Since microwave heating is a unique type of heating, materials that come into touch with food—such as plasticizers, antioxidants, and the like—and materials that might allow heavy metals—like Pb, Cd, and the like—to seep into food should generally only be used as plastic or ceramic containers. Chemical migration from PVDC, PP, PVC, CPET, and PET.

Time-temperature profiles

Since the temperature-time profiles of the six different kinds of edible oils are almost identical, Figure 2 displays the average outcomes. Table 3 shows that the temperature and time show nearly a linear relationship from microwave power of less than 100W to 900W. The edible oil will achieve the same temperature more quickly the greater the microwave power.

Table 3 Equations of heating-up curve of edible oil under different microwave power

Number	Microwave power (W)	Temperature-time equation (least squares for linear fitting)
1	100	y = 3.593x + 28.151
2	250	y = 8.2979x + 24.689
3	440	y = 16.664x + 25.175
4	600	y = 22.287x + 22.062
5	900	y = 30.527x + 23.138

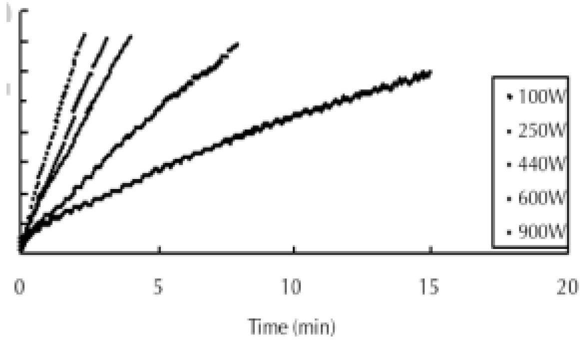


Figure 2 Temperature-time profiles of edible oil under different microwave power

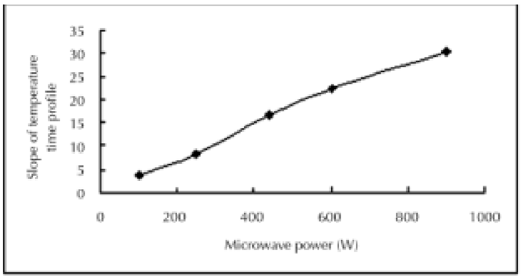


Figure 3 Relationship between microwave power and slope of temperature-time profile of edible oils.

Table 4 Sampling time of migration under different microwave power condition.

Time(min)	Microwave power(W)				
	100w	250w	440w	600w	900w
2	Δ	Δ	Δ	Δ	Δ
2.5				Δ	
3	Δ	Δ			
4			Δ		
5	Δ	Δ			
10	Δ				
15	Δ				

The rate at which a temperature is reached is shown by the temperature-time profile's slope (See Figure 3). Table 4 determines the sample duration of migration testing under various microwave power circumstances, as PE film is typically utilized below 90°C.

Suitability of Polymer Based Retortable Pouches for Packaging of Fish Products

The development of petroleum industry films and advances in thermal processing methods have led to a significant advancement in retortable packaging. In the early 1960s, a group of food packaging businesses and the US Army Natick Laboratories created the idea of the pouch as a food container. In Japan, curry was first sold in foil-free and foil-containing pouches in 1968–1969. An outside layer of polyethylene terephthalate for heat resistance, an inner cast polypropylene for pack sealing, an aluminum foil for oxygen and light barrier, and bi-axially oriented nylon for robustness were the usual components of a pouch. A thorough investigation on flexible food packaging for thermally processed foods was conducted by. A new market for canned foods was established by heat-sterilized, low-acid solid meals packaged in pouches.An aluminum foil pouch's shelf life for a retorted food product is around two years. A barrier type nonfoil pouch should last 2-3 months, whereas a nonfoil retortable pouch should last 1-2 months. Research on hamburgers packaged in retort pouches revealed that the material used for packaging affects the sensory attributes. The impact of headspace gas on thermal processing and processed product shelf life has been investigated by Komatsu et al. stated that following eight years.

Polymers and food packaging

Food packaging

Packaging is used in all sorts of industries with applications in the medical field, pharmaceuticals, food, electronic devices, etc. A variety of materials are used in order to prepare and manufacture packaging. Food packaging and its related technologies are an essential part of the food industry as they involve the protection and preservation of foods and products [5]. In fact, food packaging is designed to protect and conserve the quality of foods without deteriorating their appearance,taste, smell, or nutritional content; and also to inform the consumer about the ingredients and nutritional information enclosed inside. Consumers have a right to know what the contents of each package are, and, therefore, product information is always to be printed on the packaging. As products compete for attention from

potential buyers, there is an ever-increasing interest in creating attractive marketing solutions and improving packaging designs to have more ergonomic and effective products. As consumer demand rises, producers are going to be challenged as they encounter more concerns in terms of creating potential threats to product quality.

