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The place of chemistry in the new high school: Promoting environmental education through awareness about the use and disposal of plastic

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ABSTRACT
In view of the great problem surrounding the unconscious use and disposal of plastics and the observation within the school environment and its surroundings, the need for a study aimed at raising awareness about the use and disposal of plastics was perceived. After questioning the students about the problem of plastics, it was noted the importance of inserting this theme in the high school chemistry classes of the Adalberto Marroquim State School. This fact motivated the approach to the theme "Polymers" and, from there, the development of a didactic sequence with classes aimed at greater knowledge on the subject. The teacher's mediation is essential to assist critical development and awareness, also drawing attention to the theme of sustainability, so that the student understands the world around him and what his role is in this context with a view to mitigating environmental impacts. The main objective of this didactic sequence is for students to know how to recognize the different types of polymers, focusing on the sustainable consumption of plastic materials, so that they can actively act in the place where they are inserted, contributing to society. This problem is highlighted in Chemistry classes, seeking a place in the new scenario of education in Brazil, with a view to the implementation of the New High School, bringing the Formative Itineraries, and within these, a prominent outfit for Chemistry. At first, questionnaires with multiple-choice questions were distributed to assess the class's knowledge about plastic and its risk to the sustainability of the planet. The students' answers indicate the need for an educational product that consists of a booklet that can contribute significantly to the chemistry classes of any teacher who wants to address this theme, drawing attention both to the knowledge of "Polymers" and to the conscious use and disposal of these materials, contributing to sustainable development and effective awareness. The initial results of the work

Keywords: Plastics, Environmental education, Chemistry Teaching.

1 INTRODUCTION

There is concern, in all sectors, about the aggression to the environment caused by waste originating from the processes, services and products that are used in modern life. Synthetic and modified natural polymers, which are widely used in different packaging, have been one of the major problems of environmental pollution, mainly because these materials have occupied large volumes of municipal solid waste over the last few years (SATI MANRICH, 2000).

Polymers have been found in nature for many years, among some examples we have biopolymers such as polysaccharides, proteins and DNA found in the cells of living organisms; such as pine resin, asphalt, bitumen, amber, shellac resin, beeswax, among others (. SILVA, 2022). These materials are called natural polymers. The growth of artificial polymers has been occurring since the nineteenth century, with the discovery of the vinyl monomer cellulose, and since then, the discoveries related to plastic have been growing more and more. The discovery of polyamides, polyethylene, polyurethanes, polytetrafluoroethylene and silicones, represents a great revolution for human beings, as well as thermoplastics, with their functions and also in their competitiveness and economic viability. (FERRAROLI, 2003).

The word polymer according to Silva e Silva (2003, p.5):

> It is used to classify organic molecules made up of a large number of repeated molecular units, called groupers. Mero means parts and poly, many. So the meaning of the word polymers is manyfold.

In ancient times, man only knew natural polymers (the word polymers comes from the Greek polumeres, which means "to have many parts") which are very large molecules made up of the repetition of small and simple chemical units called monomers, high molecular weight, most of which are of organic origin and are found in nature. Among the most important are carbohydrates or sugars (cellulose, starch, glycogen, etc.), proteins (found in all living beings) and nucleic acids (SANTOS; GRANDSON; SOUSA, 2014; SOUZA; SAINTS; JUNIOR, 2011).

Currently, much has been discussed about environmental problems related to the preservation of the environment and the misuse of natural resources (SANTOS; JACOBI, 2011). In this regard, we highlight the pollution caused by the improper disposal of solid and organic waste, which causes a huge amount of garbage. This practice has been considered to be a driver of negative impacts on the environment (SANTOS; GRANDSON; SOUSA, 2014; SOUZA; SAINTS; JUNIOR, 2011).

The development of polymers has made everyday life more comfortable and practical, but at the same time we do not measure the implications of their excessive use, as well as their impact on the environment when discarded. The world increasingly demands sustainable practices in society's interaction with natural systems. In this way, there is a tendency to build a science that moves towards sustainability, whose objective is to consolidate socio-environmental activities that respect human beings and natural resources (SOUSA; SILVA; COSTA, 2019).

Thus, educators should develop practices based on environmental education, which, in addition to raising awareness among their students, can lead them to actions related to sustainable development (SOUSA; SILVA; COSTA, 2019).

Ferreira et al. (2019) on environmental education highlight:

> Environmental Education in schools acts as an agent that educates more conscious citizens and makes them able to act in the socio-environmental reality that surrounds them. The school, more than concepts and information, must work with attitudes and practical actions, so that the student can learn to practice actions aimed at environmental preservation and conservation. In the school environment, students complement their socialization, therefore, they must experience the practice of good social and environmental habits on a daily basis (FERREIRA et al., 2019, p. 202).

