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Plastics in the environment and trends for the future

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ABSTRACT

The studies carried out are about the first molecules, classification, properties and environmental problems caused by the rampant disposal of plastics. In this context, with the increase in the unbridled consumption of plastic, which has been contributing to major contamination in all environments, mostly culminating in the oceans. It should be noted that polypropylene is one of the most used polymers in the manufacture of flexible plastic packaging and the accumulation of these materials in the environment, especially in the oceans, has been causing several negative impacts on the planet's biodiversity. An alternative to the problems caused by the improper disposal of this waste would be the replacement of traditional plastics with biodegradable and compostable polymers from renewable sources whose life cycle tends to be less polluting, since, under favorable conditions, they degrade in biologically active environments, not producing toxic waste for the environment. Therefore, it becomes necessary to implement legislations that favor the use of bioplastics over conventional plastics and the changes in consumer behavior that drive the market for biopolymers. The problems of plastics in the environment and in human health are presented as a function of the understanding of the concerns, in addition to a look at priorities, challenges, opportunities that bring benefits with the application of plastics in the future. However, about the use and disposal that have been increasing, and the need to recycle and reverse this trend, so that they can be considered end-of-life materials, as valuable raw materials for new production, instead of waste.

Keywords: Synthetic polymers, Coronavirus, Environmental pollution, Bioplastics.

1 INTRODUCTION

Plastics are produced from petroleum derivatives, composed mainly of hydrocarbons, and the most commonly used are: polyvinyl chloride (PVC), polypropylene (PP), polyethylene (PE), polystyrene, nylon, and polyethylene terephthalate (PET) (URBANEK et al., 2018; MATJAŠIČ et al., 2021; BAHL et al., 2021). Polyethylene (PE) and polypropylene (PP) are the most widely used, accounting for a share of 54% (BAHL et al., 2021).

Polyethylene is widely used in agricultural environments, with the main purpose of maintaining temperature, soil moisture, and restricting weed growth (DING et al., 2019). However, after use they are broken into pieces that reduce soil quality, impairing the transport of water and nutrients, leading to crop malnutrition and reduced yield (HOU et al., 2019). Generally, the removal of polyethylene pollution is carried out through collection and incineration, which is expensive and highly toxic with the emission of harmful and poisonous gases into the air (BRIASSOULIS et al., 2015).

Thus, the management of post-consumer plastics, such as incineration and landfills, promote catastrophic damage to ecosystems, such as the release of toxic compounds into the soil and/or atmosphere, since many are greenhouse gases or carcinogenic substances.

These contaminants are emitted because of the incineration process (PERUGINI et al., 2005; TEUTEN et al., 2009; DHAKA et al., 2022). Some of these toxic compounds emitted and released are benzene, toluene, xylene, styrene, polycyclic aromatic hydrocarbons, chlorine compounds, heavy metals, carbon monoxide and dioxide, free radicals, aldehydes, acids, ketones, lactones, saturated hydrocarbons, cyclic ethers, cyclic esters, alkenes, and dienes (ARACIL et al., 2004; SIDDIQUI & REDHWI, 2009; DHAKA et al., 2022).

Another damage caused by improper disposal of plastics causes blockage of the gastrointestinal tract and strangulation in fish, birds, and mammals (SPEAR et al., 1995; DHAKA et al., 2022).

Biodegradation is defined as the environmentally friendly method, where microorganisms that have high enzymatic potential can cleave polymers into smaller monomers, which are used as a carbon source and later mineralized (ALSHEHREI et al., 2017). According to MONTAZER et al, (2020) the biodegradation of complete polyethylene has not yet been described. In this sense, research on plastics, especially polyethylene, considering the problems caused to the environment, and human health. However, plastics had important applications during the pandemic in the preparation of PPE, which is essential for protection by reducing the spread of SARS-CoV-2, in the control of the pandemic, and in the pursuit of environmental sustainability.