A study by Jacob [6] states that a package's three primary purposes are display, preservation, and protection. While figuring out these package functions is rather straightforward and reasonable, it ignores additional factors [6]. According to Robertson, packaging serves four purposes: communication, protection, convenience, and confinement. A package should be user-friendly in light of the convenience factor, which is described as consumer usability. This means that it should be simple to handle, carry, recycle, and/or dispose of as trash [7]. Based on their knowledge and experience—which is evident in their substantial study and published works—many other writers have differing views about the roles that packaging plays.

Burke [8], for instance, outlines three main categories for a successful packaging design. These three classifications are authenticity,meaning, and the package's ability to convey the brand image to the consumer [8].

Fillers and additives used in the production of polymeric food packaging materials can seep into food, contaminating it and lowering its quality. Small quantities of chemicals can leak out of packaging plastics when they come into touch with food. If the substances emitted pose a risk to human health, the movement of introducing such animals into food products may cause health issues. Consequently, understanding the interactions between food and packaging, including the species that might move from the packaging to The food is necessary to guarantee the quality of the cuisine. As an illustration, polycarbonates and phenolic-epoxy resins, which are used to coat food cans and make plastic packing containers, respectively, may emit bisphenol A into food, which may have harmful consequences on health. Understanding the degree of bisphenol A emission under various circumstances.

Packaging materials.

The food industry, along with related businesses, uses a wide range of packaging materials. These materials' primary duty is to maintain food safety and freshness during the production process, as well as during the chains of storage and distribution. Food packaging has long used glass, metals (such as aluminum, foils and laminates, tin-free steel, tin plate, etc.), plastics, paper, and paperboards, all of which have proven to be effective materials throughout time. Food goods are typically packaged using synthetic materials that are both hard and flexible [9].

Glass and paper have always been the materials most frequently used to cover and preserve objects. But like a lot of other things in daily life, these materials all have benefits and drawbacks of their own. Glass bottles, for instance, are among the earliest and most widely used packaging types. They are employed in a variety of applications and designs. Glass containers are ideal for holding liquids since they are composed of natural materials and have a nonpermeable barrier, which is one of their benefits. Their fragility is, however, their greatest drawback.

The highest grade kraft and sack paper is also provided by the paper packaging sector.Kraft paper is made by processing wood chemical pulp to create a sturdy cardboard or paperboard that is often brown in color. It is mostly used as wrapping paper or bags. Sack paper is a type of kraft paper that has a high elasticity and rip resistance, like a sponge. It is frequently used to package goods that must be robust and long-lasting. The ability of marketing specialists to create creative solutions for customers in the consumer, medical, and industrial sectors is advantageous to the paper packaging business. However, the biggest drawback of paper packaging is its susceptibility to dampness and water absorption.

Manufacturing technology has changed the entire concept of packaging throughout history, particularly after the industrial revolution in the eighteenth century. Manufacturers were forced to create more resilient and long-lasting forms of protection (packaging) in order to facilitate the transportation of goods from factories to stores and ultimately to customers' homes. Subsequently, in the 1860s, the creation and production of plastic polymers for packaging uses started [7]. To do this, hard rubber was modified. Synthetic polymers and other chemicals, including PVC and PET, were progressively developed as science advanced [10].

Petrochemical polymers, sometimes known as plastics, have long been the preferred material for packaging because of their low cost, easy to display, superior resistance to oxygen and odor compounds, softness, tensile and tear strength, light weight, and transparency [5]. The strong, lightweight, closed-cell polyethylene (PE) foam is an illustration of a petrochemical polymer. Packaging for industry and agriculture uses it most frequently. PE's insulation and16.3 Packaging materials 527 vibration control qualities make it a great material option in these applications. In addition, it has a strong resistance to moisture and chemicals and is available in a variety of forms, including sheets, tubes, pouches, bundles, and die cuts. For instance, the flexibility, light weight, surface sensitivity, affordability, and shock absorbability of PE foam in pouch form [11].

Nowadays, with the arrival of new technologies such as three dimensional (3D) printing, it is possible to have a diverse, good-quality packaging material.

The application of 3D printing technology in packaging industries has shifted the dynamic of packaging in many different aspects such as in the potential to have full color graphics and text for labels. 3D printing is a process that uses computer control to form layers and coatings for materials. It is convenient in terms of package design. People are able to provide color coatings and layers in almost any material regardless of shape or geometry [12,13]. Although the current advantage of 3D printing technology in packaging is not clear, it requires a lot of future exploration because of its huge potential.

It should be noted that the packaging industry and researchers work on the recycling and reusing of synthetic packaging materials for waste management and control. For example, PET can be recycled repeatedly, and about 681,000 metric tons of recycled PET containers and bottles are recovered each year in the United States. One method of recycling is to wash and remelt PET, and use it in new products that require PET as a component. Another method of recycling PET is to break it down with chemical processes into its raw materials. Due to this reusability, PET is highly sustainable and its sustainability is an ever-increasing pursuit for scientists and a lot of research is going into the development of facilitie that are capable of transforming used PET packages and bottles into new foodgrade PET containers and bottles. The only drawback to the reuse of PET is the amount of material collected. One of the most interesting uses of recycled PET resin is in the production of filament for use in 3D printers [14].