In view of these considerations, it is necessary for the school to promote a broader discussion in the classroom, which addresses the consequences of the use and disposal of polymers in the environment, as well as the social implications of such actions. Therefore, it is necessary for students to have a better understanding of the types of polymers that exist, their characteristics, the destination of these materials when discarded (conditions and time for their degradation) and also the effects of the disposal of the materials that society uses (SANTOS, 2017).

Thus, thinking about educational actions that involve broad knowledge about these materials and understanding the effects of their disposal on the environment becomes an important social issue. This, considering that the market is in an incessant race for the development of new products and that there are more and more new materials that become obsolete in an increasingly shorter time (GOMES, 2015; FREITAS et al., 2016).

Addressing topics such as environmental impacts, selective collection, solid waste separation, conscious use and disposal of plastic, this work aims to positively impact the school community and its surroundings by promoting environmental education about an awareness work beyond the walls of the school.

2 POLYMERS AND THEIR HISTORY

Man's first contact with resinous materials and extracted and/or refined greases took place in Antiquity, with the Egyptians and Romans who used them to stamp, glue documents and seal containers. In the sixteenth century, with the advent of the discoveries, the Spanish and Portuguese had their first contact with the product extracted from a natural tree of the Americas (Havea BrasilemsM). This extract, a product of the coagulation and drying of the Iatex, presented characteristics of elasticity and flexibility unknown until then. Taken to Europe, it acquired the name eraser for its ability to erase pencil marks. Its unlization was quite restricted until the discovery of wlchanization by Charles Goodyear in 1839. The first synthetic polymer was produced by Leo Baekeland (1863-1944) in 1912, obtained through the reaction between phenol and formaldehyde. This reaction generated a solid product (phenolic resin), now known as bakelite, a term derived from the name of its inventor. (CANEVAROLO, 2006).

Until the end of World War I, all discoveries in this area were by chance, through empirical rules. It was not until 1920 that Hermann Staudinger (1881-1965), a German scientist, proposed the theory of the macromolecule. This new class of materials was presented as compounds formed by large molecules. And this idea was strongly opposed at the time, taking a few decades for it to be definitively accepted. In recognition, Staudinger was awarded the Nobel Prize in Chemistry in 1953. On the other side of the Atlantic, Waiiace H. Carothers (1896- 1937), an American chemist, working at the DuPont company, formalized from 1929 onwards, the condensation reactions that gave rise to polyesters and polyamides. The latter of the new materials he named Nylon. (AKCELRUD, 2006).

From 1937 until the end of the 1980s, Professor Paul Floq (1910-1985) was a tireless researcher, working on polymerization kinetics, solution poieners, viscosity, and molar mass determination, among other fields. In recognition, he was awarded the Nobel Prize in Chemistry in 1974. With the advent of the Second World War (1939-1945), there was a huge acceleration in the development of synthetic polymers. As an example, we can cite the development of SBR synthetic rubber by Germany, due to the closure of its borders with natural rubber supplier countries. (CANEVAROLO, 2006).

In the early 1950s, Karl Ziegler (1898-1973), in Germany, developed organometallic catalysts that were used by Giuglio Natta (1903-1979), in Italy, for the production of stereoregular polymers (also called stereospecific), first producing isotactic polypropylene. Until then, this polymer had only been obtained in the atatic form, a viscous product with few commercial applications. The new product, a solid plastic, initiated what is currently an immense area of synthesis, called stereospecific, that is, the one that produces chemical structures in a controlled manner.

The following table shows, in a very summarized way, the evolution of the main commercial polymers. (CANEVAROLO, 2006).

Polymer	1st Occurrence	1st Industrial production
PVC	1915	1933
PS	1900	1936/1937
NYLON	1930	1940
LDPE (LDPE)	1933	1939
HDPE (HDPE)	1953	1955
PC	1953	1958
PP	1954	1959

3 CLASSIFICATION OF POLYMERS

3.1 NATURAL POLYMERS

Natural polymers, or biopolymers, are those synthesized by living organisms. The most common examples are silk, cellulose, proteins such as wool and DNA. Synthetic polymers, on the other hand, are generally produced from organic compounds, renewable or non-renewable, in laboratory processes. (FRANCHETTI; MARCONATO, 2006).

Natural products that contain polymers in their composition – such as beeswax, pitch, tar, balsam, rosin, amber, gum arabic, egg white and gelatin – were already known to the ancient Egyptians and Greeks, who used them combined with certain colored minerals to prepare coatings for architectural and aesthetic purposes. In the years 1120-220 B.C., China, Japan, and Korea used lacquers for the ornamentation of buildings, chariots, harnesses, and weapons. Tar and balsam were used as binders for protective coverings on boats. In Egypt, varnishes based on gum arabic, obtained from plants of the genus Acacia, colored with products extracted from marine animals, such as octopuses and squid, were used in the coating of vessels. (BRO; MENDES, 2016).