2 HISTORICAL EVOLUTION OF POLYMER DEVELOPMENT

The word polymer (from the Greek poly, many, mere, parts) was created by Berzelius, in 1832, to designate compounds of multiple molecular weights, with the contribution of Chemistry to industrial development, with these polymeric materials. Polymers are macromolecules that are characterized by their chemical structure, size, and intra- and intermolecular interactions, which have chemical units linked by covalence, repeated along the chain. (BRO; MENDES, 1999).

Cotton, proteins, rubber, starch, and wood (natural materials) were the first polymers that were used, where their use was mainly made from the extraction of resins from trees used in the manufacture of thickeners, paper, glues, cosmetics, jewelry and a diversity of materials (SPERLING, 2006). In the mid-nineteenth century, modified polymers began to be produced from natural macromolecules, presenting more versatility for commercial applications. The Parkesine resin, considered the first plastic material, was synthesized in 1860, produced from the modification of cellulose nitrate, by the English creator Alexander Parkes, but without commercial viability due to the high cost of manufacture and being flammable. From Parkes' discovery, the American typographer John Wesley Hyatt began to carry out his experiments with parkesin and developed celluloid. And from cellulose nitrate with the addition of alcohol, sawdust, camphor, pyroxylin and paper pulp created a natural ivory substitute. Celluloid became the first viable artificial plastic, widely used in dental prostheses, as it is a solid and stable version of nitrocellulose. (LOPES, 2007).

In the twentieth century, with the advancement in polymer science, Leo Baekeland carried out the first large-scale industrial production of bakelite resin. Later, several polymers were developed including polyvinyl chloride (PVC), polystyrene (PS), polyamide (Nylon), polyacetyl chloride (PVA), polyethylene terephthalate (PET), polymethyl methacrylate (PMMA), polyvinylidene chloride (PVDC), high and low density polyethylene (HDPE and LDPE), and molding techniques were also developed, enabling the use of these plastics in a very diverse way. (LOPES, 2007).

In 1920, with the theory of the macromolecule, proposed by Staundinger, some materials known as colloids, formed by several molecules, could originate compounds with 10,000 or more carbon molecules, being the great reference in the history of polymeric materials. Thus, several studies have led to the discovery and development of various polymers, as shown in Table 1 (CANEVAROLO 2002; ROSE; PANTANO FILHO, 2003; PADILHA, 2007).

Table 1- Historical evolution of polymers

Polymers	**1st Occurrence**	**First. Industrial Production**
PS	1900	1936/37
PVC	1915	1933
LDPE (LDPE)	1933	1939
NYLON	1930	1940
HDPE (HDPE)	1953	1955
PC	1953	1958
PP	1954	1959

Source: CANEVAROLO (2002).

3 VARIETIES OF SYNTHETIC PLASTICS AND APPLICATIONS

The different types of plastics are intended to serve the market, demonstrating applicability in many sectors. In this context, the wide variety of most used plastics are listed in Table 2,

Table 2- General Applications of Synthetic Polymers

POLYMERS	APPLICATIONS
Polyethylene	Plastic Tote Bag, Water Bottle, Food Packaging, Toy, Irrigation & Drain Pipe, Motor Oil Bottle.
Polystyrene	Disposable Cups, Laboratory Supplies and Electronic Products.
Polyurethane	Tires, Sealing, Bumpers, Refrigerator Insulation, Sponges, Mattresses and Life Jacket.
Vinyl Chloride	Car Seat Covers, Shower Curtains, Rain Covers, Shoe Soles, Greenhouses, Cables and Electricity Pipes.
Polypropylene	Bottle Caps, Beverage Straws, Medicine Packaging, Car Seats, Car Batteries and Disposable Syringes.
Polyethleno Terephthalate	Soft drink bottles and textile fiber.
Nylon	Windshield wipers, Helmets, Paints and fabrics.
Polycarbonate	Car Headlights, Baby Bottles, Kitchen Utensils, Greenhouse Roofs, Solar Heaters.
Polytetrafluoroethylene (Teflon)	Spectacle lenses and pans.

Source: Vona et al., (1995).

