A Comprehensive Review On Plasticizing Agent

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Abstract

Plasticizers are commonly used to give certain polymeric materials attractive mechanical properties. Such small molecule additives are also considered to leach from finished goods, and can affect not just the physical properties of the substance but also the distribution of these chemicals in the atmosphere and in the human body, posing long-term health and environmental risks. Plasticizers, polymer blends, and composites have all been stated to be successful in overcoming rigidity and brittleness. The aim of this analysis is to summarise the most recent research about how plasticizers affect the functional properties of biodegradable gelatin-based films. Plasticizers in films can disrupt the polymer matrix's continuity, resulting in physical changes. Plasticizers' plasticization effect improves the film structure, resulting in increased tensile strength and elongation of the films and decreased water barrier properties. We distinguish various types of plasticizers based on their chemical structure and purpose in this study, and we highlight recent developments in multifunctional plasticizer applications.

Keywords: plasticizers, uses, effect, variety, mechanism

Introduction

Plasticizers, polymer blends, and composites have all been identified as useful solutions for overcoming rigidity and brittleness. Latest research on the biodegradability and utility of maleic and fumaric esters as green plasticizers influenced the preference of plasticizer¹. Plasticizers are used to overcome the brittleness of starch, which is added to improve polymer flexibility, processing, and workability. Plasticizers are molecules that are normally small in size, such as polyols such as glycerol and sorbitol, that intersperse between polymer chains, break hydrogen bonds, and distribute the mobility of the polymer chains apart, enhancing flexibility². The essence of the polymer matrix and plasticizer, as well as solubility in the polymer matrix, plasticizer material, and thermal stability at the processing temperature, all influence the plasticizer choice³⁴.

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¹ References: 1. Plasticizer choice based on biodegradability and utility of maleic and fumaric esters.
2. Effect of plasticizers on polymer matrix and flexibility.
3. Influence of plasticizers on solubility and material properties.
4. Thermal stability considerations in plasticizer choice.
While certain polymeric materials have appealing properties, they are difficult to handle or process. In certain cases, adding a plasticizer has little effect on these properties, but it increases the material's processability and makes it easier to handle. Even if plasticizers are used in quantities up to 55 percent, the polymer remains the most important part of a polymeric material. Plasticizers are chemical intermediates whose properties have a significant impact on the performance of the products to which they are added. Plasticizers are nonvolatile, high boiling, low molecular weight compounds that are applied to a polymer to enhance processability, durability, and stretchability by changing the mechanical properties of the film, lowering the melt viscosity, and lowering the Tg of the product without changing the fundamental chemical character of the plasticized material. As plasticizers are added to a polymer framework, they increase the free volume between the polymer chains, allowing the chain segments to travel and rotate more freely, resulting in decreased polymer Tg and melt viscosity.

Furthermore, no comparative analysis of various forms of plasticizers (glycerol (GLY) and sorbitol (SOR)/antimicrobial agents (potassium sorbate (KS) and grapefruit seed extract (GFSE) integrating into corn starch (CS) with chitosan (CH) nanoclay (NaMMT) based biodegradable films for food packaging applications has been conducted. Plasticizers are among the most important additives required for the processing of polymer materials, especially polyvinyl chloride (PVC) plastics, which accounts for more than 60% of the total yield of plastic auxiliaries. Traditional petroleum-based phthalate plasticizers are the most widely used globally. Traditional phthalate plasticizers produce and consume a significant portion of total plasticizer output and sales, but they are being phased out due to possible health and environmental risks. When a plasticizer is applied to a polymer, it weakens the intermolecular subvalent bond force, lowers crystallinity, increases relative movement between molecular segments, and improves the material's plasticity. Citric acid ester, phosphates, polyesters, halogenated alkanes, and epoxy compounds are examples of plasticizers that are often used to reduce stiffness, softening temperature, elastic modulus, and embrittlement temperature.

There are two ways to change the properties of plasticization. The first is to use substances in which the polymer forms stable chemical bonds. As a result, segments that cause chain separation modify their molecular structure. Internal plasticization is the term for this effect, and it occurs when grafting methods are used to achieve it.

External plasticization is the second method, which involves mixing an inert material with the polymer at a certain temperature to produce a homogeneous mixture. Substances with varying properties and prices can be used in this situation, and the plasticizer/polymer ratio is also a variable.

**Primary plasticizers**: Primary plasticizers have the potential to improve polymer versatility effectively. The only plasticizer used is a main plasticizer, which is miscible with the polymer in all proportions. In the usual manufacturing temperature range, they can gel the polymer quickly and not exude from the plasticized substance. Adipates (e.g. dioctyl adipate), citrates, sebacates (e.g. dioctyl sebacate), azelainates, trimellitates, phosphoric acid esters, or epoxy softeners are examples of primary plasticizers; however, phthalates are the most common.

**Secondary plasticizers**: Secondary plasticizers are less polar than primary plasticizers and therefore have limited compatibility with polymers. They have a low solubility and compatibility, which is why they're often used with main plasticizers. Not only do such mixtures have less of a propensity to migrate, but they also have more consistency and tolerance to precipitation at lower temperatures.
Trends in plasticizer production

The plasticizer market is growing at the same time as the plastic industry. Plasticizer demand in the United States peaked at 2 billion pounds a year in the early 1990s, with 1.25 billion pounds of phthalates. By 1999, the worldwide market for plasticizers had risen to 10.1 billion pounds ($7 billion), while North America's gross plasticizer demand was 2.2 billion pounds. Plasticizers are currently used in large quantities in Europe, North America, and Japan, accounting for 28, 22, and 10% of global production, respectively. According to estimates from the early 2000s, the actual overall growth rate for plasticizer demand is about 2.8 percent per year.

