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Cosméticos e o Ensino de Química no Ensino Médio Brasileiro: uma revisão narrativa

Cosmetics and Chemistry Teaching in Brazilian High Schools: a narrative review

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Resumo

Os cosméticos foram criados com o intuito de proporcionar benefícios à nossa pele, cabelos, unhas e outras partes do corpo. São produtos que contêm conservantes, espessantes, agentes ativos, surfactantes e vários outros produtos. A presente revisão narrativa teve como objetivo reunir o conhecimento científico já produzido sobre a abordagem - cosméticos - no processo de ensino-aprendizagem em química. Foram utilizadas as bases de dados LILACS, SciELO, MEDLINE e BVS. Vários trabalhos foram encontrados com enfoque na química orgânica. Em suma, comprovou-se que a temática *cosméticos* é mesmo uma excelente proposta para contextualizar e fazer com que os estudantes participem efetivamente do processo de construção do próprio conhecimento.

Palavras-chave: Cosmetologia; Abordagem temática; Contextualização.

Abstract

Cosmetics, which were developed to benefit several parts of our body, such as skin, hair and nails, have preservatives, thickeners, active agents, surfactants and other compounds. This narrative review aimed at gathering scientific knowledge that has already been published about the use of a thematic approach – cosmetics – in the processes of Chemistry teaching and learning. Databases were LILACS, SciELO, MEDLINE and BVS. Several studies focused on Organic Chemistry. This review proved that the theme “cosmetics” is an excellent proposal to contextualize and make students participate in the process of knowledge construction effectively.

Keywords: Cosmetology; Thematic approach; Contextualization

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1 INTRODUCTION

Researchers and some teachers in the area of Chemical Education have expressed concern for making Chemistry teaching more interesting and creative in High School (SANTOS et al., 2021). As a result, different teaching methods have been proposed to help students understand contents that they find incomprehensible. Scientific dissemination and Chemistry Clubs are strategies to make Chemistry be better accepted by students (MUNHOZ; CAMPOS; MIRANDA, 2024). However, scientific dissemination should not only spread information but also enable students' critical development towards Science. When students get interested in themes addressed by teachers, their learning becomes more effective.

Scientific dissemination contributes to students' development, to improve knowledge of Sciences and to value scientific culture. To enable scientific dissemination to be productive, a language that is understood by High School students – the target public – must be used (LIMA; GIORDAN, 2017). Thus, to address the theme "cosmetics" with focus on Chemistry in students' everyday lives works as a bridge to more understandable and enjoyable Chemistry.

Cosmetics have been in human beings' lives since ancient times. Archeological evidence shows that they have been used for enhancing beauty and personal hygiene since 4,000 B.C. In consonance with this fact, there are records of the Egyptian who mixed natural products, such as animal and vegetable fats, bee wax, honey and milk, to hydrate the skin which was usually exposed to the sun for a long time as the result of the desert climate (ALMEIDA et al., 2019). It is a historical example of civilizations that used cosmetics but, regardless of the culture, their use aimed at similar goals, i. e., to beautify, hide flaws and disguise bad odors (REIS; BRAIBANTE; MIRANDA, 2017).

As time went by and Science and technology advanced, cosmetics became even more relevant in people's everyday lives since hygiene and beauty rituals ended up being highly regarded, improving people's self-esteem and influencing forms of life and everyday life in society directly (STREHLAU; CLARO; NETO, 2015). According to the Euromonitor International, a market research company, Brazil ranks fourth in consumption of personal hygiene products, fragrances and cosmetics worldwide, following the United States, China and Japan (SILVA; GOMES; NETO, 2021).

Resolution no. 7, issued by the Agência Nacional de Vigilância Sanitária (ANVISA) on February 10th, 2015, defines cosmetics as preparations composed of natural or synthetic compounds to be applied externally to several parts of the human body, such as skin, capillary system, nails, lips, external genital organs, teeth and mucous membranes of the oral cavity, exclusively or mainly to clean them, perfume them, change their appearance and/or treat body odors and/or protect them or keep them in good shape (SARETTA; BRANDÃO, 2021).

Brazil has trended not to acknowledge industrial property in research and development of new products, not only in the area of cosmetics. Besides, several Brazilian researchers do not protect their inventions by patents because they do not know the protection system or prefer to publish papers in journals. Therefore, the theme must be introduced to teach young researchers and professionals in the

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production sector the importance of examining resources of patent documents to collect information needed for studies of prospection (PONTES; LORCA, 2021).

