Environmental chemistry applied to High School through laboratory experiments

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ABSTRACT

The educational process must be attentive and be an agent that brings together the moments and changes that are occurring in the world, aiming at the present and future of man, as it is essential that human beings know and understand the functioning of the main industrial processes that are relate, directly or indirectly, with nature in the face of countless technological accidents that have left traces of destruction across the globe. Consequently, knowledge of Environmental Chemistry in secondary school must be one of the formal vectors of transformation at the teaching level, aiming and encouraging the formation of critical awareness in the processes in which chemical and related technologies can influence levels of environmental contamination. The purpose of this work consists of developing a learning process based on the construction of didactic models, whether using specific equipment or even using certain everyday objects, with the intention of creating in experiments the necessary and fundamental conditions for knowledge of Environmental Chemistry is both critical and systemic. To exemplify the teaching program, two themes were selected: the deterioration of batteries in the environment and the pollution and destruction of monuments and urban furniture. Based on these themes, laboratory experiments were developed to demonstrate how such products contaminate the environment. It is believed that the way of thinking in Environmental Chemistry, associating the fundamental concepts of Chemistry with the parameters that make up an environmental system, are closely linked to "feeling" or imagining the observed facts, natural or induced, that flow from the experiment.

Keywords: Environmental chemistry, Batteries, Environment, Environmental contamination.

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INTRODUCTION

Water, air, soil, flora and fauna are the pillars of physical, chemical and biological support for life on this planet where man, throughout his own history, has been modifying and transforming the environment in order to meet to its direct and indirect objectives. As examples, we can mention the diversion of rivers, the creation of large hydroelectric plants and nuclear power plants, the genetic transformations of plant or animal species, the devastation of forests, immense fires, the development of highly toxic chemical products and inconsequential industrial dumping. .

Since the beginning of civilization, waste from production systems, whether artisanal or semi-industrialized, was released into the environment, mainly into waterways or atmospheric air. There was, however, a concern about the bad smell or the black and aggressive smoke that such systems exhaled, to such an extent that both in Greece and in Ancient Rome, silver and copper foundries, olive oil factories, tanneries and The slaughterhouses were located in uninhabited areas and far from the city. With the growth of cities, these systems became increasingly closer, the aggressiveness and discomfort became a concern again, so the polluting bodies were transferred further away again. The environmental problem continued, as it was simply transferred from place to place [1-3].

In this way, it is evident that the degradation of the environment in all aspects did not appear suddenly, it was accumulated throughout distant history. But, in the last seventy years, man has observed, participated or even waited in anticipation of the development of industrial processes and energy generation, the creation, production, directly and/or indirectly, of a series of chemical products, materials and equipment used in everyday life and in most industrial segments. In this way, chemical accidents, the production of inappropriate materials and chemical and biotechnological waste dumped into the environmental system have left marks of destruction in various parts of the planet [3].

There are several historical references to societies that, in isolation, prevented or delayed the advancement of industrial civilization, however, the Industrial Revolution that took over the world from the 18th century onwards directed and propelled its industries into unbridled production, seeking the coveted markets at any cost. . For some time now, many voices have been raised in defense of the ideals of environmental preservation and conservation. However, they were trampled on, silenced and buried under the compulsive wave of industrialization driven and directed by the interests of economic power.

Since then, industrial production processes, especially chemical ones, have continued to exert strong pressure on the environment, given the risks inherent in their manufacturing processes, when they incorporate current topics: effluents, waste, leaks, packaging, garbage toxic etc., which most of the time are confused or interconnected. In rapid march, as if defying common well-being, highly corrosive and toxic pollutants ascend to the skies or enter the earth, making the harmful chain of phenomena of varying toxicity increasingly gigantic. Apart from the elementary ethical principles of the right to life and enjoyment of citizenship, industrial enterprises gain space in an unusual march to the expected scientific-technological order in favor of ecological activities [4, 5].