Nevertheless, the use of petrochemical polymers (plastics) has many disadvantages such as a poor water vapor transmission rate (depending on the goal of packaging, it is sometimes an advantage) and a significantly negative effect on the environment. In fact, the worst disadvantage of these polymers is their nonbiodegradability and noncompostability, which has a great impact on environment pollution and global warming.

The waste disposal problem of petroleum materials and their nonrenewable nature have caused a spike in the level of interest in the sustainable development of biodegradable polymers, recycling, and/or environment protection. The degradation of materials causes structural and morphological transformations that can result in major changes in the properties of polymer materials. Generally, biodegradable polymers get hydrolyzed and turn into methane (CH_4), carbon dioxide (CO_2), mineral mixtures or compounds, or biomass. To create biodegradable polymers, bio-origin materials obtained from cellulose, starch, and microbial fermentations are used. This has led to their incredible success in the food packaging industry in the past few years [5,15,16].

Packaging materials

Food Polymers

A polymer is a substance with a vast molecular structure made up of chains or rings with several unique repeating units (monomers). Polymers may be understood more simply by looking at their Greek roots, "poly" and "mer," which translate to "many" and "parts," respectively. Because of their many applications across several sectors, both natural and synthetic polymers have a wide spectrum of properties. Plastics and resins are made of a wide variety of synthetic materials [1]. In actuality, plastics are long-chain molecules derived from alkenes that have been mixed with additives to form polymers. Typically, one or more hydrogen atoms are swapped out for another atom to create various polymers [9]. The packaging sector frequently uses plastics because of how easily they can be molded and transformed. A wide range of packaging possibilities, including shape, color, size, weight, function, printing, etc., are made possible by the various properties of plastics [1]. The beneficial properties of polymers, such as their ease of manufacture, toughness, and stability, have made them an essential element of contemporary life [17]. To put it another way, manufacturers benefit from plastics because they are lightweight, flexible, and/or malleable, which allows them to be shaped into any shape using a variety of techniques including blowing, extrusion or coextrusion, casting, laminating, etc.

This enables the packaging of unusual items that are challenging to fit into standard or simple containers. Due to their barrier properties, which serve to keep items fresh, avoid contamination, and extend shelf life, polymer plastics are beneficial for several aspects of food packaging. Because food industry manufacturers and enterprises may decrease waste by storing meals for longer than they would in the absence of polymer packaging, polymer packaging can be considered environmentally helpful [1]. For instance, polymers for applications involving modified atmosphere packing (MAP) were examined by Tajeddin et al. [9]. These compounds can also be utilized in stiff or semirigid packaging solutions, such a tray lidding. They are the primary constituents of the flexible package structures employed in MAP.The most common polymeric materials (plastic films) utilized for MAP applications include PEs, such as LDPE, linear LLDPE, HDPE; PP; PS; polyesters, such as PET or PETE, polycarbonate (PC), and polyethylene naphthalate; PVC; polyvinyl dichloride; polyamide (PA) or nylon; and ethylene vinyl alcohol [9]. However, for various reasons, scientists are still trying to modify the structures of some of these polymers. As an example, Kobayashi and Saito [18] studied the structural development of PC and poly(methyl methacrylate) blends by biaxial stretching simultaneously. These biaxially stretched films are widely used as packaging materials for industrial and food items because the biaxial stretching procedure may improve the mechanical and gas barrier properties of polymer films [18]. Another instance is Han et al. [19] produced polyvinyl formal (PVF) by reacting formaldehyde with polyvinyl alcohol (PVA). Compared to PVA, the synthesized PVF exhibited a lower melting point, a higher glass transition and decomposition temperatures (Tg), and a higher melting point. Compared to PVA, the synthesized PVF could be melted and treated at substantially lower temperatures. In a Haake mixer, the synthesized PVF and polypropylene carbonates (PPC) were melted and combined.

Polymers, or plastic materials, are the materials most commonly utilized in the packaging sector, as was previously established. For instance, it is estimated that 95%–99% of plastics are used in packaging in North America in one category of packaging analysis.

In contrast to other packaging materials like steel, aluminum, glass, paper, and so forth, packaging materials based on plastic account for 39% to 100% of the entire market demand in North America for the packaging categories included by this study.

A case study of the replacement of plastic packaging with other packaging materials [24].

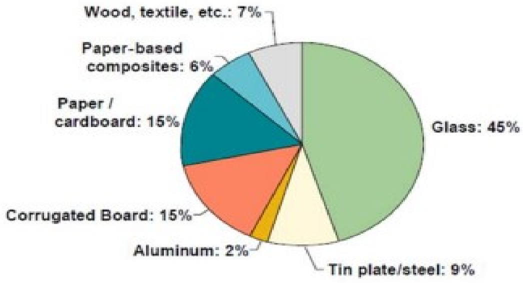


Figure 3.1

Actually, a model for a hypothetical replacement of plastic packaging was created by Brandt and Pilz [24]. If other materials (tin plate and steel packaging, aluminum, glass, corrugated board, cardboard, paper and fiber cast, paper-based composites, and wood in this study) were substituted for plastic packaging (LDPE, LLDPE, HDPE, PP, PVC, PS, expanded polystyrene, and PET in this study), the findings of their investigation would be summarized in Fig. 16.1 [24].As illustrated in Fig. 16.1, there may be additional options to replace polymeric materials, as well as the possibility of substituting other packaging materials (which is a topic of much discussion and should be addressed elsewhere). These alternatives could include new technologies and the use of renewable natural materials.