Considering that the thematic approach is recommended in Chemistry teaching to qualify citizens, contents of official curricula in Basic Education may be related to cosmetics by means of contextualization since it is a real-life theme (VASCONCELOS et al., 2021). Contextualization aims at carrying out this approximation to favor students' construction of knowledge and contribute to their critical and transformative development. It enables construction of meanings that incorporate values because it explains everyday life, leads to comprehension of real problems, both social and cultural ones, and, thus, makes it easier to experience the process of discovery. Contextualization should lead to significant learning of contents throughout school life in order to associate it with citizenship. It happens when students understand that Chemistry is part and parcel of life (JESUS; MIRANDA, 2023).

The theme "cosmetics" is an example which involves several scientific concepts that – more importantly – may be found in most people's lives. Chemical composition of cosmetics has great potential to trigger debates about Chemistry contents, mainly Organic Chemistry topics, such as functional groups, classification of carbon chains and everyday Chemistry.

Therefore, we believe that approaches to concepts in Chemistry need to be structured from an epistemic perspective in which students experience scientific concepts based on a relevant social context and make them state their opinions about discussed and experienced topics coherently and decisively. Thus, this paper is a narrative review of literature which aimed at answering the following question: *How can cosmetics contribute to the process of scientific literacy by associating real-life themes with Chemistry contents by means of contextualization?*

2 METHODOLOGICAL PROCEDURES

This literature review involved identification and selection of relevant studies of the theme "cosmetics and Chemistry teaching". The survey investigated three databases: LILACS, SciELO, MEDLINE and BVS. We highlight that reviews have a descriptive and analytical character and that they focus on certain areas of studies available in the literature so as to construct a "state of knowledge" of a research theme or program.

Regarding procedures, all selected studies were read, analyzed and summarized. No time frame was established. The following descriptors were used: cosmetics and Chemistry teaching, contextualization of cosmetics in Chemistry lessons, cosmetics in everyday life, thematic cosmetics workshop, organic cosmetics and cosmetics in High School.

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3 THEORETICAL BASES

This study was guided by the investigation into the theme considering the following topics for the analysis: methodological assumptions and parameters that define Chemistry teaching, relevance of learning and efficacy of employed guidelines.

3.1 RELATIONS BETWEEN CHEMISTRY AND STUDENTS' EVERYDAY LIVES

The concept of Chemistry is related to life. Such statement makes sense since Chemistry teachers are used to saying that "Chemistry is all around us". But, if it is true, how come we often meet people who cannot associate this Science with their own lives? Besides, is Chemistry teaching needed for our everyday lives?

Chemistry teaching has become aseptic and exclusive. Just those people who are labeled "intelligent" and master mathematical reasoning are able to solve Chemistry tasks and calculations while most people feel impotent towards the monster of Chemistry which increasingly drifts away from their lives. It is unfortunate that Chemistry teaching makes students memorize contents that they cannot understand. On the contrary, they could be associated with everyday concrete facts and lead to meaningful and useful learning for their lives.

Effective Chemistry teaching that promotes citizenship is reached when students internalize, produce and re-formulate chemical knowledge. It should enable them to understand chemical processes that occur in everyday life, to analyze social effects of technologies that belong to Chemistry and to perceive social reality and construction of scientific knowledge, thus, developing the skill of voicing their opinions critically.

It is important to think about Chemistry teaching in Brazilian High Schools since emphasis on transmission of knowledge has been common. Excessive concern for contents has been explained by teachers' classic statements, such as "I need to follow the program" and "I need to prepare my students to take college entrance exams". Unfortunately, few teachers state "I need to prepare my students to face life".

The need to improve ways of teaching so that contents may be connected to students' everyday experiences may attract their attention and, consequently, arouse better learning of topics addressed in school. Thus, school contents should be related to everyday life aiming at comprehension of real-life information, such as being aware of risks posed by some chemical products, knowing how to interpret chemical terms found in labels of food products and understanding combustion processes in vehicles and their effects on the environment and animals. As a result, it would be relevant to educate conscious and critical citizens since this kind of information, which is disseminated by several means of communication, may provide many themes to be discussed in school (SOUSA; IBIAPINA, 2021).

To contextualize teaching requires innovation of methodologies used in school. Innovation may be understood as an act that involves several dimensions, such as cognitive, cultural, technological, social, ethical and political aspects. It requires people's commitment, planning, intervention, systematization, evaluation, and integration; thus, it is not neutral, but it is introduced intentionally and persistently in a

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unique context. As a result, contextualization only takes place when everybody who is involved in the educational process participates. Besides, they must take decisions that enable continuity and improvement of the process in order to promote involvement with the fate of Education and its everyday practice (SOUSA; IBIAPINA, 2023).