The Industrial Revolution over the last hundred years has contributed to the development of culture and the well-being of people, but it has also, decades after decades, left trails of destruction in the exhaustion of natural resource sources, in the contamination of seas, rivers, air and soil. , in the disfigurement of the landscape and even in the destruction of monuments that perpetuate the history of Humanity. Human activity has transformed the environment in which it lives and in which it lives, fundamentally altering natural characteristics and threatening, directly or indirectly, human survival.

In this same dimension, the Environmental Management Programs adopted by companies with a vision of the future aim at the obligation to comply with all legal requirements, whether municipal, state and federal, and other standards disseminated in society so that they can become competitive in an increasingly globalized market and demanding regarding environmental issues. Technologies and products that do not consider environmental preservation should soon be banned from commercial routes.

However, the fact that nature has fundamental and inalienable rights, rights endorsed and vitalized by past generations, rights assured by survival and wisdom, ends up generating dissatisfaction and indifference. In this way, it is important to build critical awareness that involves the transformative and regulatory actions of technology, disorderly development, industrial contamination, poverty, ignorance and public health aiming at a better quality of life for the Earth's inhabitants.

Recognizing the rights of nature is recognizing the rights of education. Ensuring education rights is recognizing the right to citizenship. Recognizing the right to citizenship implies establishing a subject of law who now has legal capacity based on the country's constitution [4]. Therefore, education has to be present, attentive and be an agent that brings together the moments and changes that are occurring in the world , aiming at the present and future of man, as it is essential that human beings know and understand the functioning of nature.

Education focused on the environment must be the formal vector of transformation at all levels of education, encouraging the formation of public awareness of environmental knowledge. Where the current concept of environment must be broad in covering the physical, chemical, biological, economic, sociological, anthropological, ethical, philosophical and legal domains.

The constant presence of Chemistry in the various industrial segments and also in everyone's daily lives is one of the main reasons to justify the importance of teaching chemistry at all levels of the educational process, as attested by Professor Attico Ignácio Chassot [6-8] when he says:

> "...we must teach chemistry to allow citizens to interact better with the world around them". "Understanding science also makes it easier for us to contribute to controlling and predicting the transformations that occur in nature. This way, we will be able to propose these transformations, so that they lead to a better quality of life".

There is a growth in social ordering by establishing concepts of limits, distances, times, responsibilities in relation to natural resources, seeking the best quality of life, etc. This culture in formation can be called post-modernity, characterized by the post-industrial economy and the understanding of man as a multidimensional being. The speed of transformations is no longer measured by mechanical modules but by digital electronics, consequently generating new ideas and new scientific and technological directions, which are quickly disseminated and absorbed by the productive sector and society in general. These facts are consensus among teachers, scientific associations and educational policy leaders, causing the need for changes in educational parameters in the face of advances in science and technology [9].

There are still undergraduate courses in the country, including those in Chemistry, which adopt the model of technical rationality, in which the theoretical focuses of the content are approached in a way dissociated from practical activities, which reinforces the mistaken conception that these two aspects of knowledge They are sides of the same coin that can be examined separately.

In view of this, upon finishing his undergraduate course in which he acquired theoretical knowledge about teaching, the teacher dedicates himself to the practical facet of pedagogical work, entering the school environment, keeping in mind the application of concepts studied in his undergraduate course, in an attempt to build a pedagogical practice that will translate your professional "doing".

To raise awareness and clarify knowledge and related information, two issues were highlighted in this chapter: pollution and corrosion of historical monuments and urban furniture and corrosion from the deterioration of electrochemical batteries discarded in the environment.