According to the polymer market, the growth of the most consumed industrial products worldwide is related to their properties and economic value, being suitable materials for the application of packaging and durable goods (GONÇALVES, 2009). Thus, the sectors that most demand polymers are as follows: Packaging (30%); Automotive (20%); Electronics (15%); Civil construction (15%); Textiles (15%) and Others (5%) (ROSA; PANTANO FILHO, 2003).

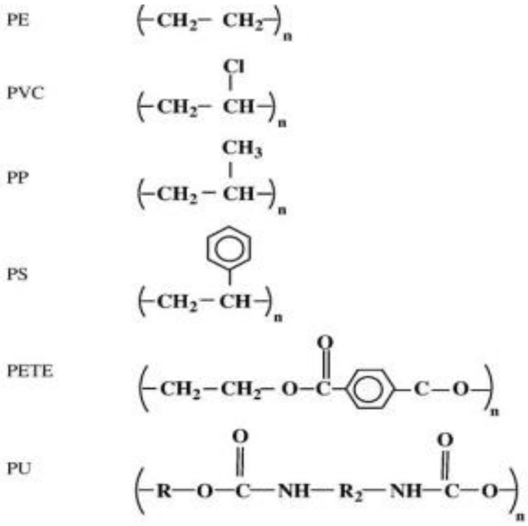
All polymers are macromolecules, but not all macromolecules are considered polymers. Almost all these materials have a molecular weight between 104 and 106, however, it is possible to find some natural polymers with a very high molecular weight of 108 or more. The degree of polymerization is established by the number of groupers in the polymer chain, usually known as n or DP ("degree of polymerization") (MANO; MENDES, 1999; DE PAOLI, 2009). The molecular weight of the polymer is made up of the molecular weight of the monomeric unit Mu and the product of the degree of polymerization n (NOGUEIRA; SILVA; SILVA, 2000).

3.1 CHARACTERIZATION OF SYNTHETIC POLYMERS

Cross-linked polymers have cross-links where a union occurs between two main chains. These bonds can be weighted in such a way that a polymer lightly or highly, or with low or high cross-link density, respectively, is obtained (LUCAS; SOARES. MONTEIRO, 2001).

Regarding their chemical structure, they can be classified as homogeneous, when the chain is composed only of carbon atoms, and as heterogeneous, when it is composed of atoms that are different from carbon, as shown in Figure 1 (MANO; MENDES, 1999).

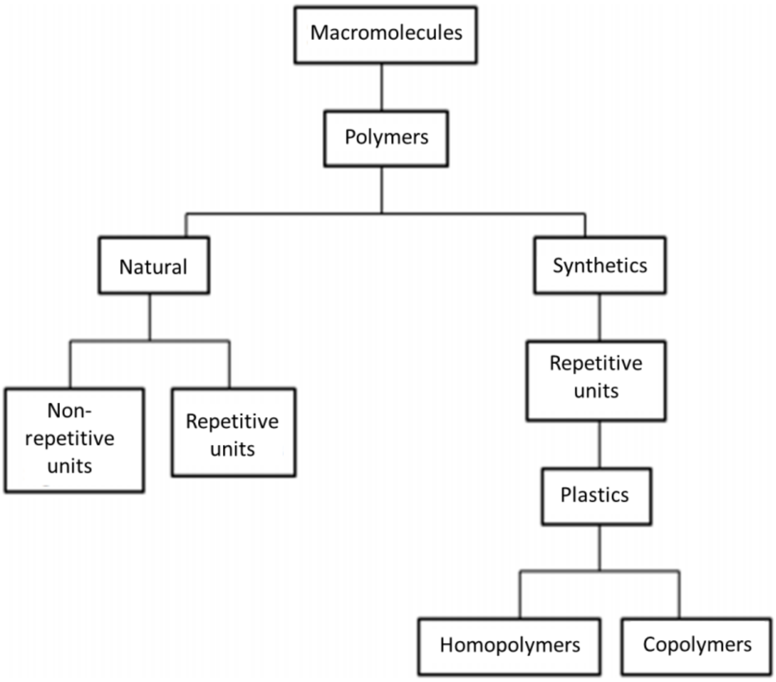
Figure 1. Structures of plastics of conventional petrochemical origin: Polyethylene (PE), Polyvinyl chloride (PVC), Polypropylene (PP), Polystyrene (PS), Polyethylene terephthalate (PET), Polyurethane (PU). [Source: (D.L. Paiva et al., 1988]



To understand the synthesis and degradation of plastics, it is important to understand the morphology, structure, and physical, chemical and mechanical properties of polymers, and to understand the difficulties and motivations, as shown in Figure 2.

