

Bisphenol A, the Villain of Plastics: Chemistry Teaching to Raise Students' Awareness in a High School in Southeastern Brazil

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Abstract:

Traditional expository classes, whose only didactic resources are the blackboard and the teacher's talk, are neither the only alternative nor the most productive one to teach Chemistry. Keeping it in mind, this study aimed at addressing one of several topics in Chemistry – plastics – by problematizing everyday situations, since the composition of some plastic packaging includes harmful compounds, such as bisphenol A (BPA). Specifically, BPA is an industrial chemical product which has been broadly used in its monomeric form to yield epoxy resins and polycarbonate plastics. Since it has excellent physical and chemical characteristics, it has been used as lining of metal packaging, besides the manufacturing of milk bottles and household items. However, BPA, even at low concentrations, may cause infertility, nervous system disorders, diabetes, cancer, obesity, precocious puberty and cardiovascular diseases. In order to make Chemistry teaching more attractive, this study aimed at informing students about effects of BPA at the Instituto Federal do Triângulo Mineiro - Campus Uberlândia Centro (IFTM - UDICENTRO), a high school located in Uberlândia, Minas Gerais (MG) state, Brazil. Thus, questionnaire about BPA was applied to the students and the theme and the adverse effects of this compound were discussed from a chemical point of view. Results of the study and both students' learning and awareness-raising were considered satisfactory. Teaching which includes students' reality is capable of improving their comprehension and make Chemistry classes more attractive and pleasant.

Keywords: bisphenol A; packaging; contextualization; chemistry teaching

1. Introduction

Chemistry is an extremely important science since it is interrelated with everything that surrounds us, from rock formation to the constitution of human beings. Even though several day-to-day processes are related to Chemistry, in school, students consider it a difficult course which is often taught in a decontextualized way, a fact that hinders comprehension. Since it happens because relations are not established between human beings and the world, an alternative is the study of contextualization, an outstanding aspect in Chemistry teaching which has been used by

teachers, textbook writers, curriculum designers and researchers in Chemistry teaching [1].

In Chemistry teaching, there are many concepts which most students cannot learn because they are not capable of associating the content they study with their everyday routine; as a result, they lose interest in the course. Traditional teaching methods often fail. Strategies that not only contextualize Chemistry contents, but also help students develop capacities and abilities in oral and written communication must also be used to stimulate research and trigger critical thinking [2].

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In the class context, problematization enables teachers to ask questions about students' views and search for pedagogical tasks that value this decodification process. Thus, it is a bridge that connects knowledge that students bring to class with scientific knowledge, since discussion of scientific content addresses elements that are pedagogically problematized in dialogues with students. Problematizing practices enable people to look at their situation as a problem; as a result, educators and learners become subjects of a process of learning construction [3].

Bisphenol A (BPA) is a synthetic chemical product which has been extensively used in almost all plastics. It is considered an endocrine disruptor that leads to changes in thyroid hormones and causes several diseases, such as breast and prostate cancer, diabetes, hyperactivity and heart conditions. Contamination with BPA at little amounts is the result of leaching from compounds of plastic containers into the food inside. Regarding packaging, BPA is mainly released when it is heated, but also when it is frozen; in both cases, food that is stored in it is contaminated. Besides, frequent exposure to BPA also affects the central nervous system, causes brain feminization in men and triggers obesity [4].

BPA was first made by Russian chemist Alexander Dianin in 1891 and synthesized by Thomas Zincke in 1905, when he combined phenol and acetone at Philipps-Universität Marburg (Germany). BPA (Figure 1) is composed of two phenolic rings isolated by a quaternary carbon and bonded by two methyl radicals [5].

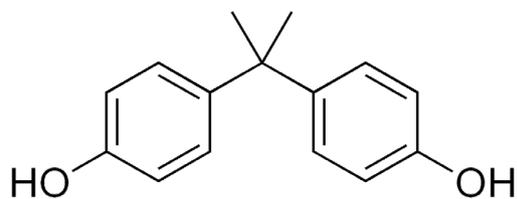


Figure 1. Chemical structure of bisphenol A

As mentioned before, food is mainly exposed to BPA when it is stored in plastic containers made from polycarbonate and epoxy resins, which can be found in food can linings. The problem is that BPA is the monomer basis

for the synthesis of those types of material which have direct contact with any stored food [6].

The United States Environmental Protection Agency (USEPA) has established that the daily reference dose for oral exposure to BPA should be 0.05 mg/kg of body weight, while the European Union recommended that the daily safe dose was 0.01 mg BPA/Kg of body mass in 2002, based on studies that were available at that time [7]. In Brazil, the Agência Nacional de Vigilância Sanitária (ANVISA) prohibited manufacturing and sales of milk bottles that contain BPA in January 2012; its main argument is that studies that were carried out with animals showed that BPA may cause several health problems [7].