POLLUTION AND CORROSION OF MONUMENTS AND URBAN FURNITURE

According to Hinrichs et al. [10], air pollution levels in a given area depend on the quantity and type of pollutants emitted by polluting sources and the meteorological conditions that lead to the dispersion of pollutants. Discharges from chemical and petrochemical industries, steel mills, motor vehicles and waste incineration are largely responsible for the pollutants found in the atmosphere. These pollutants can be gases, fine or thick chemical mists, dust, smoke or combinations of these emissions. Among the most common are carbon dioxide (CO_2), carbon monoxide (CO), sulfur dioxide (SO_2), ammonia (NH_3), hydrogen sulfide (H_2S), nitrogen oxides (NOX), hydrogen fluoride (HF), sulfate, in the form of H_2SO_4 and some organic compounds such as methane, ketones, alcohols, benzene, etc.

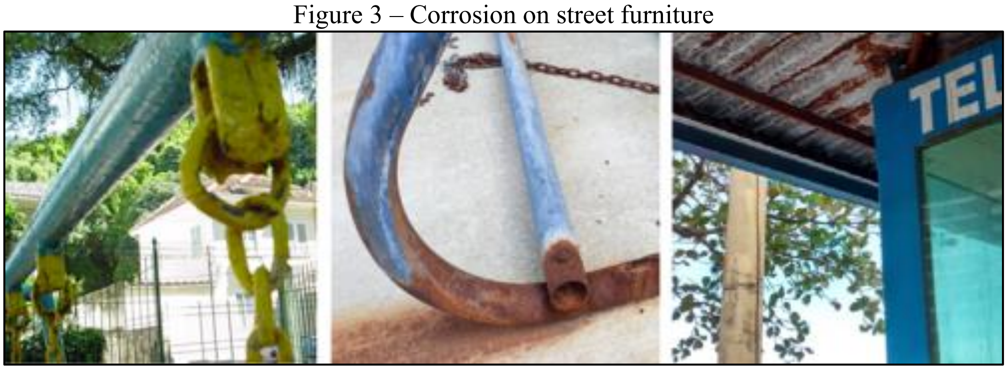
Research work on atmospheric pollutants shows that the SO_2 content present in the atmosphere, estimated at around 160 to 180 million tons per year, comes mainly from the burning of fossil fuels and the oxidation of sulfur and hydrogen sulfide. SO_2 has harmful effects on human health, vegetation and metallic and non-metallic materials. Part of this emission is oxidized to sulfur trioxide (SO_3) which can be converted into sulfuric acid, whose formation depends on the moisture content, ozone, nitrogen oxides, particulates present in the atmosphere, temperature and ultraviolet light intensity [10-12].

Historical monuments and all the urban furniture that surrounds a city suffer daily from the perverse association of corrosion with environmental pollution [13] according to the deterioration traces in the photographic sequence presented in Figures 1 to 3.

Figure 1 – Aspect of corrosion on electricity poles

Figura 2 Corrosão em praças públicas

Figure 3 – Corrosion on street furniture



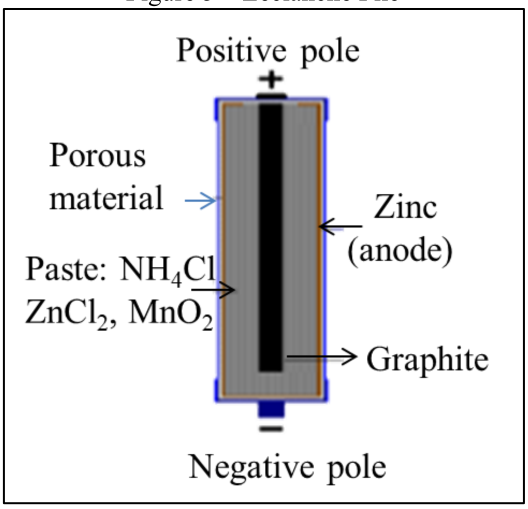
BATTERIES AND ENVIRONMENTAL CONTAMINATION

The first pile built in the world is credited to Alessandro Volta, who on March 20, 1800, demonstrated in the presence of Sir Joseph Banks, president of the Royal Society, in London, that a pile of silver and zinc discs, arranged in a Shaped like a column and separated by cards soaked in salt water, it spontaneously generated electricity, without the need for any electrostatic machine. In figure 4, below, the Volta battery (1800) and other old batteries are shown.

