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Opinion

In an era where the Chemistry has to be Green! Red Alert!

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[In memory of Professor Hugh Douglas Burrows (1945-2023)]

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Abstract

The line dividing green chemistry from pseudo-green chemistry becomes fragile. The pressures to present as quickly as possible results in scientific and business spheres, associated with the incessant search for funding in strategic areas, such as the Environment and Health, leads to the development of "fast science", which is not always accurate.

Keywords: Green chemistry; pseudo-Green chemistry; Fast science

Chemistry has to be Green! Red Alert!

Science and technology should, undoubtedly, use all the instruments available in the genesis of a superior quality of life globally. Historically, chemistry, undisputed as a central science, has always tried to be governed by this principle. Nevertheless, chemistry expanded in the last decades of the 20th century, guided by a growing awareness of the necessity to preserve the environment, even aiming for an improvement in the quality of life through reflections on its modus operandi. The ends no longer justify all means, and the "clean chemistry perception" has emerged! In 1962, Rachel Carson "threw the first stone" in this area by publishing the environmentally oriented book, Silent Spring [1]. This served as an alert for the public and scientific community and stimulated the development of the modern environmental movement. In 1969, President Richard Nixon established the U.S. Environmental Protection Agency (EPA), a federal regulatory agency responsible for protecting human health and the environment. The EPA's first major decision was to ban the use of DDT and other chemical pesticides. This agency was decisive in the preparation and approval of environmental legislation, originally in the United States, but a practice that gradually extended to European countries.

Until the 1980s, the interests of the chemical industry in this area were mainly dedicated to pollution clean-up and identifying evident toxins. However, a major paradigm shift started to emerge among chemists, who began to study avenues of preventing pollution in the first place. Within this context, several leaders in industry and government initiated international discussions addressing the problems and looking for preventative solutions. The EPA's office of pollution, prevention and toxics was founded in 1988, and the 1990s marked the acceptance of pollution prevention as a necessity. This also resulted in "Green Chemistry" becoming accepted as a mainstream scientific field. Within this perspective, a green paradigm should be considered whenever one makes

advances within the area of chemistry. Over the last two decades, much has been written and reflected on green chemistry! This includes its principles, benefits, utility, need for good practices, or technological advances based on sustainable chemistry protocols. Today, many industries use chemical technology with minimum environmental impact. The importance of green chemistry is also reflected by the continuing increase in high quality scientific publications [2-7].

The greatest practical contributions for society within this research field are, obviously, perceived to be those made visible to public opinion. However, too much research globally has been presented as green- or sustainable chemistry without obeying its minimum principles or undergoing rigorous evaluation. We are talking, in this case, of "pseudo-green chemistry", which has been wrapped up in a fashion where almost everything that happens within the chemistry domain must have something "greenish". Unfortunately, reference to all research of this type is unfeasible, just as any kind of generalization would be unfair. In the vast majority of these cases, "the part" instead of the "whole" of the question, is highlighted.

Let us consider, as a model of pseudo-green chemistry, a synthetic protocol comprising several reaction steps that use as core substrate tetrachlorodibenzodioxin (the most toxic dioxin in its series). Imagine that in the first instance all the reaction steps are carried out in benzene solution, and after that conditions are devised for replacing the highly toxic benzene by water. Does this constitute green-chemistry? Probably not! Procedures based on highly dangerous substances cannot be considered as green, even using water as a reaction medium. Similarly, cases of pseudo-green chemistry frequently occur within the catalysis field. It is quite common to designate a process of chemical catalysis as sustainable when it occurs in an innocuous environment, ignoring the toxicity of the catalytic framework itself (often containing very hazardous heavy metal species) or the method(s) used in its generation. If dirty protocols are used to yield new structures, which, in turn, make other processes cleaner, it is nonsense in most cases to consider these as green!

The line dividing green chemistry from pseudo-green chemistry becomes tenuous. The pressures to present as quickly as possible results in scientific and business spheres, associated with the incessant search for funding in strategic areas, such as the Environment and Health, leads to the development of "fast science", which is not always accurate [8-11]. Historically, the greatest advances in science have been made with time to reflect. It is now time in the green-chemistry field for such a reflection. It is time for the funding entities and journal editors associated with this particular area start to narrow criteria in order to avoid the view that, in the near future, all research in chemistry is considered sustainable. Furthermore, prevention of chemical problems is frequently overlooked, with the idea that new clean methods can be easily developed to solve all side effects. I believe that the first approach, whenever possible, should consider the prevention. This is a red alert, in an era where chemistry should be green! With all the obvious benefits to society achieved in recent decades through the use of sustainable chemistry procedures, it is crucial to reflect on what is less good in this research field to avoid entering into irretrievable anarchy. The scientific community, in particular, must accept responsibility for an effective scrutiny of "real" green chemistry, protecting society and ensuring the economic benefits arising from the global environmental advances.

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Conflicts of Interest

The author declares no conflict of interest.

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