Polymeric materials can be classified into different forms, such as molecular structure, mechanical behavior, chain nature, morphology, type of reaction, type of monomers, and spatial arrangement of monomers. Based on molecular strengths, polymers are classified as elastomers, fibers, thermoplastics, and polymers (ALVES, 2005;).

Figure 2 – Flowchart of some polymer classifications.



Source: LUCAS; SOARES; MONTEIRO (2001); OLATUNJI, (2016); OLATUNJI, 2016;)

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4 SYNTHESIS AND CATEGORIES OF SYNTHETIC POLYMERS

Regarding the shape behavior when polymers are subjected to high temperatures, they can still be classified into thermoplastics and thermosets. Thermoplastics, linear and branched polymers, are those that soften when heated, being considered a very important characteristic, because in this way it is possible to mold the plastic, so that it can be reused several times (ANDRADE, 1995 apud ALVEZ, 2005). Thermosets, which originate from cross-linked polymers, are those that, when heated once, soften and undergo the process called curing (irreversible chemical transformation), becoming rigid. After this procedure occurs, the plastic becomes insoluble infusible, no longer softening, consequently, in this way, it cannot be reused in molding for new materials, presented in Tables 4 and 5. (CANEVAROLO, 2002; ALVES, 2005).

According to morphology, polymers can still be classified as amorphous and semi-crystalline. Those in which molecules are randomly oriented are called amorphous; and the semicrystalline ones are formed by amorphous and crystalline regions, where in the molecular chains they are perfectly aligned. Strong intermolecular interactions make the material resistant and harder than amorphous ones (ALVES, 2005).

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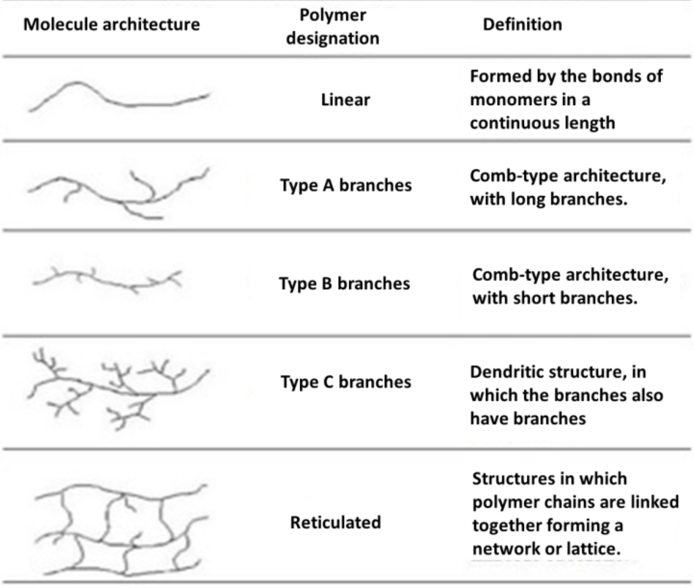
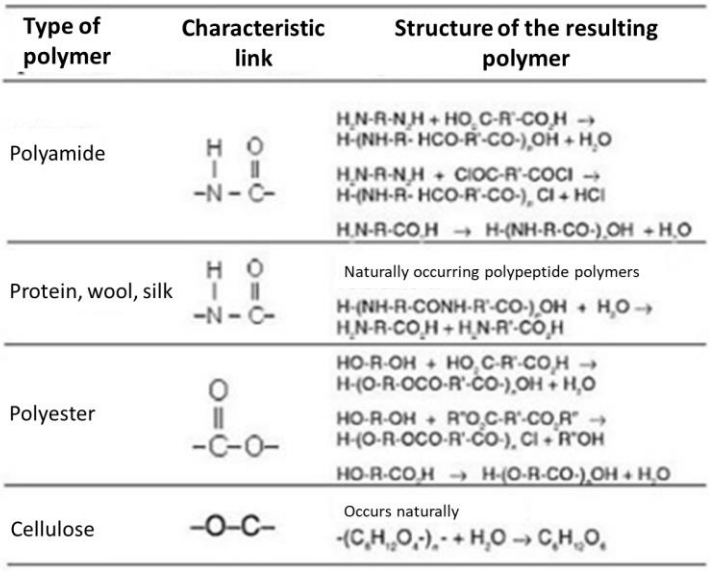
Table 4 – Classification of polymers according to their form fixed by the bonds