Figure 4- Old batteries from 1800 to 1904

Dry batteries, spontaneous energy processing, similar to current batteries, called Leclanché batteries (Figure 5) were basically made up of a zinc electrode and a graphite electrode, surrounded by manganese dioxide (MnO_2) and placed in a porous medium, together with an ammonium chloride solution (NH_4Cl). Zinc constitutes the negative pole and graphite, the positive pole, thus providing a potential difference of 1.3 to 1.5 Volts.

Figure 5 – Leclanché Pile



The reactions involved in this stack are:

Anodic reaction:Zn $\rightarrow$ Zn + 2 e

Cathodic reaction: $2\ NH_4^+ + 2e \rightarrow 2\ NH_3 + H_2$

The gases generated in the cathode area can inhibit the energy supply process and cause an explosion due to the presence of hydrogen. Manganese dioxide (MnO_2) present in the paste oxidizes hydrogen to water, while NH_3 in gaseous form it is absorbed by zinc chloride ($ZnCl_2$) as shown in the following reactions:

$$2\,MnO_2 + H_2 \rightarrow Mn_2O_3 + H_2O$$

$$ZnCl_2 + 2\,NH_3 \rightarrow Zn(NH_3)_2Cl_2$$

As the battery is used, the quantities of substances that react will reduce the production of electrical energy and, consequently, the battery will wear out.

Batteries and cells are made of metals and metallic salts with high polluting power, such as mercury, cadmium, zinc and lead. Some have an acidic character (H_2SO_4, $ZnSO_4$, $ZnCl_2$) and others have an alkaline character (KOH).

The battery is an example of non-spontaneous energy production. The Ni-Cd batteries shown in Figure 6 are used in various electronic devices.

Figure 6 – Nickel-Cadmium (Ni-Cd) Batteries

The reactions involved in this battery are:

Anodic reaction: $Cd + 2\,H_2O \rightarrow Cd(OH)_2 + 2H^+ + 2\,e$

Cathodic reaction: $2NiO(OH) + 2\,H_2O + 2e \rightarrow 2\,Ni(OH)_2 + 2OH^-$

Global reaction: $Cd + 2\,NiO(OH) + 2\,H_2O \rightarrow Cd(OH)_2 + Ni(OH)_2$

One of the advantages of this battery is that it continues to operate regularly even with a high degree of discharge.

The Ministry of the Environment in Brazil calculates that 152 million common batteries and 40 million alkaline batteries and around 12 million cell phone batteries are discarded into the environment annually in São Paulo, according to data from CETESB (the company from S.Paulo (Brazil) of environmental sanitation). The sum is more than 200 million units each year. In Rio de

Janeiro, the annual estimate is 98 million units, totaling around 11 tons of batteries deposited in landfills per year.

Due to their chemical composition, batteries are considered toxic waste in domestic waste. They exemplify the complicated relationship between the consumer and the environment. Daily life in society shows a significant increase in the use of batteries from the most diverse electronic equipment used by modern societies, such as calculators, portable radios, flashlights, cell phones, etc., generally discarded in household waste. Consequently, the most dangerous elements found in landfills are mercury, lead, zinc and cadmium.

METHODOLOGY

According to Chassot [7-8], many ideas have been discussed to guide proposals aimed at a more critical Chemistry Teaching. It is important that Chemistry is seen as a whole, regardless of its areas (General Chemistry, Physical Chemistry, Inorganic and Organic Chemistry, etc.), making it more effective in finding solutions to problems that high school students face. yourself daily.

Knowledge must be closer to things in nature, "so that real life and school experience coexist in a more dynamic and interactive way". Scientific understanding must be achieved by understanding action, moving Chemistry away from the theoretical field and bringing it to reality. Laboratory experimentation, with a demonstrative nature, must give way to a type of experimentation, through which knowledge can be constructed.