In paintings dating back to 15,000 years B.C. (Figure 1), found in caves in the regions of Lascaux, in southwestern France (Figure 2), and Altamira, in northern Spain, colorful mixtures were already used that are preserved to this day. It is believed that these paintings were made with an "air brush", that is, the pigment was blown by an appropriate fragment of bone, pierced, and the powder adhered to the fat or oil used to form the drawings on the surface of the walls of the cave. The pigment was mixture of powders of sand, clay, charcoal, dried blood etc. Other rock markings – that is, those made on stone – may have been produced with primitive compositions of cladding. The coating compositions consist of a polymeric, resinous material, dissolved or dispersed in solvent liquids, and may also contain pigments, dyes and various additives. Paints are the main coating compositions; In general, they receive the specific designations of varnishes, lacquers, enamels and primers. Varnishes are transparent paints, colored or not; lacquers are opaque paints, colored or not; Enamels are opaque paints, colored or not, reactive. Primers are opaque paints, colored or not, with a high content of solids. (BRO; MENDES, 2016).

3.2 SYNTHETIC POLYMERS

The initial concept of polymer (from the Greek, poly, much, and mere, part), is generally used for industrial polymers, whose synthetic origin is well defined and known. The concept of a macromolecule (from the Greek, makros, large, and from the Latin, molecule, molecule) is more general and comprehensive, as it only requires the compound to have a large mass, without conditioning to the repetition of the segments, mere. The word polymer was created in 1920, in Germany, by Staudinger (Hermann Staudinger, considered the Father of Polymers), when he stated that there were substances, natural or synthetic, that were not aggregates, such as colloids, but molecules with long chains, with defined terminal groups. For a decade, this concept was much discussed and criticized by scientists and only from 1929 onwards it began to be accepted without restrictions. Thus, the word "macromolecule" is broad and general, applicable to any chemical structure as long as it is large. The word "polymer" also requires that, in addition to being large, the chemical structure has repeated units, the "meros". (BRO; MENDES, 2016).

Currently, the production volume of polymers exceeds the corresponding combined productions of steel and aluminum (but not in mass, because metals are denser). There is a wide variety of polymeric materials, such as polymethylmethacrylate (PMMA), polycarbonate (PC), polyethylene terephthalate (PET), and polydimethylsiloxane (PDMS), which have different chemical and physical characteristics that make them convenient in the manufacture of different microfluidic devices (LIMA, 2012).

Macromolecules containing a PDMS segment are generally hydrophobic and exhibit properties such as low irritation potential, low surface tension, low temperature flexibility, thermal and oxidative stability, gas permeability, and dielectric properties. In addition, an important fact, these polymers are non-toxic and are biocompatible (LEHNINGER, 2022).

Amorphous vitreous polymers such as PMMA, which offers advantages of low cost, easy fabrication, biocompatibility and high flexibility, and PDMS, which is an elastomeric polymer, optically transparent, flexible, biocompatible, highly permeable to oxygen and low cost, represent an excellent alternative to the incorporation of polymeric materials in the manufacture of μTAS. Due to the characteristics of these polymers, they represent a good alternative for their application in the manufacture of microfluidic devices. For this purpose, block, graft and network copolymers containing PDMS segments have been examined, where the greatest interest has been focused on block copolymers containing a PDMS segment, given their broad scope for many applications (RIPPEL, 2009).

Materials obtained from synthetic polymers have a wide range of properties depending on their microstructure. They can be hard, elastic, hard, opaque, transparent, tough, electrically conductive, permeable etc. Today in Today it is easy to obtain polymers with good mechanical properties (comparable to the steel); thermal (thermal stability up to 500 C) and more transparent than crystal (AKCELRUD, 2006).

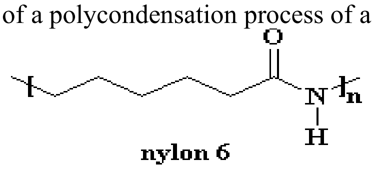
To determine the physical properties of a polymer, a wide variety of techniques and equipment either use tests or specifications according to the standard or not. The properties that are determined in this equipment are termed mechanical, chemical, electrical, thermal and optical. There are thousands of different instruments to perform these tests. Undoubtedly, the most used characterization for a first evaluation of the material is the stress-strain relationship. From the slope of the graph, we obtain the modulus in stress (and refers to hardness) and resistance to deformation (CALLISTER, 2002).