Molecule architecture	Polymer designation	Definition
	Linear	Formed by the bonds of monomers in a continuous length
	Type A branches	Comb-type architecture, with long branches.
	Type B branches	Comb-type architecture, with short branches.
	Type C branches	Dendritic structure, in which the branches also have branches
	Reticulated	Structures in which polymer chains are linked together forming a network or lattice.

Table 5 – Condensation-Formed Polymers



Type of polymer	Characteristic link	Structure of the resulting polymer
Polyamide	$-\overset{\mathrm{H}}{\overset{\vert}{\mathrm{N}}}-\overset{\mathrm{O}}{\overset{\Vert}{\mathrm{C}}}-$	$H_2N\text{-}R\text{-}N_2H + HO_2C\text{-}R'\text{-}CO_2H \rightarrow H\text{-}(NH\text{-}R\text{-}HCO\text{-}R'\text{-}CO\text{-})_nOH + H_2O$ $H_2N\text{-}R\text{-}N_2H + ClOC\text{-}R'\text{-}COCl \rightarrow H\text{-}(NH\text{-}R\text{-}HCO\text{-}R'\text{-}CO\text{-})_n Cl + HCl$ $H_2N\text{-}R\text{-}CO_2H \rightarrow H\text{-}(NH\text{-}R\text{-}CO\text{-})_nOH + H_2O$
Protein, wool, silk	$-\overset{\mathrm{H}}{\overset{\vert}{\mathrm{N}}}-\overset{\mathrm{O}}{\overset{\Vert}{\mathrm{C}}}-$	Naturally occurring polypeptide polymers $H\text{-}(NH\text{-}R\text{-}CONH\text{-}R'\text{-}CO\text{-})_nOH + H_2O \rightarrow H_2N\text{-}R\text{-}CO_2H + H_2N\text{-}R'\text{-}CO_2H$
Polyester	$-\overset{\mathrm{O}}{\overset{\Vert}{\mathrm{C}}}-\mathrm{O}-$	$HO\text{-}R\text{-}OH + HO_2C\text{-}R'\text{-}CO_2H \rightarrow H\text{-}(O\text{-}R\text{-}OCO\text{-}R'\text{-}CO\text{-})_nOH + H_2O$ $HO\text{-}R\text{-}OH + R''O_2C\text{-}R'\text{-}CO_2R'' \rightarrow H\text{-}(O\text{-}R\text{-}OCO\text{-}R'\text{-}CO\text{-})_n Cl + R''OH$ $HO\text{-}R\text{-}CO_2H \rightarrow H\text{-}(O\text{-}R\text{-}CO\text{-})_nOH + H_2O$
Cellulose	$-O-C-$	Occurs naturally $\text{-}(C_6H_{12}O_4\text{-})_n\text{-} + H_2O \rightarrow C_6H_{12}O_6$

Source: Lucas; Soares; Monteiro, (2001).

4.1 CHARACTERISTICS AND PROPERTIES OF THERMOPLASTICS

Thermoplastics have the following characteristics: high molecular weight polymers; chains in the polymer are associated with intermolecular forces; the intermolecular force acting between the chains becomes weak with increasing temperature and produces a liquid with high viscosity; And these polymers can be remodeled. These polymers are different from thermosetting polymers because thermosetting polymers do not fuse when heated.