Based on this, experimental models are proposed that aim to build scientific knowledge in chemistry, opening a way to critically understand environmental problems that, for the most part, arise from chemical processes, precisely industrial chemical processes.

RESULTS

EXPERIMENTOS COM PILHAS

The batteries were chosen to develop an experimental model, taking into account the contamination problems generated by their unconscious disposal in the environment. The gelatinous electrolyte is prepared by adding 12 g of colorless gelatin with 50 mL of cold water, in a 500 mL beaker. The solution is left to rest for 5 minutes, and is then placed on the heating plate (temperature 70□C), until all the gelatin is dissolved. The volume of the solution is made up to 500 mL with an aqueous solution containing 3.5% (by mass) NaCl.

First, the gelatinous mass, still hot, is placed in the transparent plastic container (dimensions: 10 cm x 10 cm x 5 cm), in such a way that it occupies half the volume of the container. Then the gelatinous mass is left in the refrigerator to harden for about 12 hours.

When the gelatinous mass is hard, various types of piles are placed and then the volume is filled to the brim and left in the refrigerator to harden for around 12 hours as shown in Figure 7.

The aim, through these experiments, is that students are able to: visualize the gradual deterioration of batteries in the soil, understand the mechanisms of the reactions involved, compare and estimate the deterioration of various types of batteries in the environment and critically evaluate environmental contamination caused by heavy metal contamination in the soil.

Figure 7 – Used batteries immersed in gelatin with the addition of 3.5% NaCl

Next, the experiments to demonstrate the deterioration of used batteries are presented in Figures 8 to 10.

Figure 8 – Release of hydrogen after 5 days and the formation of FeO.OH

In Figures 9 and 10, after three and four weeks of immersion in the gelatinous saline solution, intense corrosion of the carbon steel casing that surrounds the batteries can be observed, with the release of hydrogen and the formation of hydrated ferric oxide, as shown below. reactions:

$$2\ H_2O + 2e \rightarrow H_2 + 2\ OH^-\text{(cathodic reaction)}$$

$$Fe - 2e \rightarrow Fe^{2+}\ \text{(anodic reaction)}$$

$$Fe^{2+} + 2OH^{-} \rightarrow Fe(OH)_2$$

$$2\ Fe(OH)_2 + H_2O + \frac{1}{2}\ O_2 \rightarrow 2\ Fe(OH)_3$$

$$2\ Fe(OH)_3 \rightarrow 2FeO.OH + 2\ H_2O$$

Figure 9 – Corrosion of the carbon steel casing; (A): 3 weeks of immersion; (B): 4 weeks of immersion