The study of the mechanical properties of a polymer is a necessity to correlate the response of different materials under a variety of conditions and thus be able to rescue the behavior of these materials in practical applications. There is no polymer (or any other material) that exhibits all the properties required for all products, so different polymers must sometimes be combined, although nowadays the use of a large number of different polymers is limited in one application for the problems that originate in their recovery (recycling). Combined with other materials such as steel, the coefficient of thermal expansion must be taken into account (CANEVALORO, 2006).

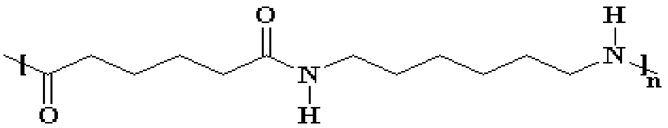
The first fully synthetic polymeric material was made in 1909 by Leo Hendrik Baekeland (1863-1944) when he produced the phenol-formaldehyde resin known as bakelite. It was from that moment that the great revolution in the plastics industry began, making it possible to generate materials on a commercial scale. This compound is chemically stable, moldable when heated, and very rigid when cooled, making it resistant to heat and electricity.

Since the discovery of Bakelite, research for the development of polymeric materials has deepened. In 1920, Staudinger (1881-1965) proposed the concept of macromolecules, contradicting the belief at the time that polymers were colloidal aggregates. For this discovery, he was awarded the Nobel Prize in 1953. Synthetic polymers 32 Research and discovery of new techniques for obtaining synthetic materials enabled advances in polymerization techniques, especially chemists Hermann Staudinger and Wallace H. Carothers (1896-1937), pioneers in this field. Staudinger carried out work on polyaddition and Carothers studied polycondensation, discovering one of the most important materials: Nylon 6,6, in 1935, by the company americana DuPont.

Figure: Representation of a polycondensation process of a polymer (Blass, 1985).



nylon 6



nylon 6,6

3.3 POLYMERS AND THEIR RELEVANCE IN SOCIETY

The most important polymers today, from a practical and economic point of view, are synthetics. However, unlike natural polymers, they are not found ready-made so that we can adapt them for our use. They must, as the name implies, be synthesized. In order for a micromolecular substance to give rise to a polymer (macromolecular substance), it must have a functionality equal to 2 or more. In other words, the molecule must have at least two active sites that can allow the growth of the polymer chain. For example, an ethylene molecule has a double bond. This unsaturated region has functionality 2 as it allows the growth of the polymer chain. Ethylene is therefore a monomer that will give rise to a polymer: polyethylene. Another interesting example is the ethylene oxide micromolecule that will give rise to polyethylene oxide. The process that chemically transforms the monomer into a polymer is called polymerization (Guerreiro, 2003).

Since the beginning of the last century, the use of polymers has become more and more frequent in society. It is enough to look around to realize the enormous amount of objects produced by man and that use polymeric materials as raw material for their different elaborations. From beverage bottles, supermarket bags, plumbing pipes, expanded polystyrene containers, coatings for cookware and cans, baby bottles, wall paints, prostheses, toothbrushes, vehicle bumpers, carpets, blankets, tires or supports for electronic components, polymers are present in the vast majority of utensils we use in our daily lives (LIMA, 2012).

With the development of the polymer industry, many products that In the past, they were produced with materials such as glass, ceramics, steel, etc. Today they are replaced by various types of plastics that, due to their versatility, lower weight, ease of handling, lower production cost, among other aspects, more effectively meet the intended requirements for the products. The use of plastics, both in new applications and as a substitute for traditional materials (metals, wood, glass), has experienced a significant increase in recent years (MANO; MENDES, 2016).

Today's developed societies are no longer able to survive without the use of plastics, and there are countless situations in which the use of this material is evident. Currently, there are more than a thousand different types of plastics that are used for the most varied purposes, such as for the production of fibers and new materials for the textile industry, for the construction of construction materials with better performance and lower costs than traditional materials, for the transport industry, of which the automotive industry stands out, in the pharmaceutical industry, for the production of packaging, household appliances, etc. (LIMA, 2012).

3.4 AWARENESS: THE PATH TO REDUCING THE NEGATIVE IMPACT CAUSED BY IMPROPER PLASTIC DISPOSAL

The abusive use of single-use plastics has brought numerous problems to the environment: improper disposal in the soil, depletion of landfills and pollution of aquatic environments. The slow decomposition of plastic in soil and water generates a series of substances that are harmful to human health. In addition, marine fauna has especially suffered from the impacts of this large amount of plastics. Society has recently started a process of raising awareness in an attempt to reduce the use of disposables, which represent 40% of the plastic waste generated (ABRELPE, 2018).