Plasticizers used in industry today

PVC, poly(vinyl butyral) or PVB, poly(vinyl acetate) or PVA, acrylics, cellulose moulding compounds, nylon, polyamides, and some copolyamides are among the most commonly plasticized polymers. PVC accounts for around 80% of all plasticizers used on average. The chemical composition of the plasticizer determines the degree of plasticization of polymers. Chemical structure, MW, and functional groups are also included. Plasticizers with a medium melting point and a minimal number of polar groups are more flexible and plasticizing.

Plasticizers come in a variety of forms.

Polyethylene glycol (PEG-400)

PEG has emerged in recent years as a potent phase-transfer catalyst capable of a wide range of useful organic transformations under moderate reaction conditions. PEG is also a low-cost, simple-to-handle, thermally stable, non-toxic, and recyclable medium. As a result, PEG-400 has proven to be an effective catalyst for a variety of chemical reactions.

Glycerol

Triglycerides are made up mostly of glycerol, which can be present in animal fat, vegetable oil, or crude oil. Glycerol comes from the processing of soap or biodiesel. It has been known since 2800 BCE, when it was discovered when fat combined with ashes was heated to make soap. According to IUPAC, glycerol is known as propane-1,2,3-triol, and is the easiest of the alcohols. It is also commercially known as glycerin, 1,2,3-propanetriol, trihydroxypropane, glycero|tol or glycidic alcohol. Glycerol is an oily liquid; it is viscous, odorless, colorless, and has a syrupy-sweet taste. Glycerol is a liquid containing three hydrophilic hydroxyl groups that are responsible for it being hygroscopic and its solubility in water.

Triethyl citrate

Triethyl citrate (TEC) is a renewable source plasticizer that is non-toxic and environmentally beneficial to humans, wildlife, and the environment. TRI or TEC has been used as a plasticizer in polymers such as PLA and PVC, with confirmed reductions in glass transfer and melting temperatures, implying improved flexibility and processibility.

Plasticizing Agents' Mechanism

Soluplus is a new amphiphilic polymer that can be used as a solubilizer for polymeric materials. It's a grafted copolymer of polyvinyl caprolactam, polyvinyl acetate, and polyethylene glycol. Hot melt extrusion,
KinetiSol dispersing, and electrospinning techniques improved the solubility and dissolution rate of BCS Class II drugs like Itraconazole, Meloxicam, and Spironolactone\textsuperscript{49,50}. When pure Soluplus films were pulled from the Teflon mould, they still separated into small fragments, making it difficult to make intact films. As a result, developing pure Soluplus film formulations without the addition of a plasticizer would be extremely difficult\textsuperscript{51-54}. To fully exploit Soluplusability\textsuperscript{®}s as a solubilizer and solid dispersion carrier, plasticizers would be used to adjust the thermal and mechanical properties of the formulations\textsuperscript{55}. PEG-6 is the most effective plasticizer in modifying the mechanical properties of the Soluplus\textsuperscript{®} formulations\textsuperscript{55}.

**Effect of Dibutyl Phthalate Replacement with Dibutyl Sebacate on Eudragit®**

RS Polymers Eudragit® RS polymers are commonly used as rate-controlling film formers for sustained-release dosage forms\textsuperscript{56}. The type of plasticizer used in Eudragit® RS 30D influences the drug release characteristics by influencing the surface and mechanics of the film created by the polymer. To increase the plasticity of the polymer and lower the required film formation temperature, which is approximately 45°C, the film coating process using Eudragit® RS 30D polymer dispersion coating solutions requires the necessary concentration of plasticizer\textsuperscript{57}. Many synthetic polymer film coating systems consider dibutyl phthalate to be very safe, and it is used in a very limited volume. The use of dibutyl phthalate has been well researched and published in the literature, with results indicating that it decreases the brittleness of synthetic film forming polymers and improves the film's mechanical properties\textsuperscript{58}.

**Sorbitol Plasticizer's Impact**

Poly(vinyl alcohol) (PVA) is a type of environmentally friendly polymer that has properties including water solubility, clarity, fine flexibility, biodegradability, and barrier properties\textsuperscript{59}. Plasticizing is a physical alteration of PVA. PVA may be melt processed by incorporating small molecular compounds that could form associations with the matrix\textsuperscript{60}. PVA's most powerful plasticizer is water. Water will evaporate during fermentation, leaving the resulting films brittle due to the lack of plasticizers. As a result, water is often used as a plasticizer. Polyol, such as glycerol, is another plasticizer that can be used in PVA films\textsuperscript{61}. This plasticizers increased the stability and ductility of the resulting films by increasing the mobility and free volume of the PVA. Plasticizers are often chosen for a device based on the amount of plasticizing needed, the plasticizer's retainability and compatibility, and the desired physical properties of the films. Sorbitol's active hydroxyl groups make it a good plasticizer for polymers with a lot of -OH or –NH\textsuperscript{62}.

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