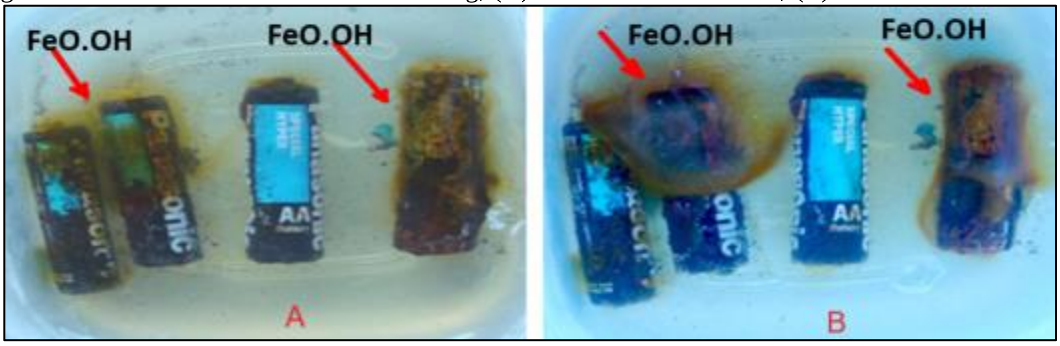
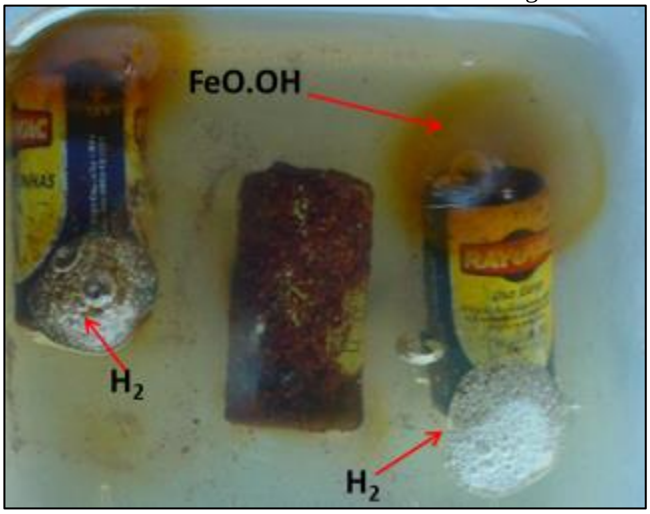


Figure 10 – Intense corrosion of the carbon steel casing of the batteries



In order to make students aware of the environmental problems generated by the disposal of batteries in the environment, visits and interviews should be scheduled with battery manufacturers, distributors and even with street vendors who change used batteries in wristwatches. Interviews must be semi-structured, carried out with groups of students, based on the following basic questions:

- Is there any guidance from the manufacturers of these batteries regarding disposal?
- How are they disposed of in urban waste?
- Do you know if these batteries cause pollution problems?

EXPERIMENTS AIMED AT EVALUATING THE CORROSION OF MONUMENTS AND URBAN FURNITURE

In order to create a saline and polluting environment to evaluate the deterioration caused in monuments and urban furniture, an experiment was developed under accelerated conditions, essentially consisting of a transparent plastic chamber, with a capacity of 50 L, where humidity is continuously maintained. reignant (95 to 100%), saline and pollutant through continuous bubbling of air in the two internal containers containing, respectively, a 3.5% sodium chloride solution and a 2M sodium acid sulfite solution ($NaHSO_3$) as shown in the scheme in Figure 11. The bubbling system with the diffuser is shown in Figure 12. The exposure time established for the test was 600 hours and the internal temperature in the chamber must be stabilized between 24 and 25 °C.

Figure 11 – Schematic and transparent plastic chamber where the tests were carried out under simulated conditions of SO2 and NaCl at 100% humidity

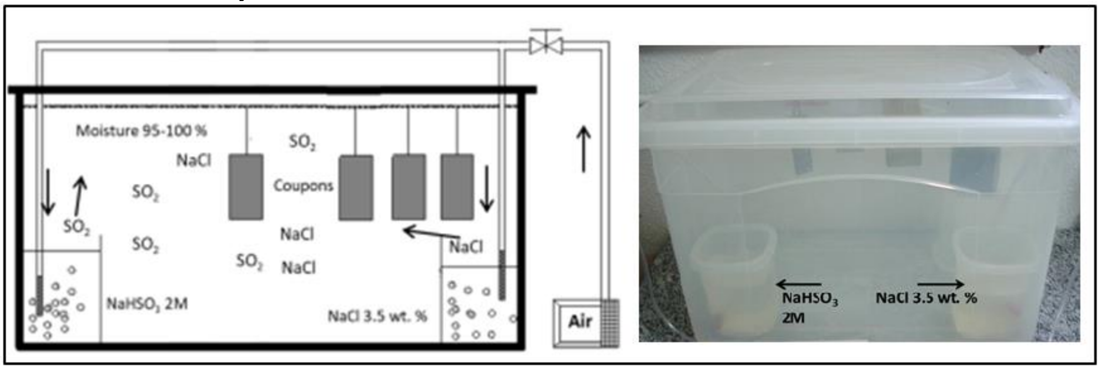
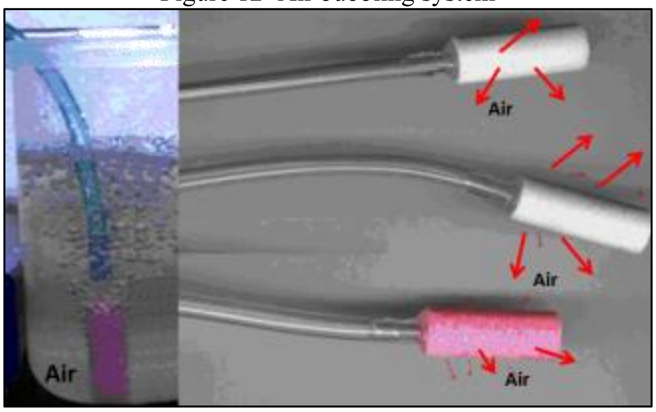