Concern for the environment is a path of no return, not least because humanity depends on it, and considering that oil is a finite good, a new field emerges with incalculable production prospects. And in this scenario, Brazil has a privileged position as a producer of natural or biodegradable polymers. One of the great problems of contemporary society is the issue of garbage. With the increasing use of polymeric materials, these have become a major headache. Today, the methods of collecting and deposing these materials are not efficient, which is also made difficult by the long time required for the degradation of plastics (SENAI, 2017).

One solution to this obstacle is recycling. However, the management The development of innovative technologies and new markets for recycled plastic depends on the development of innovative technologies and new markets for recycled plastic, and that, in the specific case of Brazil, although poorly developed, the material collection system can be thought of in an innovative, efficient and low-cost way (SENAI, 2017).

It can be said, therefore, that the reduction of the volume of plastic waste through management measures to minimize its production, reuse and recycling of this material represent ways to mitigate the environmental problems generated by its disposal. In Brazil, data on the production and management of municipal solid waste (MSW) reveal that there are 19,000 tons/day of waste that is not collected in the country and that, as a consequence, ends up in improper disposal sites, in addition to showing that 75% of Brazilians do not separate their waste to carry out reverse logistics (ABRELPE, 2018). Thus, only 8.2% of the plastic waste generated was recovered for recycling in 2017 (ABRELPE, 2018).

Due to the limited circulation of information on the fundamentals of urban cleaning, there is little understanding on the part of citizens of their role in waste management (EIGENHEER, 2010).

The growth of the world population has increased the need to increase the consumption of products and services by human beings, on the other hand, industries, in order to meet this great demand of the population, have generated several environmental impacts from the unsustainable methods of production that have been adopted over time (CARDOSO et al., 2009).

3.5 THE IMPORTANCE OF RECYCLING PLASTICS

With the development of the polymer industry, many products that were formerly produced with materials such as glass, ceramics, steel, etc., are now replaced by various types of plastics that, due to their versatility, lower weight, easier handling, lower production cost, among other aspects, more effectively meet the intended requirements for the products. Thus, large quantities of plastics are produced on a daily basis that need to be treated at the end of their useful life (SILVA, RABELO, 2017).

The treatment of plastics is currently a social and environmental problem of enormous importance. | 32 The process of mechanical recycling of plastics is not simple. It's not just about putting all the plastics in a container, melting them down and processing them again. In order to be able to recycle plastics, they must be separated by type (SILVA, RABELO, 2017).

One of the biggest hurdles to the recycling process is the sorting process. Unfortunately, most plastic products are mixtures of different plastics, not consisting of just one type of plastic. For example, a shampoo bottle can have two different plastics in its constitution: the bottle cap can be made of PP and the body is made of HDPE, or a bottle of water can be made of PET and its handle is made of HDPE. The flexible packaging that is often used in food products is most often laminated, consisting of several different plastic films, and may also incorporate aluminum films (as in the case of coffee packaging), (SILVA, RABELO, 2017).

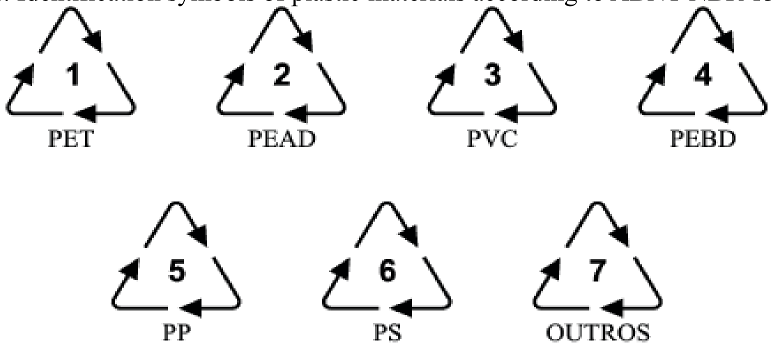
All these flexible films are adhered to each other by adhesives, in a process called complexing, with or without solvents, depending on the type of adhesive used. In order to be able to recycle these materials, which represent a large number of the materials that exist in everyday life, it is necessary to separate them, so that they can later be incorporated, together with the virgin raw material, into a production cycle (SILVA, RABELO, 2017).

The incorporation of recycled materials in virgin raw materials alters the properties of the products, thus, depending on their specifications, the incorporation is made in a greater or lesser percentage. The recycling process involves washing and shredding the materials to be recycled and adding them, in varying percentages, to the virgin raw material. One process that does not require the separation of plastics is energy recycling. This process consists of the combustion of plastic materials with a view to their energy use. Chemical recycling is also a way of treating plastic waste and does not require prior separation of plastics. This process allows the conversion of plastic waste into chemical or combustible substances of interest to the industry (SILVA, RABELO, 2017).