Thermoplastics are recyclable. These are lightweight, high-strength polymers and act as flame retardants (xx).

Additionally, polypropylene has a low tolerance to ultraviolet rays, additives such as prevented amines stabilize light and extend shelf life compared to unmodified polypropylene. Clarifiers, flame retardants, glass fibers, minerals, conductive fillers, lubricants, pigments, and a variety of other polymeric additives can improve the physical and/or mechanical properties of polypropylene.

4.1.1 Polypropylene Copolymer (PP Flake)

Polypropylene copolymer (PP Cup) is a transparent material, more flexible and resistant (except chemical resistance) than homopolymer. When modified with elastomers, it becomes more resistant to impact. In addition, it has high mechanical resistance at low temperatures.

4.1.2 Copolymer polypropylene can be either heterophasic or random.

Random copolymer polypropylene is produced by the random addition of a comonomer (usually ethylene) in the polymerization reaction. In this way, ethylene partially replaces propylene in the polymer chain.

The presence of the co-monomer decreases the tendency to crystallization, which results in an increase in impact strength, greater resistance to bending, and increased transparency of the polymer. Due to the low crystallinity, random copolymer polypropylene also has lower density and lower melting temperature.

Heterophasic (or block) copolymer polypropylene is a type of polymer where there is an elastomeric phase dispersed in the matrix, arising to meet the demand for polymeric materials with good impact resistance, including at low temperatures, a property not found in homopolymer polypropylene. However, because it is a polymeric material, it has a high coefficient of thermal expansion when exposed to temperature variations, in addition to having a high thermal contraction after its injection.

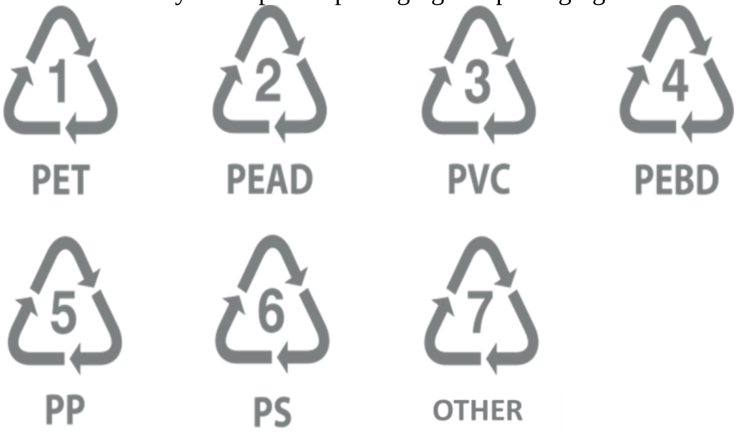
5 FORMS OF IDENTIFICATION OF PLASTICS

These codes indicate the type of polymer that is in the products. When the numbering is located, the waste is separated and segregated according to its nature. Code "7 – Other Plastics" is used for less common plastics, such as polyamide, polycarbonate, or other miscellaneous combinations of other polymers. The standard in this case suggests that the use of the polymer acronym should be below the symbol.

Much of the plastics that have already been consumed are sent to landfills or are incinerated, only 7% is recycled. This process has great complexity, and can be divided into four categories of recycling: primary, secondary, tertiary and quaternary. Primary recycling, also known as closed-loop, corresponds to a mechanical processing and has as a product a material with similar characteristics, the secondary, or declassification recycling, produces materials where the properties differ from each other, but is still considered a mechanical recycling. The tertiary, raw material recovery or chemical recycling, aims at the recovery of the chemical elements, that is, the raw material, through the depolymerization of the original plastic. And finally, quaternary, or energy recovery, aims to recover the energy that the compounds of the initial steps possessed (Figure 9) (WILLIAMS & WILLIAMS, 1999; FISHER, 2003; SONG et al., 2009; HOPEWELL et al., 2009

The NBR 13.230 standard of ABNT brings the symbology of identification of plastic products and raw materials, according to Figure 3.