Figure 12- Air bubbling system



The specimens that represent the constituent materials of monuments and urban furniture and participate in the experiment are: concrete, bronze (copper and tin alloy), carbon steel, painted carbon steel.

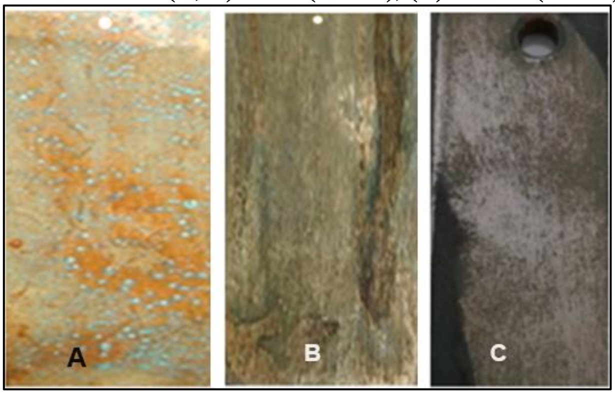
Figures 13 to 16 show the corrosion aspect of the specimens after 600 hours of testing.

Copper and its alloys such as bronze (Cu-Sn alloy) and brass (Cu-Zn) are generally part of monuments and urban furniture and consequently suffer from industrial saline atmospheric corrosion, mainly in public squares located in the port area. industrial, where salinity and pollution represented by gases CO_2, NO_X e SO_X are present.

In this specific test it is verified that in coupons made and referred to as brass (Cu-Zn alloy) and bronze (Cu-Sn alloy) a layer of Cu_2O (cuprous oxide) is initially formed, dark in color and with a small amount of CuO (cupric oxide). However, when considering the oxidizing conditions in this test, the following compounds can be found on the surface of the test specimens: Cu_2O, CuO,

$Cu(OH)_2$, CuCl, $CuCl_2$, $CuSO_3$, $CuSO_4$, $Cu(OH)_2.CuCl_2$, etc. forming various dark and greenish colors [14-16].

Figure 13 – Aspects of surface corrosion: (A, B) Brass (Cu-Zn); (C) Bronze (Cu-Sn) after 600 hours of testing



The carbon steel sheets subjected to the conditions prevailing in the test referred to in Figure 14 suffered surface corrosion based on the following reactions:

$$H_2O + ½\ O_2 + 2e \rightarrow 2\ OH^-\text{(cathodic reaction)}$$

$$Fe - 2e \rightarrow Fe^{2+}\ \text{(anodic reaction)}$$

$$Fe^{2+} + 2OH^- \rightarrow Fe(OH)_2$$

$$2\ Fe(OH)_2 + H_2O + ½\ O_2 \rightarrow 2\ Fe(OH)_3$$

$$2\ Fe(OH)_3 \rightarrow 2FeO.OH\ + 2\ H_2O$$

In the tests referring to Figure 15, carbon steel sheets coated with low quality paint were used to demonstrate that when choosing paints for external painting in industrial saline environments, the quality and application of the paint are fundamental issues. The appearance of the test specimens shows the development of the intense corrosive process.