Recycling emerges as one of the possible solutions to minimize the harm caused by the massive use of polymeric materials by the developing society. However, for cultural reasons, human beings still resist making recycling a habitual practice. Therefore, in order to start this long journey of critical and conscious learning, it is necessary that people begin to become familiar with the subject as soon as possible, and there is nothing better than the school environment to bring this emerging environmental attitude to light (OZÓRIO, SOUZA, ALVES, JOB, 2015)

In Brazil, the technical standard for plastics (NBR 13.230:2008) was developed according to international criteria. The numbering separates plastics into six different types of materials (PET, HDPE, PVC, LDPE, PP, PS), and there is still a seventh option (others), usually used for plastic products manufactured with a combination of various resins and materials, are listed below: (SILVA, RABELO, 2017).

Figure (1): Identification symbols of plastic materials according to ABNT NBR 13230:2008



1 - Politereftalato de etileno
2 - Polietileno de alta densidade
3 - Policloreto de vinila
4 - Polietileno de baixa densidade
5 - Polipropileno
6 - Poliestireno
7 - Outros

1.PET, transparent and unbreakable is an extremely lightweight material. Mainly used in the manufacture of carbonated beverage (soft drinks) packaging, in addition to the food industry in general. It is also present in the hospital, cosmetics, textiles and other sectors (SENAI, 2017).

2. HDPE is a lightweight, unbreakable, rigid material with excellent chemical resistance. Widely used in packaging of products for home use such as: Detergents, fabric softeners, grocery bags and bags, pots and housewares. Its use in other sectors is also very large, such as: oil containers, drums for chemical products, paint drums and technical parts. 3. PVC is a transparent, lightweight, temperature-resistant, unbreakable material. Typically used in packaging for mineral water and edible oils. In addition to the food industry, it is widely found in the pharmaceutical sectors in serum, blood and hospital supplies. A strong presence also in the civil construction sector, especially in pipes and frames (SENAI, 2017).

LDPE is a flexible, lightweight, transparent and waterproof material. Due to its qualities, LDPE is widely used in flexible packaging, such as: bags and sachets for supermarkets, milk and yogurts, industrial bags, garbage bags, plant seedlings and textile packaging (SENAI, 2017).

4. PP is a rigid, shiny material with the ability to retain aroma and resistant to temperature changes. It is usually found in technical parts, boxes, in general, housewares, wires and cables. Stronger jars and packaging (SENAI, 2017).

5. PS is a waterproof, lightweight, transparent, rigid and shiny material. PS are used in pots for yogurts, ice cream, sweets, plates, lids, disposable razors, and refrigerator linings (SENAI, 2017)

6. In this group, the other types of plastics are classified, for example: polycarbonate (PC); polyurethane (PU), polyamide (PA). Usually, they are found in technical and engineering parts, shoe soles, sports equipment, computer bodies, and telephone devices (SENAI, 2017).

4 METHODOLOGY

The development of this research was aimed at elaborating, developing and analyzing a teaching sequence on polymers that addresses the different aspects and relationships between chemical knowledge, interactions with the environment and classroom discourse focused on sustainability and students' awareness about the use and disposal of plastic. The present research was carried out in a state school, located in the city of Batalha, in the hinterland of Alagoas.

The planning of the didactic sequence was carried out based on the content "Polymers", applied in the third grade of high school. Of the four third-grade classes, the class with 31 students duly enrolled was selected, with an average of 28 attending each class of the didactic sequence.