Considering problems caused by BPA and the contextualization of this compound in Chemistry teaching [8], this case study aimed at investigating knowledge of the use of packaging that contains BPA in everyday activities and its implication for human health. Chemistry teaching showed to be a strong ally in raising students' awareness of the issue and enabled several students to effectively learn a theme that was unknown to them.

2. Results and Discussion

Results of this study were satisfactory, since students' learning was significant throughout the activities. Students and researchers who participated in the study were enthusiastic, not only about the study itself but also about the course of Chemistry, and stated that when learning Chemistry involves everyday topics, it is much more attractive. It was also observed when researchers applied questionnaires and gave a brief talk about the theme in the school, since students showed much interest and got involved in the discussion, which is different from what happens in conventional Chemistry classes.

One hundred students were interviewed. Firstly, students were questioned about their previous knowledge of the compound BPA; 11 % answered that they already knew it while 89 % said that they did not know it. Therefore, most students did not know it and had never heard about it. These answers were expected since very little knowledge produced by scientific researches is disseminated in the society. On the

other hand, students who represented 11 % that knew BPA said that they had learned about this compound in Chemistry and/or Biology courses, food packaging, newspapers, speeches and YouTube. When they were asked whether they used plastic containers to store food, 93% answered that they always used it on a daily basis, a common habit many families have. Only 7 % said that they do not use plastic containers and prefer glass ones because they are more hygienic. In the group of students who use plastic containers, 57% stated that they heat their food up in microwave ovens, while 43 % of them said that they don't. Regarding information on packaging, 87 % answered that many labels on plastic containers used for food storage do not specify that the material is BPA-free. Only 13 % of students mentioned that they were sure that all containers had information related to the fact that there was no BPA in their composition and that they were more expensive than conventional ones which did not provide data on the compound.

Another question was related to a common habit in Brazil, i. e., "drinking coffee in plastic cups". Does this habit pose risks to health? Fifty-four percent of students answered that it does not, while 46 % said that it does and some students added that hot coffee may extract undesirable and harmful compounds from the plastic material. Seventy-three percent of participants answered that plastic containers release more BPA when they are heated, 2 % said that it happens when containers are frozen and 25 % stated that both processes lead to expressive BPA release. A newspaper published that plastic material that contains BPA releases high concentration of the compound when it is heated and frozen, even when containers have grooves [9].

In the second phase, after students were taught about risks that BPA poses to human health, they had to answer new questions (second phase of the questionnaire). The first question was about using the best type of containers to store food. In this phase, 51 % of interviewees said that they would make the right choice and use only glass containers because they are inert, reliable and BPA-free, while 40 % of them said they would keep using both – plastic and glass containers – but highlighted the importance of checking specifications on their

labels which should inform whether they are really BPA-free. Finally, 9 % of students stated that would keep using the common plastic containers because they are easily found and cheaper than the others; some of them also added that their parents just buy them, since they have no idea what BPA is and would not think about looking for such information on labels. However, 93 % of interviewees acknowledge the importance of making the right choice when household items are bought to store food and emphasize that this attitude may bring beneficial changes to the whole family's health, even if it happens in the long term. Seven percent of students do not see this change as something significant, since consequences are not immediate. It should be highlighted that, even after the talk that aimed at raising students' awareness, only 61 % of them said that they feel confident to safely choose household items for food storage, while 39 % said that they still felt insecure and badly prepared to do it; many of them also questioned how reliable manufacturers were.

The questionnaire ended by asking students the best way to make knowledge of BPA reach people in their everyday activities. Most interviewees answered that the objective would be reached when the theme was publicized by social networks (in a connected world), speeches were given in schools, programs and articles were shown in the media, explainer videos were shown to the population and infographics, besides concise and "appealing" labels, were used on containers (for instance, "BPA-free" should be written on them).

Other studies of Environmental Education have been carried out in Brazilian schools [10-12] with the use of different methodologies but the same objective of this study, i. e., raise elementary and high school students' awareness and develop their critical thinking. However, this paper reports the second study published in Brazil that addresses toxicology and contaminants found in everyday practices, specifically in the ones of students who attend IFTM Campus Uberlândia Centro. The pioneer research into BPA which can be found in the literature – there are very few ones – aimed at giving information on risks posed by BPA to children who attend city and state schools in Rio Grande do Sul state, in the south of Brazil [13]. It

was conducted at IFTM Campus Uberlândia Centro and also aimed at teachers' continuing education and at influencing Chemistry teacher education college degree programs. Literature has highlighted the importance of educators in processes that aim at raising environmental awareness and the need for deeper discussions about Chemistry teaching and environment [14].