Biodegradable polymers

Individuals are always coming up with fresh concepts for improving product packaging. Initially, it was possible to recycle packaging materials; but, these days, new and improved biodegradable and environmentally friendly materials are constantly being developed. Businesses have started to switch to superior materials already [25]. Because they originated on Earth, the majority of synthetic polymers, including PE, PET, PA, polyethylene furanoate (PEF), polyurethanes, etc., are in reality biobased products; nonetheless, they are not biodegradable and are not sustainable. Materials that break down due to the enzymatic action of living organisms (such as bacteria, fungus, and yeasts) are referred to as biodegradable. Water (H2O), CO2, and biomass are the final products of the breakdown process underbiomass and CH4 in anaerobic circumstances, and hydrocarbons in aerobic settings [26]. Therefore, the primary task is to substitute biodegradable, sustainable materials for traditional packaging, such as starch blends, polybutylene adipate-co-terephthalate, polylactic acid (PLA), polyhydroxyalkanoates (PHAs), and PBS.

As per the European Bioplastics Organization's declaration, a plastic substance may be classified as bioplastic if it possesses both biobased and biodegradable properties. It makes sense to switch from petroleum-based plastic to natural-based polymers as the production of synthetic plastics, which are not environmentally friendly, requires 65% more energy and produces 30% to 80% more greenhouse gas emissions than bioplastics [27, 28 as quoted in 17].

Currently, bioplastics make just 1% of the 320 million tons of plastic that are produced each year. However, as more high-level biopolymers, applications, and products come to market and demand increases, the market is expanding steadily. In addition to the study conducted by the Nova-Institute and the European Bioplastics Organization, the volume of bioplastics produced globally is expected to increase from 2.05 million tons in 2017 to 2.44 million tons in 2022. The primary ingredients fostering this development in the realm of biobased, biodegradable polymers are PLA and PHAs [29]. For practically every common plastic substance and its associated application, there exists a bioplastic replacement. The properties of these new bioplastics will undoubtedly resemble those of the conventional ones.

Considering that their beneficial properties have been established. Beyond this, depending on the substance, bioplastics should be provided with further benefits like a lower carbon footprint or additional waste management choices like industrial composting, in addition to their similar properties to regular plastics. As an illustration, both industry and scientific research are currently devoting significant resources to improving high gas barrier bioplastics as a substitute for traditional polymers derived from fossil fuels [30].

In general, biopolymer materials are derived from polysaccharides, proteins, or lipids, based on the compositional units. In order to get better biopolymer material properties, they can be treated, that is, laminated or formed as composites. In addition, biopolymer materials can be made to be edible and/or active with strong antioxidant and/or antimicrobial properties [2]. Sources of these biodegradable polymers are lignocellulose products, wood, straw, pectin, chitosan/chitin, gums, wheat, starches, cassava, potatoes, maize, etc. [22]. Chitin and chitosan are the main and most abundant sources of natural polymers subsequent to cellulose. Chitosan has proven useful for the development of bioactive materials due to incomparable properties like non-toxicity, biodegradability, chelating, anticoagulant, antioxidant, and antimicrobial characteristics, and biocompatibility[31].

Biopolymers can also be produced by microorganisms through the fermentative processes of altered bioresources such as PHAs and biomass may be produced directly from various plants [4]. In addition, there are some plastic and paper products made from raw materials such as bamboo, wood, recycled paper, bagasse (sugar cane), etc. Bioplastics are made from components found in plants like hemp oil, soy bean oil, and corn starch. Bagasse has the least effect on the environment. Because it is strong and does not deform easily, it is suitable for use in take-away boxes, plates, bowls, and ice cream cups. It is heat and water resistant and will not suffocate food stuffs [25]. However, different types of wood are used for different packaging materials.

Furthermore, plants like bamboo are consumed as packaging materials. They come from renewable resources that are compostable and biodegradable.

For instance, prepared cellophane is used for bags and sheets because it can block out or keep in air, grease, and bacteria really well and can be sealed by heat [32].

The environmental impact of paper products was compared with that of plastic products in terms of four factors. On the whole, the results showed considerably less of an environmental impact for paper products including 50%:70% lower missions of greenhouse gases [25].