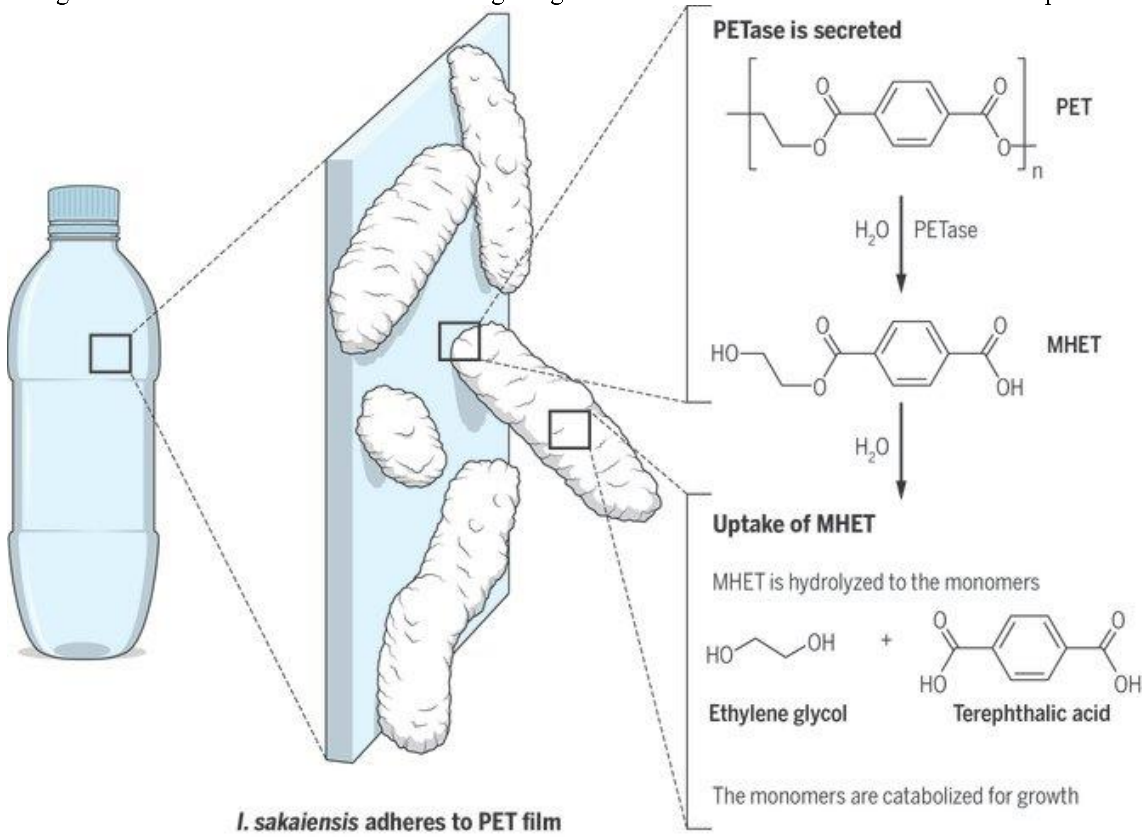
5 DEVELOPMENT OF THE DIDACTIC SEQUENCE

The didactic sequence consists of 6 lessons, with proposals based on the following themes:

5.1 LECTURE 1: INTRODUCTION TO THE STUDY OF POLYMERS

Planned for a class of 1 period of 50 minutes, initially a debate will be held, using a figure of a bacterium that decomposes plastic in the environment, demonstrating the following images and reading the following text "Can *Ideonella Sakaiensis* contribute to the reduction of pollution?".

Figure 2: Source:science/salvation-for-the-garbage-what-we-know-about-the-bacteria-that-eat-plastic



Then, the theme was addressed through the following question: "Would we be able to live without plastics today?" as a challenge/problem. After the initial activity, each student received a sheet with a questionnaire with questions such as:

- What do you mean by plastics?
- What is the importance of plastics in your daily life? Cite examples of where you make use of plastics.
- Do you think plastic materials can cause harm to the environment?
- Do you use plastics consciously?
- Have you ever heard the word polymer? What is a polymer?

5.2 LESSON 2: SECOND PEDAGOGICAL MOMENT

Knowledge Organization: Planning for a 50-minute class. Students were introduced to the definition of polymers and plastics, the processes of obtaining and transforming polymeric materials. After the lecture through slides, the class was divided into 5 teams, 4 teams composed of 6 students and 1 team with 7 students. Each team was responsible for researching a type of polymer present in everyday life, seeking all its historical development to present in the next class.

5.3 LECTURE 3: POLYMERS: CLASSIFICATION AND TYPES

Third Pedagogical Moment - Organization of knowledge: Planning for a class of a period of 50 minutes. For the presentations, all groups researched a type of polymer that is present in everyday life, they also looked for the historical process on the development of the polymer, presenting the main events related to its development and concepts. It is important to highlight

Since the source of research used by the students was the internet, it was necessary for the teacher to intervene to clarify some important points not addressed.

Team 1: Pan Handles (Bakelite) Team 2: Plastic bags (polyethylene) Team 3: Tire (rubber)

Team 4: Household items (polypropylene) Team 5: Toys (PVC)

Equip 6: Bumper (polypropylene)

5.4 LECTURE 4: POLYMERIC REACTIONS

Fourth Pedagogical Moment - Organization of knowledge: present the main processes of polymerization, in order to enable their understanding of such processes. Initially, we introduced the concept of polymeric reactions and then carried out an experimental activity on "Homemade polymer" to then explain the types of reactions.