Figure 3. ABNT NBR 13.230 standard with the symbology of identification of plastic products and raw materials. [Image source: ABNT NBR 13230 Standard - Recyclable plastic packaging and packaging - Identification and symbology].



6 PROPERTIES OF THE MAIN TYPES OF PLASTICS

6.1 POLYETHYLENE TEREPHTHALATE – PET

Rigid and transparent material undergoes slow crystallization, is amorphous, absorbs a lot of moisture (as it is an ester) melts under temperatures close to 265ºC. It has excellent impact resistance, low permeability to gases (CO2). Some applications of PET are: filaments (weaving threads), magnetic tapes, X-ray films, printing laminates, food cooking packaging, carbonated beverage bottles, food bottles, cosmetics, and cleaning products.

6.2 HIGH DENSITY POLYETHYLENE – HDPE (HDPE)

Opaque material due to its higher density and high degree of crystallinity. It has higher mechanical properties than LDPE and LLDPE. It is resistant to low temperatures, light, waterproof, rigid, with excellent chemical and mechanical resistance. Very chemically resistant, which allows its application in the packaging of cleaning products and chemical products. Also used in the manufacture of auto parts.

6.3 POLYVINYL CHLORIDE – PVC

This plastic material has great importance due to its great versatility, that is, with the addition of additives such as plasticizers, lubricants, stabilizers, pigments and dyes, fillers among other additives, it is possible to obtain a multitude of "grades" with very different properties for different applications. PVC is used in food, cosmetics, and medicine packaging; in hoses in general; in civil construction in pipes and fittings, in conduits, in covering wires and cables, in lining, in floor covering, in frames and windows; as "synthetic leather" for the footwear, handbags and upholstery industry; medical-hospital accessories, among other various applications.

6.4 LOW-DENSITY POLYETHYLENE AND LINEAR LOW-DENSITY POLYETHYLENE – LDPE AND LLDPE (LDPE AND LLDPE)

Material with low electrical and thermal conductivities. It is resistant to chemical attack. It is non-toxic. Flexible, light and transparent (when at low thicknesses). Widely used in packaging for food and personal care products, pipes for irrigation, wire insulation, etc. LLDPE is mainly used in the production of flexible food packaging.

6.5 POLYPROPYLENE HOMOPOLYMER – PP HOMO

High temperature resistant material that can be sterilized. Good chemical resistance and few organic solvents can solubilize it at room temperature. Compared to HDPE, it has lower density, higher softening point, higher surface hardness, higher rigidity, lower impact resistance, higher sensitivity to oxidation, better resistance to cracking stress and higher brittleness at low temperatures. Material widely used in the manufacture of hinged parts, auto parts, food packaging, fibers and monofilaments, among others.

7 IMPACTS CAUSED BY PLASTICS TO THE ENVIRONMENT

7.1 APPLICATION OF PLASTIC IN REDUCING SARS-COV-2 CONTAMINATION

The novel Coronavirus (SARS-CoV-2) has wreaked havoc around the world, affecting almost every country. Several countries are currently battling the second or third wave of the virus, which is wreaking far worse havoc than the first. A variety of plastic-based personal protective equipment (PPE) has been instrumental in protecting people during the COVID-19 pandemic. Every day, a significant amount of single-use PPE, including masks, gloves, protective aprons, face shields, safety glasses, containers with disinfectants, plastic shoes, and aprons (made mostly of polypropylene) are discarded by healthcare workers and the general public. Although, this personal protective equipment reduces the spread of SARS-CoV2, the lack of sustainable management poses a serious threat to public health and the environment. Because the SARS-CoV-2 virus can survive in discarded medical waste for up to 168 hours, medical waste coming from hospitals, clinics, medical centers, home isolation, and quarantine facilities where the infected individual is receiving treatment is likely to spread and increase the infectivity of the virus. Therefore, the environmental consequences for human health of single-use personal protective equipment aimed at the proper use of plastic in PPE to reduce the spread of SARS-CoV-2 (PRATA et al., 2020; ZAKIA et al., 2023; MORAES, G.H.; COLTRO, 2023).