Synthetic polymers and biopolymers hybrids

An further option is to use a blend of natural and synthetic polymers, as indicated in Table 4. Numerous studies, including those demonstrate that the production of synthetic polymers and biopolymer hybrids increases some of the mechanical properties of biopolymers while decreasing the amount of synthetic polymer materials found in nature. For instance, Cannarsia et al. [48] investigated the effects of replacing PVC films with biodegradable polymers in order to limit microbial contamination of meat and preserve meat qualities like color. Ten meats from organic farms that were slaughtered when the animals were between sixteen and eighteen months old were placed on PS plates and sealed with PVC.

Nanomaterials.

There haven't been many uses for biodegradable films (natural polymers) in food packaging because of their poor mechanical and barrier properties.

There is a lot of promise in using nanocomposites to increase Table 16.2's use. Several natural biodegradable polymers' benefits and drawbacks [26, 36–43]. Benefits of raw materials Negative aspects Starch Availability and reasonably low price low mechanical properties and hydrophilic nature chitosan Good mechanical properties, antimicrobial and antifungal activities Brittleness, high water vapor permeability, low permeability to carbon dioxide and oxygen Zein Low water solubility (depending on the purpose of packaging), excellent film formation, good tensile and moisture barrier properties, and antimicrobial resistance

Table 4 List of common biodegradable polymers used in food packaging [33].

Family/group	Natural polymers/ renewable materials	Source	Examples
1. Biomass products [from agro-resources (agro-polymers)]	Polysaccharides	Plant/algal	Starch (wheat, potatoes, maize, etc.), cellulose, pectin, konjac, alginate, carrageenan, gums
		Animal	Hyaluronic acid, chitosan/chitin
		Fungal	Pullulan, elsinan, scleroglucan
		Bacterial	Chitin, chitosan, levan, xanthan, polygalactosamine, curdlan, gellan, dextran
	Proteins	Plant	Soya, zein, wheat gluten, resilin, polylysine, polyamino acids, poly(g-glutamic acid), elastin, fibrin gel, polyarginyl–polyaspartic acid
		Animal	Collagen/gelatin, casein, serum, albumin, silks, chitin [34], whey
	Lipids/surfactants		Acetoglycerides, waxes, surfactants, emulsan
2. From microorganisms (obtained by extraction)	Polyesters		Polyhydroxyalkanoates, poly(hydroxyl butyrate) (PHB), poly (hydroxybutyrate co-valerate) (PHBV)
3. From biotechnology (conventional synthesis from bioderived monomers)		Polylactides	Poly(lactic acid) (PLA)
4. From petrochemical products (conventional synthesis from synthetic monomers)			Polycaprolactones, polyesteramides, aliphatic copolyesters (e.g., PBSA), aromatic copolyesters (e.g., polybutylene adipate-co-terephthalate (PBAT)), polyurethane (PU)
5. Synthetic or natural polymers reinforced with any other renewable resource-based materials	Variety of biofibers (as reinforcement)	Green polymers and resins	Lignocellulosic natural fibers, lignin, shellac, natural rubbers, vegetable (herbal) oils
		Biorenewable reinforcement	Ranging from natural clays to natural fillers including wood, straws, rice husk

Table 4.2 Some advantages and disadvantages of a number of natural biodegradable polymers [26,36,43].

Raw material	Advantages	Disadvantages
Starch	Availability, relatively cheap cost	Hydrophilic character, poor mechanical properties
Chitosan	Antimicrobial and antifungal activity, good mechanical properties	Low oxygen and carbon dioxide permeability, brittleness, high water vapor permeability
Zein	Good film forming, good tensile and moisture barrier properties, low water solubility (depending on the aim of packaging), resistant to microbial attack	Glossy appearance, tough, greaseproof, hydrophobic, brittleness, low water solubility (depending on the aim)
Whey protein isolate (WPI)	Desirable film formation, good oxygen barrier	Low tensile and strength properties, high water vapor permeability
Gluten	Low cost, good oxygen barrier properties, good film forming	High sensitivity to moisture, brittleness
Soy protein isolate (SPI)	Abundant, inexpensive, nutritional raw material, excellent film, high water absorption (this property may be good or bad depending on the aim of SPI application)	High water absorption, sensitivity against oxygen permeation, poor barrier properties, weak mechanical properties

Depending on the purpose, glossy appearance, toughness, hydrophobicity, grease-proofness, brittleness, and low water solubility Isolation of whey protein (WPI) favorable film development and an effective oxygen barrier.

The use of nanoparticles is a fantastic technique for improving the properties of biobased films [40]. Applications of nanotechnology in food packaging can create polymerstructures that are stronger, lighter, or more effective. Using titanium or silver dioxide nanoparticles as antimicrobials is one way to prevent food from spoiling. Indeed, adding nanoparticles to food packaging is a useful method of keeping moisture, CO2, and O2 out of the food and helping to keep it from spoiling [50].

Nonetheless, a wealth of important research has been conducted on diverse nanocomposites made of different materials. As an illustration, Ozilgen and Bucak [51] examined the functional characteristics and relationship between the nanostructures and the performance properties of bacterial polysaccharides (such as xanthan, cellulose), plant/algal polysaccharides (such as starch, agar,r, alginate, pectin), and animal polysaccharides (e.g., chitosan), and their main applications in the food industry [51].