It is a very rich field for teachers because several real-life tasks involve physical, chemical and biochemical processes which may be unnoticed. Since everybody experiences these spontaneous processes but does not think about them, thinking about them may take us to levels beyond ordinariness. “Everyday Chemistry” should be highlighted in a conception that emphasizes its social role by means of social, political, philosophical, economic and religious contextualization, rather than as a passing fad.

Therefore, to enable a significant proposal of Chemistry teaching and learning, relations must be established between certain empirical knowledge and certain explanatory theoretical models introduced by Chemistry so that both teaching and learning may become valid and significant and contribute to people’s reading of the world. Keeping in mind the intention to use real-life themes to trigger learning, emphasis is given to social themes to integrate Chemistry with social aspects, i. e., chemical concepts are co-related to a theme in the search for new answers and new questions related to the content (SILVA; BRANDÃO, 2017).

3.2 DEFINITION OF COSMETICS, HISTORICAL CONTEXT AND A “PITCH” OF CHEMISTRY

Material called cosmetics exhibit either natural or synthetic constitution and have been used since ancient times in personal hygiene, protection, odorization and beautification. Several organic and inorganic material are used for protecting and/or highlighting traces of beauty. Such compounds are usually called cosmetics or makeup. The word cosmetics is derived from the Greek *kosmetikós*, which means “skill in ornament”. There is archeological evidence of the use of cosmetics to beautify and emphasize personal hygiene that dates to 4,000 B.C. (KUMAR, 2005; SILVEIRA; NASCIMENTO, 2022).

In the Bible, the Christian holy book, there are reports of the use of cosmetics by the Israeli people and other peoples that lived in the area now known as the Middle East. Examples are eyelashes (Jezebel’s) died with a product derived from coal, beauty treatments and balm baths which Esther used for smoothing her skin and several perfumes and oils that Maria, Lazaro’s sister, used for washing Jesus’ feet. Flower oils and essences, together with hair dyes, were the first products used for making up the body (VITA, 2009; SILVEIRA; NASCIMENTO, 2022).

The first records of the use of cosmetics were found in Ancient Egypt. The Egyptian used to paint their eyes to avoid contemplating their god Son directly. Thus, they used animal and vegetable fats, bee wax, honey and milk to make creams that covered their bodies. In Ancient Greece, blush was made from natural compounds – blackberries and seaweed – whose color was added by vermillion (mercury sulfide), a reddish mineral. This product was often applied to the lips, just like modern lipstick. This attitude made it easy to ingest blush, a fact that may have led to poisoning (VITA, 2009; SILVEIRA; NASCIMENTO, 2022).

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The high society in Rome used to take baths in jenny milk to beautify skin. The Greek and the Roman were the first peoples to make soap from plant extracts, such as olive oil and pine oil, which were common in the Mediterranean, and from alkaline minerals resulting from rock grinding. Actors in the Roman theater were great users of makeup to be able to incorporate different characters in their work. Paste was produced with natural pigments extracted from plants (saffron or mustard) or from rocks. Actors often died of intoxication since several mineral pigments contained lead or mercury in their composition (SILVEIRA; NASCIMENTO, 2022).

The habit of painting nails originated in China in the 3rd century B.C. Colors of nail polish showed the social class that people belonged to. Emperors painted their nails black and red and, later, these colors were replaced with gold and silver. In the Middle Ages, saffron (used as a spice these days) was used for coloring the lips, soot collected from fireplaces and chimneys was used for darkening eyelashes, sage was used for whitening teeth and egg white with vinegar was used for getting velvet skin (CEZIMBRA, 2008; VITA, 2009).

However, cosmetics faced several obstacles throughout history. A Greek law issued in the 2nd century prevented women from hiding their true appearance with makeup before the wedding. In 1770, the British Parliament enabled marriages to be annulled if the bride wore makeup, dentures or fake hair but, years later, heavy makeup became fashionable in England and in France. In the latter, its use was interrupted after the French Revolution when only older people and theater artists were allowed to wear it (ECO, 2004).

In 1880, the use of makeup was resumed and the year is considered the beginning of the modern cosmetic industry. Only in the 20th century, due to advances in the fine chemical industry, cosmetics became general-purpose products. In the 1970's, makeup colors became popular and suited haute-couture collections in France, Italy and England. When a famous fashion designer launched a new collection of colors and shapes for clothes, the colors were produced to be exhibited in eyes and lips. However, advanced formulas of pigmented cosmetics were only launched at the end of the 1980's (HEEMANN et al., 2010).