7.2 DISPOSAL AND HANDLING OF POST-CONSUMER PLASTICS

It is estimated that the amount of plastic waste that will be generated in the year 2060 will increase to 265 million metric tons (LEBRETON and ANDRADY 2019). In addition to causing visual pollution, plastic waste causes changes in biogeochemical cycles and environmental matrices (SANZ-LÁZARO et al. 2021; WANG et al. 2021).

Most of this waste is consumed in high- or upper-middle-income countries. This problem arose a few years ago, and it has already been found that more than 75% of all plastic that has been produced has become waste (SILPA KAZA et al, 2018).

Of all solid waste collected in urban cleaning, 13.5% is plastic. Of this total, most are disposable packaging, such as bottles, bags, jars, jars, and films (VILHENA et al, 2018). According to the National Association of Waste Pickers (ANCAT), PET, LDPE and HDPE represent almost 70% of the types of plastics that are found in urban waste in 2018, as they are the main constituents of packaging (ANCAT - National Association of Waste Pickers).

Plastic waste is classified according to its size into megaplastics (> 1 m), macroplastics (2.5 cm–1 m), mesoplastics (5 mm–2.5 cm), microplastics (1 – 5,000 µm), and nanoplastics (< 1 µm) (Lippiatt et al. 2013). Their residues are pollutants that are persistent to degradation, remaining for long periods and potentially affecting the biota (VAN BIJSTERVELDT et al. 2021; AZEVEDO-SANTOS et al. 2021). Given its ubiquity, a diverse set of organisms interact with plastic waste in their daily lives (e.g., nesting material), can entangle, and/or ingest plastic (JAGIELLO et al. 2019; KÜHN and VAN FRANEKER 2020; AYALA et al., 2021; AYALA et al. 2022a,b).

The accelerated consumption of plastics generates a large amount of waste, which the world is not prepared to deal with. In 2022, Brazil generated 64 kilograms of plastic waste per person. Plastic waste is the most common pollutant found in the planet's water bodies, accounting for 48.5% of the materials that leak into the seas. The most recent data show that about 22 million tons of plastics leak into the environment each year worldwide, and a considerable part of it is destined for the oceans (MORAES and COLTRO, 2023).

The scarcity of space for the creation of new landfills and the high costs have influenced the changes with this plastic waste. The problem of the impacts generated becomes even more serious when disposed of incorrectly. However, techniques such as recycling and incineration began to be used more frequently, emphasizing that some types of plastics, when incinerated, generate toxic greenhouse gases, such as PVC, which produce hydrochloric acid, which is corrosive and toxic (GEYER, JAMBECK, and LAW, 2017).

8 FINAL THOUGHTS

In principle, all recycling processes are possible, but there are several implications that make it difficult to carry out these processes. Most thermoplastics are composed of a variety of polymers and other materials, such as paper, metals, adhesives, pigments, paints and antioxidants, complicating the primary recycling process, which is the most used process in this category of materials, especially in plastic packaging. In order to be able to carry out mechanical recycling, it is necessary to separate the polymer from the material of non-plastic artifacts and sources of contamination, which can be stable in the degradation process and/or during processing. Thus, sources of contamination include chemical or pharmaceutical residues deposited in plastic packaging, as well as residues from contact with industrial, domestic or hospital waste.

Chemical recycling benefits the recovery of the petrochemical constituents of the polymer and discards most of the mishaps that are directed towards mechanical recycling. However, this recycling has a high cost in relation to the low cost of the raw material, being economically unfeasible, and this procedure is of high cost, being necessary to polymerize the molecule so that it can be polymerized again, The incineration of energy materials is also associated with energy recycling, without the appropriate technology, which can result in emissions of toxic gases harmful to health and the environment.

Therefore, with the environmental problems caused by plastic waste as the main focus of environmental pollution issues, it is essential to create initiatives based on the "New Plastic Economy", directed towards a vision in the circular economy, for plastic that never becomes waste. Therefore, innovative strategies must be used to eliminate problematic or unnecessary plastic packaging through redesign, innovation, and new delivery models becomes a priority.

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