

## Thinking Green Chemistry: beyond the technological optimism and pitfalls of a possible slogan

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### Abstract

Faced with a society organized as the basis of voracious economic and mechanistic paradigm it is necessary to question some contradictions, among them, how to keep the frenetic rhythms of production and consumption on a planet which has finite source of material? And which for some years it has already given clear signs of depletion, primarily associated with quality in the provision of basic environmental services. Thus, it is important to discuss the influence of ideas such as: sustainable development, technological advances, principles of thermodynamics, thermodynamic-ecological paradigm and green chemistry. In the meantime this essay aims to make a reflection/discussion on three important issues: 1) The emergence of some myths credited by technological optimism from the fundamentals of thermodynamics; 2) The ownership of the philosophy of Green Chemistry as a slogan; 3) The importance of education in green chemistry, on the premise of being an integrated, cross-sectional component and a prospective character leading to deeper understanding of environmental issues.

**Keywords:** Green Chemistry. Technological optimism. Slogan. Education in green chemistry.

## 1 Considering the issues of Technological Optimism

Our inquiries have, as the start point, the following question: How to reconcile a global economy based on the growth of production consumption goods on a planet whose sources of raw materials and energy are finite?

We should bear in mind that everything around us is transformed nature, such as, a glass, shoes, and other objects. The natural environment is the suppliers of raw materials to consumer goods to be produced. Thus, chemical industry, because of its versatility occupies a privileged place in the production chain because it meets the needs of the basic industries to those of consumer goods.

In its productive processes, the chemical industry has taken from the natural environment, low entropy materials so that consume a certain amount of energy, which is usually achieved by burning fossil fuels, and dispersing in high entropy material environment as gases and heat. At investigating these events from the fundamentals of the laws of thermodynamics, it appears that closed systems, like the earth, cause the increase in entropy of the environment. That is, it is impossible for human intervention without irreversibly increasing entropy.

In this context Georgescu-Roegen (1986; 2005) draws our attention to the relationship between the economic process and thermodynamics. According to the author, the important point that should be considered by the economy is that the law of entropy is the root of scarcity (GEORGESCU-ROEGEN, 2005). And opposes the insistence of certain economist currents, when they claim that the resources can be adequately measured in economic terms and not physical. The question is: how to grow if there is a finite amount of accessible low entropy matter and energy resources limited to keep rhythms of this growth? That is, the limits to growth are not exclusive of an economic analysis of the market, on the other hand, nature imposes physicochemical limits.

Regarding the point of view of physicochemical limitations of nature, as we point out, there is a finite amount of materials that can be used in the manufacture of consumer goods, and for chemical perspective, the environment is already showing clear signs of difficulty to be able to debug many substances released daily. The rhythms accelerated production and consumption, and that amount of waste has not given the necessary conditions for the resilience of the environment. In addition to that, a significant number of exogenous substances take much longer to be debugged.

For the researcher, several myths were created in this context, including: the fallacy of endless substitution, the belief that to get rid of pollution we just have to do the same things differently. A similar and necessary point for discussion is the debatable thesis that we will always be able to find replacement for stable resources, as well as the unlimited ability to increase the productivity of any type of energy, based on the belief that technology has no limits (GEORGESCU-ROEGEN, 2005).

In this respect Huesemann (2003), in his article, *The limits of technological solutions for sustainable development*, calls into question what he defines as technological optimism, which is supported by ideas, such as that all raw materials and energy used in industrial processes derived from renewable sources do not cause side effects to the environment; and that waste thrown at compatible rates with the assimilative capacity of the environment do not cause harmful effects. Another aspect worth mentioning the author's viewpoint is related to the association between eco-efficiency and sustainable development. According to him, business leaders, who defend the great capitals, argue that eco-efficiency is a primary tool for the realization of industrial sustainability (HUESEMANN, 2003).

Similar conceptions are found in chemical speech enshrined in defense of Green Chemistry (GC) as "the challenges of sustainability will be met when new technologies provide products company that have a more environmentally appropriate management" (ANASTAS; KIRCHHOFF, 2002, p 686.). And it is clear concern in order to maintain industrial activity and economic sustainability, as in the transcript below "should be easy to predict which reactions, environmentally friendly products and processes will improve the competitiveness of the chemical industry" (TUNDO *et al.*, 2000, p. 1208).

Corroborating the above dialogue, Marques and Machado (2014), in a review article in which investigated the relationship between green chemistry and environmental sustainability show that the GC has emerged with a strong connection to environmental sustainability, which is considered by researchers as an important tool for sustainability. Directed toward the reduction and the risk of negative impacts of chemicals; to increase eco-efficiency and support for economic growth; connecting chemistry with the economy, but precisely concerned in getting processes and sustainable technologies.

This kind of thinking reinforces the common sense conceptions bringing some understanding that the thrifty use or saving of natural resources, coupled with the power of science and technology to produce new technologies are sufficient to promote the sustainable development (SD). And so people believe in speeches as sustainable consumption, green economy, to solve environmental problems without taking into account the finiteness of natural resources is something physically inevitable (BARBOSA; MARQUES, 2015). And that environmental problems are beyond the physical, chemical and biological planet, they are social problems.