3. Material and Methods

This case study aimed at raising awareness in a school community in Uberlândia, Minas Gerais, Brazil. The school that was chosen to participate in the study was IFTM – Campus Uberlândia Centro and the level was the high school, where 100 students were interviewed. Interviewees' ages ranged between 14 and 18 years old. The questionnaire was applied in two different phases. The first one was applied before students were taught about the theme in order to know their previous knowledge about BPA. A bibliographic review about implications of using packaging whose components included BPA and health problems generated by this compound was explained to students after they had answered the questionnaire. Afterwards, students used the knowledge of packaging and BPA they had acquired to answer the second questionnaire. Both the interviews and the talk about chemical knowledge were used for raising students' awareness.

The 10-question questionnaire, which was divided in two parts, is described below.

Part I (first phase)

- 1) Have you ever heard anything about bisphenol A, a.k.a. BPA? If so, where have you heard about it?
- 2) Are you used to using plastic packaging to store food?
- 3) Do you heat this packaging up in the microwave oven?
- 4) Does this plastic packaging hold the specification "BPA-free"?
- 5) Do you believe that the habit of having some coffee in a plastic cup may be dangerous to health?

- 6) In your opinion, do plastic containers release more BPA when they are heated in microwave ovens, frozen or in both situations?

Part II (second phase)

- 7) If you need household items, will you use the ones made from glass, plastic or both?
- 8) May choosing appropriate household items lead to beneficial changes to health in the long term?
- 9) Are you aware of risks when you choose a container to store your own food?
- 10) In your opinion, what should be done to make information about the topic reach people in their everyday practices?

4. Conclusions

Results of this study showed that the application of the questionnaire and the development of a brief talk, which aimed at raising awareness in the school community, led to dissemination of knowledge about the compound BPA and its use in different types of packaging. The use of these types of plastic containers was problematized and discussions focused on risks they pose to human health. In addition, most students' way of thinking was found to have changed after the study while the need to investigate and publicize toxic compounds which are part of everyday life – but may pass unnoticed – was confirmed. In short, Chemistry teaching is a powerful tool and an effective form to make learning more pleasant and applicable when it is adequately used by teachers.

References and Notes

- [1] Wartha, E. J.; Silva, E. L.; Bejarano, N. R. R. *QNEsc.* **2013**, *35*, 84. [\[Link\]](#)
- [2] Ferreira, L.; Braibante, M. E. F.; Kraisig, A. R. *REDEQUIM.* **2019**, *1*, 176. [\[Link\]](#)
- [3] Leite, L. R.; Lima, J. O. G. *Rev. Bras. Estud. Pedagog.* **2015**, *96*, 380. [\[Crossref\]](#)
- [4] Hoffmann, S. B.; Bitello, A. A. *Rev. Cad. Ped.* **2016**, *13*, 75. [\[Crossref\]](#)
- [5] Bernardo, P. E. M.; Navas, S. A.; Murata, L. T. F.; Alcântara, M. R. S. *Rev. Inst. Adolfo Lutz* **2015**, *74*, 1. [\[Link\]](#)

- [6] Michalowicz, J. *Environ. Toxicol. Pharmacol.* **2014**, *37*, 738. [[Crossref](#)]
- [7] Oliveira, G. C. P.; Araújo, J. V. S.; Junior, A. M. C.; Palombit, K. *Jorn. Inter. Bioc.* **2017**, *2*, 11. [[CrossRef](#)]
- [8] Lopes, T. C.; Nunes, I. C. D.; Couto, A. M.; Melo, K. C.; Melo, T. E. M.; Rodrigues, A. C. V.; Corrêa, A. S. Abstract at the 52^o Congresso Brasileiro de Química – Química e Inovação: Caminho para a Sustentabilidade, Recife, Brazil, 2012. [[Link](#)]
- [9] Evaluated at: <http://gnt.globo.com/bem-estar/materias/bisfenol-saiba-como-evitar-a-substancia.htm>, Accessed in October, 2019.
- [10] Bianchini, D. C.; Frank, J. C.; Seben, D.; Rodrigues, P.; Rodrigues, A. C. *REMOA.* **2015**, *14*, 188. [[Crossref](#)]
- [11] Figueiredo, O. A. T.; Heckler, D.; Croda, J. P.; Lazarotto, S.; Gazzana, D.; Silva, V. A.; Guerreiro, L. *Experiência* **2016**, *2*, 14. [[Crossref](#)]
- [12] Santos, E. T. Educação ambiental na escola: conscientização da necessidade de proteção da camada de ozônio. [Final course paper]. Santa Maria, Brazil: Universidade Federal de Santa Maria, 2007. [[Link](#)]
- [13] Silveira, C. R.; Barreto, J.; Nunes, S. M.; Chaves, I.; Martínez, P. *Expressa Extensão* **2018**, *23*, 24. [[CrossRef](#)]
- [14] Junior, L. P. C.; Fernandez, C. *Quim. Nova* **2016**, *39*, 748. [[CrossRef](#)]