Kadam et al. [39] developed a film implanted with titania (TiO2) nanoparticles using sonic technology to gain a consistent distribution of nanoparticles in WPI and characterized the results using different sonification levels. Their results showed that the incorporation of nanoparticles helps to recover the mechanical properties and to increase the thickness of films. They stated that WPI films implanted with nanoparticles can present a high promise for extending shelf-life and quality, and increasing the food safety in food packaging applications [39]. In addition, Malathi et al. [42] prepared SPI films implanted with titanium dioxide nanoparticles. The implanted nanoparticles successfully enhanced the opacity and thickness of the films [42].

Some methods for biopolymers production

There are different methods for producing biopolymers like solution casting, melt mix, electrospinning, thermo pressing and casting, and extrusion blowing [17], which can be used to change the properties of these materials. For instance,

Lopusiewicz et al. [53] used various fungal melanin concentrations as a modifier to prepare PLA-based composites using an extrusion method. The results showed that the mixing of fungal melanin with the PLA has the possibility to be developed as a value-added modifier due to improving of the overall properties of PLA. The mixture of PLA/melanin films exhibited valuable antioxidant activity and were active against Pseudomonas aeruginosa, Enterococcus faecalis, and Pseudomonas putida [53]. In another study, Thanakkasaranee et al. [54] prepared a series of poly(etherblock-amide) (PEBAX)/polyethylene glycol (PEG) composite films (PBXPG) using the solution casting procedure to investigate the effects of the integration of different molecular weight PEGs into PEBAX, and whether and how it would improve the composite films' performance in gas permeability as a function of temperature.

Based on the results, it was concluded that the high (H)-PBXPG composite films are suitable for safe microwave cooking and other applications as self-ventilatin

products [54]. In addition, Guidotti et al. [55] synthesized a biobased polyester (butylene 1,4-cyclohexane dicarboxylate) consisting of random copolymers as a material for flexible and sustainable packaging solutions using the lamination method. On the one hand, the linear butylene moiety was replaced by glycol subunits with alkyl pendant groups of diverse lengths. On the other hand, copolymers with different cis/trans isomer ratios of cyclohexane rings were produced. The presence of side alkyl groups considerably affected the formation of ordered phases that influence the functional properties, primarily the mechanical performance and barrier response. Specifically, the end products showed extensively improved barrier properties and a better flexibility compared to the homopolymer and all other polymers that are generally utilized for flexible packaging [55].

Biopolymers and active packaging

A trending topic in improved packaging designs is the incorporation of additives into packaging materials. Antimicrobial packaging contains films that have antimicrobial additives incorporated into a polymer film used for barrier protection.

These films maintain good physical barrier properties as well as the quality of the food. Accordingly, in the past few years, antimicrobial films for packaging Biopolymers and active packaging.

applications have received growing attention from the food industry [31].

Kuorwel et al. [56] investigated biodegradable polymers derived from polysaccharides and protein-based resources for their potential usage to design packaging systems for the protection of food products from microbial contamination [56].

Food-grade biopolymers as well as their inherent nutritional properties, can be adapted and designed for improving food quality and safety with imparting functions like active antibacterial and antiviral properties [57]. For example, food hydrocolloids are high molecular weight long-chain biopolymers that are made of high molecular weight polysaccharides and proteins. Hydrocolloids are commonly used as functional food additives in many food products to save or improve the sensory characteristics of the foods and drinks, to improve the shelf-life of the food products, to formulate the production processes so as to be simpler and more efficient, and to produce functional food products.

They can form films with applications as edible films and active packaging [51]. Razavi and Behrouzian [58] considered biopolymers from food hydrocolloids as fat replacers within foods such as cheese, ice cream, sauce, and yogurt due to consumer demand for low-fat or fat-free food products.

Hydrocolloids, the largest number of biopolymers have functional properties such as textural, viscosity, and feel that let them represent the sensory and flow characteristics like fat behavior [58]. The academic research and constant pursuit of improved technology designs in the packing industry has led to innovative solutions for the enhancement of food safety and its quality along with extending shelf-life. One of such researches was done with the aim of comparing two barrier materials, namely biodegradable natural PHB and petrochemical PU, mainly focusing on their antibacterial agent realization performance. The study indicated that the kinetic energy released by chlorhexidine digluconate (which was the active agent in both polymers), was considerably different because of the surface degradation and superposition of diffusion in PHB. This brought to light the effect of active biodegradable packaging on the base of PHB [59].

Liang and Wang [60] prepared an active film by incorporating different concentrations of cortex philodendron extract (CPE) as an active agent into an SPI. The results showed that the crystallinity of the films and new hydrogen bonds formed between molecules in the films were reduced. With the incorporation of CPE, the barrier performances against light, oxygen, and water vapor as well as the antioxidant activity of the SPI films were increased. The SPI/CPE films were successful against Staphylococcus aureus (Gram-positive bacteria). Thus they suggested that the shelf-life of foods may be extended with the use of SPI/CPE films [60].