Since pigmented cosmetics use insoluble metallic oxides to generate color, high exposure to them has led to several studies of their harmful effects on the human body (BOCCA et al., 2014). Products that are applied near the eyes and genitalia may contact their mucous membranes and be absorbed due to fine epithelial layers in the areas. As a result of the exposure, there is control over metals that compose makeup. Even so, there may be contamination with toxic and bioaccumulative metals, such as Cd, Co, Cr, Ni, As, Hg and Pb, deriving from metallic apparatus used throughout product manufacturing (AHMED et al., 2017). There are several studies of safety of topical cosmetics in humans; they show that allergy caused by exposure to makeup is associated with nickel, chrome and cobalt and that nanoparticles of metallic oxides pose risks to humans since they enable the chemical elements to be absorbed, even though they are inert and insoluble (CONTADO; PAGNONI, 2012).

In Brazil, the ANVISA is responsible for cosmetic legislation. Cosmetics are controlled by its Technical Chamber of Cosmetics (CATEC/ANVISA) and by Resolution no. 211, issued on July 14th, 2005. Its official definition of cosmetics includes all products aiming at personal use and perfumes that are made from natural or synthetic compounds to be applied externally to several parts of the human body,

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such as the skin, capillary system, nails, lips, external genital organs, teeth and mucous membranes of the oral cavity, exclusively or mainly to clean them, perfume them, change their appearance and/or treat body odors, protect them and/or keep them in good shape. The ANVISA also regulates that Cd, Cr and Pb cannot be used for producing cosmetics and that the maximum content limits of impurities in cosmetic colorants are 500 mg/L, 3 mg/L, 20 mg/L and 100 mg/L for Ba, As, Pb and other elements, respectively (ALMEIDA et al., 2019).

3.2 FORMULATION OF COSMETICS

The ANVISA determines that there is a specific cosmetic for every area of the body. For instance, body moisturizer, sunscreen and soap are used on the skin; conditioner, shampoo and smoother are applied to hair; lipstick is used on lips; and toothpaste is used for brushing teeth. Since every area has its characteristics, every product aims at a specific area and has a different formulation (LADEIRA et al., 2021).

One of the steps of cosmetic manufacturing is the evaluation of formulation stability, which is a fundamental process, not only when something needs to be reviewed in the formula but also to verify product validity. Several factors, such as time, temperature, humidity and reactions among ingredients, may destabilize a cosmetic formula. It may affect some properties of the product and consumers' health; therefore, it is important to check whether they are safe (LADEIRA et al., 2021).

Several cosmetics need to be free from microorganisms that may affect consumers and the products. Thus, some compounds are added to formulations to prevent microorganism proliferation, i. e., biocides, such as organic salts, ethanol and formaldehyde, are used (HALLA et al., 2018). Basic composition of cosmetic formulations has six classes, which are: i) excipients or vehicles; ii) antioxidant agents; iii) chelating agents; iv) pH correctors; vi) preservative agents; and vii) active ingredients (HALLA et al., 2018).

Excipients give shape to cosmetics and are the most abundant compounds in formulations. For instance, starch, talc and cellulose polymers are used in solid preparations and the ones with little liquid. Regarding vehicles, the main one is water (which is subject to several treatments before being used), followed by ethyl alcohol and polyalcohols. Preservative agents, such as benzoic acid, formic acid and organic salts, increase useful life of products, a fact that prevents microorganisms from growing (HALLA et al., 2018).

Chelating agents, such as disodium and tetrasodium EDTA, avoid alteration in stability of formulations, mainly odor and consistence. Antioxidant agents slow down oxidation of components since many products are sensitive to oxygen. An example of an antioxidant agent is hydroxybutyric acid, which is an organic acid (HALLA et al., 2018).

Another important class which is directly connected to the theme of this paper is the one of pH correctors. They must be considered because every cosmetic must have an ideal pH, depending on the area of application. There are correctors that increase pH, such as sodium hydroxide and triethanolamine, and some that decrease it, such as citric acid and inorganic acidulants. Finally, the class of active ingredients

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determines activities of cosmetics, such as anti-drying and anti-acne ones. Examples are ammonium lactate and salicylic acid, respectively (HALLA et al., 2018).

Concerning formulations, cosmetics are classified into two risk groups, considering that they may cause irritation, besides allergy. Consumers must pay attention to risks resulting from product ingestion or inhalation. Cosmetics with basic properties which do not need much information in their instructions are classified into Risk I, i. e., low risk. Examples are makeup, perfumes, soaps, toothpaste, moisturizers and shaving products. Risk II products comprise intimate liquid soaps, hydrogen peroxide, sunscreen, mouthwash, antiperspirant deodorant and bleaching agents. They require more information in their instructions since they have specific benefits that need evidence of safety and effectiveness (ZHENG, 2022).