5.5 LESSON 5: PLASTIC AND THE ENVIRONMENT: A SOLUTION TURNED PROBLEM

Fifth Pedagogical Moment: Dialogued exhibition focusing on the problem of the incorrect use and disposal of plastics, in the search for new knowledge showing the need to raise awareness about the use and disposal of plastic. At this time, several images were brought about problems caused by the accumulation of plastic in the environment. The students also studied about plastic recycling and reflected on its importance for the environment. A debate was developed from the reading of an opinion article entitled: "Plastic pollution, a problem for everyone", **by** Cíntia Carolina Munhoz with Daiane Aguilar da Cunha and Vanessa de Oliveira Braga that deals with pollution caused by plastics. The purpose of this class was to sensitize students about the importance of recycling in order to minimize the impact of plastic pollution on the environment, students had the opportunity to request garbage bins that were positioned in the school environment.

5.6 LECTURE 6: AWARENESS: THE KEY WORD TO MITIGATE ENVIRONMENTAL IMPACTS

Fifth Pedagogical Moment: hands-on moment. The teams formed in class 3 were responsible for developing an external work, doing awareness work in 6 municipal schools in the municipality of Batalha, Edite Macário Municipal Elementary School; Antôno Rodrigues de Melo Municipal Elementary School; Maria Nicácia Amorim Municipal School of Basic Education; Ana Maria de Melo Municipal School of Basic Education; Arlete Correia Madeiro Municipal School of Basic Education and João Vieira Neto Municipal School of Basic Education in order to warn of the risks that the environment runs with the use and disposal of disordered plastic. Each team was responsible for producing pamphlets raising awareness among the school community of the schools visited. Below are copies of the pamphlets (Figure-3 (A, B, C and D) used for the pamphleteering, made by the students themselves, many of them reported that they used the canva platform.

A B

C D

The teams (Figures 5 to 8) distributed a questionnaire with multiple-choice questions to assess the degree of knowledge of each class about polymers and their risks to the environment. Then they gave a presentation in the classrooms. These same teams invited volunteer students from the second grades so that they can continue the awareness work in the following year, since the students in the sample are in the 3rd grade of high school, since the intention is to continue this work, the students worked together with the second grades.

Figure 5 Figure 6


Figure 7 Figure 8


6 RESULTS AND DISCUSSIONS

The proposal of the six-part didactic sequence described in the work aims to build, together with high school students, not only knowledge about a current theme, but also to develop a critical and environmental awareness. In this way, the development of the theme polymers, biased towards awareness about the use and disposal of plastic, inserted in environmental themes, in order to warn about the unbridled consumption of products containing plastics.

In the first, second and third moments of the didactic sequence, the knowledge about polymers in general was explained to the students, so that the knowledge would facilitate the next steps. The next steps were aimed at raising awareness about the importance of the conscious use and disposal of plastic. This phase took place in the municipal schools of the municipality of Batalha-Alagoas, each team determined in class 3 was in charge of visiting the schools and creating their pamphlets in order to promote awareness about the use and disposal of plastic. At the time of the visits to the schools, some second-grade students were asked to accompany the teams so that they could observe in order to continue to this awareness-raising work subsequently.

7 FINAL THOUGHTS

The approach to themes that promote environmental education in classrooms is fundamental, as we cannot fail to think about educational practice away from subjects that concern environmental awareness. The contextualization of chemical content to environmental themes is one of the ways to give meaning to the treatment of science in school education.

The design of the didactic sequence was elaborated from activities that could provide reflection, learning about awareness and about the use and disposal of plastic and recycling of these materials. From this didactic sequence it was possible to conceptualize polymers, identify their main characteristics, addressing the themes and properties of substances and materials, promote environmental education and address damages and risks caused to the environment for awareness within the school space and outside it.

The highlight of the research was the visit to the schools of the municipality of Batalha, providing interaction with the community, sharing assimilated knowledge and verifying in practice how it can contribute and make changes. The results of the questionnaire applied show that the participants of the research have no knowledge about what polymer is, many of them gave reports that were surprising, because for them there is no way to live without plastic bags, without plastic in general, many of them stated that they have never heard the word polymer, in this way, the need for this work aimed exactly at this target audience was perceived, The ninth-graders answered the questionnaires, the sixth-, seventh-, and eighth-graders participated in the leafleting, received pamphlets, and the third-graders provided some clarifications about raising awareness about the use and disposal of plastic. All consumption has an impact, whether positive or negative, on the economy as well as on nature and society. Once you are aware of these impacts, it becomes easier to maximize the positives and reduce the negatives. When talking about plastics, it is necessary to analyze their life cycle in the management of all processes, to reduce the impacts caused to the environment. Since the gradual production and utilization of plastic outstrips society's ability to manage it effectively until the end of its useful life.

Therefore, the conscious consumption of plastic depends on the awareness of the population and awareness of this problem begins in the classrooms.

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