Figure 14 – Surface aspects of carbon steels after 600 hours of testing

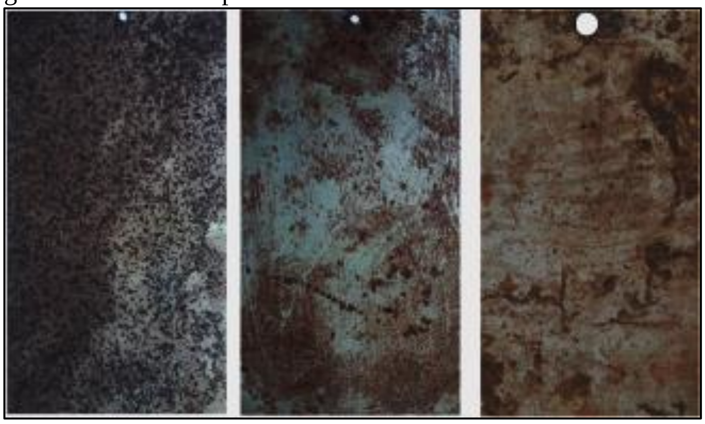
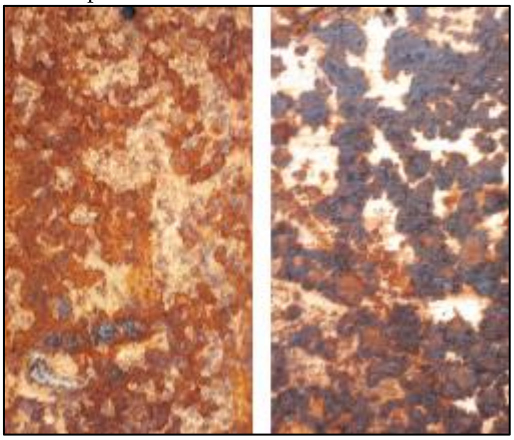


Figure 15 – Surface aspects of coated carbon steels after 600 hours of testing



The concrete specimens subjected to the corrosion tests, shown in Figure 16, were polished to highlight the attack with small cavities suffered by the saline and acid corrosive medium of the test.

Figure 16 – Surface aspects of concrete specimens after 600 hours of testing

The aim, through this experiment, is for students to be able to: visualize the gradual deterioration of the materials that make up monuments and urban furniture; understand the mechanisms of the reactions involved and critically evaluate the atmospheric pollution caused in cities.

In order to make students aware of the relationship between the causes and effects of atmospheric pollution that deteriorates monuments and urban furniture, visits and interviews should be scheduled with those who frequent squares and public places and with those responsible for maintaining public heritage.

Interviews must be semi-structured, carried out with groups of students, based on the following basic questions:

- Is there any effect of air pollution on monuments and urban furniture?
- Do buses, cars and trucks contribute to an increase in air pollution?
- Do you know of any type of protection used to conserve this heritage?

CONCLUSIONS

- Laboratory experiments must be constructed with the aim of identifying and characterizing the scientific methods used in Chemistry and the recognition of scientific parameters and laws that govern environmental phenomena.
- In the development of the learning process, in terms of environmental education based on Chemical Science and laboratory experiments, a progressive interpretation of neural events is essential, as there is a need to develop a series of parameters, such as: active and progressive search , selection, exploration and integration of new experiences. All of these factors aimed to build a conscious mind, which relates knowledge to critical vision, a fundamental item in the process of interaction and interrelationships between Chemistry and the Environment.
- Laboratory experiments must be concerned with guiding participating students to develop curiosity towards research and questioning, giving them basic experience in the type of that leads to qualitative and quantitative results aimed at relationships with the environment

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