In another study, Liang and Wang [61] developed a pH-sensing film using a natural dye extracted from litmus lichen (LLE) and tamarind seed polysaccharide (TSP). The characterization outcomes exhibited that the interaction between LLE and TSP was via hydrogen bonding. The film color differed from orange (pH 4.0) to blue/violet (pH 10.0). A full cream milk spoilage test indicated that this film is a perfect solution for detecting this spoilage problem. Therefore the developed pH-sensing film can be utilized as an assuring food spoilage indicator [61].

Recycling of Plastic Packaging Materials

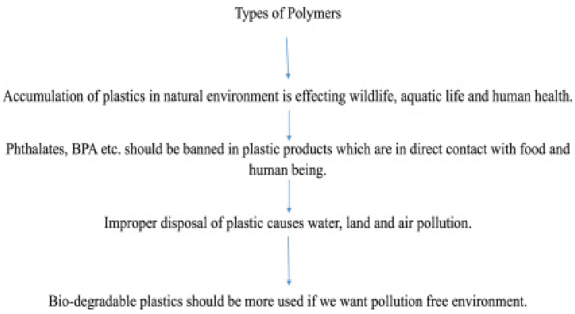
Packaging materials currently contribute significantly to economic progress but also pose major ecological challenges. The primary material used for packaging is plastic, and once consumed, these materials cannot be disposed of due to the pollution they generate [18]. "White pollution" is the name given to this kind of pollution. Recycling offers ways to cut down on the amount of oil used, carbon dioxide emissions, and waste that needs to be disposed of. Recycling that is mechanical, chemical, or organic can all be used to put this into reality. Mechanical recycling is a process that turns waste materials into "new" (secondary) raw materials while preserving or reconstituting the original polymer qualities of the material without altering its fundamental structure. It is a tried-and-true method for recovering material from traditional plastics (like PP).

PS, PET, and polyethylene (PE). Its primary benefit is in the fact that a portion of the resources used to produce the plastic materials are kept for use in the Encyclopedia of Polymeric Nanomaterials in the same, related, or other application. The majority of grades of biodegradable plastics as well as conventional plastics derived from biofuel may be recycled using this mechanical process. Waste that is contaminated or mixed can be recycled chemically to provide gaseous fuel or feedstock for chemical plants. Although feedstock recycling systems are more expensive than mechanical recycling, they fulfill the material recovery concept in general. Chemical recycling techniques include pyrolysis, hydrogenation, and gasification.

Future needs and trends: influence of polymers on the environment

This is an era where plastic pollution is increasing hazardously. Plastics are spreading all over the environment due to this it's a big threat to the equilibrium of the environment and health of the human beings. Its not due to their properties but it is also a strong carrier of pesticides, poly aromatic hydrocarbons, diphenyl, pharmaceutical products etc. Majorly plastics are being used everywhere like in packaging, water bottles etc. We have about to reach the stage where we require to produce biodegradable or recyclable plastic. It reduces the usage of oil, CO2 emission and reduces the quantity of waste to be disposed. Phthalates, BPA and others should be banned in plastic products which are in direct contact with food, children and biodegradable plastics should be more used. Our study focused on varieties of plastics, its hazardous impact on the environment especially on the environment, its recycling strategies and use of biodegradable materials.

Plastic pollution is on the rise in our day and age. 6.3 billion tons of plastic have been manufactured since the 1950s, and the seas or landfills are where these plastics end up. Polymers, which are mostly produced from petrochemicals, make up plastic. Plastics are primarily utilized everywhere, such as in water bottles and packaging. We are now on the verge of reaching the point at which it is necessary to develop recyclable or biodegradable plastic. Recycling is the most crucial step in lowering this. It lowers the amount of garbage that has to be disposed of, as well as CO2 emissions and oil consumption. In this article, we examined the many types of plastics and their detrimental effects on the environment, particularly the aquatic and overall environments.



Plastic waste buildup in the environment

The amount of plastic waste in landfills and the environment is growing daily. Furthermore, it is important to note that around 70% of the weight of the municipal garbage stream is made up of plastic waste [29].

In 2018, the subject of World Environment Day was "Beat plastic pollution." It was a call to action for all of us, saying that the time has come to act and implement some solutions to lessen the largest issue, which is plastic disposal.

We have now arrived at the point where the consequences for wildlife, marine life, and public health Compared to terrestrial environments, the degradation of light plastics in marine environments occurs much more slowly [30]. Polymer degradation can be chemical and physical change which occur in environmental conditions like light, wind, rain (moisture), heat etc. [31]. The plastic under these conditions is digested and turns into small fragments but not completely digested [32]. These semi-digested plastics are by mistaken eaten by marine animals while capturing the prey [33].

Techniques used for plastic disposal

Landfills: In our homes more than 90% of waste is managed by this method from which more than 10% waste is plastic [54].

Landfilling is one of the common method for managing public waste, but due to scarcity of land this method is now becoming a big problem [55]. By this method, many environmental problems occurred like in atmosphere methane gas is released. Methane has approximately 20 times higher greenhouse gas potential (GHG) than carbon-di-oxide. Another issue was leachate production due to landfills.