3.3 A DIDACTIC PROPOSAL TO TEACH CHEMISTRY WITH THE USE OF THE THEME “COSMETICS”

Application of a **didactic intervention** with the use of the theme “cosmetics” enabled students to deepen their knowledge and to understand concepts of pH and functional groups. The survey of students’ previous conceptions showed a deep gap in their learning processes related to pH and functional groups. The use of a **didactic sequence** led to more significant learning since it integrated the theme “cosmetics” with students’ experiences. Thus, students may use chemical knowledge and concepts to solve everyday problems (ARAUJO et al., 2022).

Another study deals with appropriate disposal of cosmetics and awareness raising by means of a **podcast**. The authors highlighted that the theme “cosmetics”, inserted into the Science, Technology, Society and Environment (CTSA) approach proved to be an effective trigger of discussions that are important to the modern society, such as formulation of hair products, negative effects of their residues on the environment and appropriate disposal of their packaging. Discussions on appropriate disposal of domestic packaging and the podcast “Cosmetics: did I buy them, use them and throw them away?!” became a **tool that made Chemistry teaching easier** (CASELA; SOUSA; TRAVAIN, 2023).

The theme “cosmetics” has been usually chosen to teach functional groups to High School seniors. A proposal that addresses functional groups in cosmetics by means of **inquiry-based instruction** was recently applied and showed that students are encouraged to take on a new attitude towards a problem to share hypotheses, discuss them and re-structure them to develop arguments and get a conclusion (CUNHA et al., 2023).

Another study showed the importance of asking students to “get their hands dirty” and produce a **mini-course in cosmetics** and functional groups. It enabled students to relate Chemistry to real-life experiences since learning should not be restricted to what teachers teach in school. It also enabled to show the importance of studying Chemistry and how the science is related to their lives when they understand its practical implications; in this case, their relation to production and use of cosmetics (FREITAS et al., 2016).

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A recent study carried out with High School students confirms the importance of addressing relevant and significant themes, such as cosmetics, in school. This theme belongs to **students' everyday lives** and may help to teach Organic Chemistry in school (KLEIN; LUDKE, 2020).

The theme “cosmetics” was also involved in the study of investigation and discussion about **Social Representations** (SR) constructed by two groups of students. In the study, students aimed at understanding how Chemistry influences learning of different classes (High School freshmen and seniors). Results showed that, as years went by, explanations and constructions became more grounded in specific concepts of Chemistry and enabled students to develop better answers to explain everyday situations (OLBERTZ; HILGER, 2022).

Nail polish has already been part of a unique proposal to teach functional groups by means of **experiments**. This approach enabled contextualization of chemical concepts, such as functional groups and reactions, by investigating chemical composition of nail polish labels and carrying out experiments to identify and synthesize organic compounds (REIS; BRAIBANTE; MIRANDA, 2017).

Since there has always been interest in changes in capillary characteristics, a study introduced a methodological proposal to teach Chemistry based on students’ reality. The theme **hair straightening** was used for developing activities to teach **chemical elements and formulas** (VIEIRA; JESUS; BRONDANI, 2018).

Cosmetics were considered heroes or villains in a scenario in which students were able to reflect on their continuous use and harmful effects of their improper use. Teachers also associated the content with **chemical classes and properties**, based on theoretical concepts that students had previously learned (YAMAGUCHI; FERREIRA, 2019).

Finally, deodorants and antiperspirants were also studied by High School students at the Instituto Federal do Triângulo Mineiro - Campus Uberlândia Centro, in Uberlândia, MG, Brazil. Freshmen were able to learn about the chemical element aluminum and its toxicity. The theme was added to and **contextualized** parallel to the teaching of the periodic table (MIRANDA; FERREIRA, 2022).

4 FINAL REMARKS

In this narrative review, literature findings showed that studies published as papers or chapters in books reached similar results. The theme “cosmetics” really arouses High School students’ interest. The topic brings together, clarifies and promotes debates by involving students since they know several cosmetic products that are part and parcel of life. This review also showed that using different teaching methodologies is a way of favoring both teaching and learning processes. Distinct methodological routes guided by teachers encourage and stimulate students, a fact that leads to construction of significant learning. In short, didactic strategies must be proposed to make Chemistry lessons more dynamic and to enrich traditional content-based lessons.

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