Beyond the fact that synthetic polymers are persistent in seas and cause water pollution due to their manufacture, they also represent a serious problem on land since they are frequently disposed of in landfills, where they will continue to slowly seep poisons into soil over decades. Less than 1% of the 102.1 billion plastic bags—a synthetic polymer—that Americans alone use year are recycled, according to the Clean Air Council group. In addition to their gradual release of toxic compounds into the soil, these synthetic polymers are so long-lasting and non-biodegradable that additional landfill space will always be required as long as synthetic polymer use persists and increases.

Bio-degradable plastics

The plastics which can be decomposed by the action of micro-organisms and results in the production of CO2 and H2O are named as biodegradable plastics. Recent studies revealed that there is huge difference in the disposal cost of Biodegradable and normal plastics To replace the petroleum-based plastics researchers suggested biodegradable plastics, mulch film and photodegradable plastics. Bio-degradable plastic which plays a great role in mulch film which is environment friendly are.

In our environment disposal of plastic is one of the major issues, as it has hazardous impact on human, wildlife, marine organisms and whole environment. Though plastics are very useful product in human life but its production and disposal both releases toxic chemicals. And reducing the toxicant released from plastics our community will make our environment clean. For doing this action, urgent need of policies, health authorities and government agencies are required. Phthalates, BPA etc.

Food Phoning

According to the U.S. National Institutes of Health, millions of seabirds perish each year as a result of ingestion of synthetic polymers that were mistaken for food, making this one of the most prevalent environmental issues linked to the pollution of synthetic polymers. This information pertains to 44% of seabird species. Due to their crucial ecological function in regulating fish and crustacean population numbers, shorebirds' widespread extinction poses a serious threat to the ecosystem.

Pollution from Production

In addition to obviously polluting the seas, the manufacture of synthetic polymers can have negative environmental effects. The DuPont chemical firm spilled contaminants used in Teflon manufacture into local watersheds over several decades, according to evidence provided by the Environmental Working Group group. The U.S. Environmental Protection Agency states that this substance builds up in fish gills and can move rapidly up the food chain.

Plastic Waste

Grocery bags and other plastic materials that are disposed of quickly clog drains and landfills. Animals like dolphins and turtles may consume trash that floats out to sea. The animals suffer from health issues caused by the plastic, including as nutritional depletion and stomach and intestinal blockages. Because plastic cannot be broken down by an animal's digestive system, it typically results in death. Plastic fragments can also entangle themselves around an animal's head or body, injuring or killing the animal.

Results and Discussion

For many years, polymers have helped ensure the safety and security of food by extending its shelf life and providing protection against contamination, manipulation, and damage. These polymers are primarily used in creative and clever packaging that is made with multilayer materials that have à la carte barrier properties, but they can also be edible polymers with comparable qualities. More security and longer shelf life for food items are now possible thanks to sophisticated polymers with clever properties that may be used for enhanced food packaging, food treatment, and the identification and measurement of target chemical species. However, the success of polymers in this area results in a constant increase in the volume of waste produced, which presents issues for recovery and recycling that need to be addressed by industry and researchers in the upcoming years. In addition, there are opportunities from prospects that are concurrent from an industry and research perspective.

Summary

In this day and age, synthetic polymers are generally manufactured from petrochemicals, which are nondegradable. The use of biodegradable polymers decreases the toxic effects that nonrenewable plastics have on the environment. Even though the complete replacement of all conventional polymers with environment-friendly materials is an almost impossible task to achieve, it is possible to at least try to do that in some applications such as in food packaging.

Common materials for producing green and environment-friendly packaging materials typically come from natural resources such as (but not limited to) plants or animal polysaccharides, plants or animal proteins, wood pulps, etc. These materials (bioplastics) can have applications in edible coatings, paperboards, carry bags, wrapping films, containers, etc.

To make up for the shortcomings of bioplastics, however, the incorporation of nanoparticles is a great method to enhance the performance of biobased films. It also reduces the waste associated with the packaging of processed foods that extend the shelf-life of fresh foods.

Even though, the use of bioplastics in replacing traditional plastics seems promising, it is, as the saying goes, “too good to be true!” Even if the use of nanotechnology helps in reducing the defects of bioplastics, the food industry applications of all bioplastics still require further investigations and research. For example, as the migration of monomers to food is a highly concerning issue in conventional packaging materials, the same issue should be considered for new bioplastic technology as well. The presence of nanoparticles, especially metallic nanoparticles, in bioplastics and their migration to foods can cause contamination and other health and safety problems that science may not yet be aware of. Therefore it is essential to study, assess, and understand the properties, structures, and behaviors of advanced materials for future food packaging applications. The best practice for a greener tomorrow, however, is to have the packaging industry and consumers reduce their production and usage of packaging materials respectively, and to create less waste in general.

Conflict of Interest

There is no conflict of interest in the publication of this article

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