Also, in relation to technological optimism, Huesemann (2003) warns the speeches that suggest that non-renewable materials are sustainable as they can be recycled. According to him, most industrial metals and catalysts (aluminum, copper, lead, nickel and iron) possess technological feasibility and cost for recycling. Packaging materials, solvents and refrigerants are technically feasible but not economically. Finally, dyes, pesticides, explosives, fuels, lubricants, and others are not feasible in both respects. From the thermodynamic point of view the energy required for the purification of materials of the latter group increases dramatically as the material is more dispersed (HUESEMANN, 2003).

The laws of thermodynamics imply that all activities of the industrial and economic system have unavoidable negative environmental consequences and human limits meet such ingenuity, coming to believe that technological inventions do not produce undesirable consequences; and finally, under the continued economic growth regime, improved eco-efficiency alone will not guarantee the reduction of negative environmental impacts. So it is impossible to complete recycling of materials coming from non-renewable sources (MARQUES; MACHADO, 2014).

The paradigm of recycling and reusing take advantage of the idea that eco-efficiency on the use of technological innovations as described in the excerpt below:

The representation of a circular diagram and closed itself promotes understanding of the economic process remains without the production of waste, in order to fully consume all the material resources and energy involved. If this were possible, it could be considered that environmental sustainability would be perfect, following the precepts proposed in the Brundtland Report, therefore, being the infinite physical resources (reversible ultimately) would suffice their thrifty use to secure them for future generations. However, when observing any economic activity (production and movement of goods) we can see that is not quite what happens because waste is generated (BARBORA; MARQUES, 2015, p. 1127).

In this scenario, Huesemann (2003, p. 25) concludes that "the use of non-renewable materials are inherently unsustainable, because the cycle of materials cannot be completely closed, and result in the dispersion of materials that are the causes of environmental problems". For Georgescu-Roegen (2005, p. 13) the endless replacement fallacy and boundless technology cannot support themselves because "the replacement within a finite stock of low affordable entropy, whose irrevocable deterioration is accelerated by the use, will not be able to continue indefinitely". Barbosa and Marques (2015) bring us a reflection on the role of science and technology - key elements of the speeches of eco-efficiency advocates, as a means that cannot solve the problems of environmental pollution, as before the thermodynamic laws of nature, what we can get "is to delay such exhaustion" (BARBOSA; MARQUES, 2015 p. 1128).

Finally Huesemann (2001) points out that environmental problems, which are complex, are not preliminarily technological problems, on the contrary, they are social and moral order. And so, believing that technical solutions are obtained in the short term leads the public think that the use of technologies can solve problems, which is useless unless modes of consumption, its values and its behavior are radically changed.

## 2 Considering the questions of a possible Slogan

When investigating the time line of environmental epistemology it is remarkable that the discourse on GC and SD emerge from the same period due to political, environmental, social and economic, which brought complaints such as the depletion of the ozone layer, scandal supertanker Exxon Valdez spill in Alaska, the unfortunate Chernobyl nuclear accident. These and other configured the global atmosphere on the eve of the considered greater political meeting to discuss environmental issues RIO-92.

For many chemicals, Machado (2011), Vilches and Gil Pérez (2011), Marques et al. (2013), GC and the SD have an intrinsic relationship as point Hjeresen, Schutt and Boese (2000, p. 1543) "The importance of green chemistry as an alternative in the developing world cannot be overemphasized. Sustainable development depends on the supply of goods and services to a growing population without sacrificing environmental quality".

The speeches are tools used by various sectors of society to persuade certain target audience, so that its objectives are achieved. Among them has been sustainable development. Jickling (1992) warned of the obscurity surrounding the understandings: economic, political, philosophical and epistemological, citing for lack of philosophical analysis. As for Huesemann (2001; 2003), the definition of DS is vague, and there is no consensus between the interests of economists and ecologists. Thus, in the present level of decision-making and public policy continue reigning the economic criteria and sectorial actions, as well as attempts to internalize environmental externalities through new economic calculation tools for environmental management (LEFF, 2009).

According Sauv  (2005) in this perspective, the environment is reduced to a set of resources for the economy, and the greater concern for the sustainability of natural resources is not to run out in short time, seen as the main obstacle to the growing escalation of economic growth. Novo (2009) says that the spread of this concept has been marked in some ambiguity, by some who wanted to understand, that this formula could still be practiced based on the previous model of unlimited growth, called by the author of a radical understanding. According to her, based on this criterion, the criticism of SD, end up being weakened, because since when the term was coined has undergone a continuous process

of reading and transformations, and currently not naively incorporates the most perverse of economic intentions.

The SD concept does not have its origin in physics and or chemistry, but in a political speech produced from a social historical context. To Marques and Machado (2014), many chemicals cannot link these issues to the fundamentals of the laws of thermodynamics, which according to them is due to the fact that the super-specialization, the process by which they were formed, reducing their ways of rationalist thinking into Cartesian components. Making a significant obstacle in understanding the complexity that involves environmental problems.

Our research on the subject have called us to attention to some obstacles involved in conceptions that support green chemistry (PITANGA, 2015; 2015a), mainly due to the lack of philosophical and sociological analysis related to such speeches. These concerns set out the proposed warnings for Michael Cann and called Brown Chemical; Machado (2007, 2009) and their reports False cases of Green Chemistry; Ferreira, Rocha and Silva (2013), when signal to a green painted sustainability; and especially Steinhäuser et al. (2004) and Zuin (2011), when questioned about the care for green chemistry does not become a slogan. Thus the graft proposed by Zuin (2011, p 15) allows us to reflect on these concerns:

In the sphere of techno-scientific innovations, which become the object of desire of researchers in the field of chemistry, distinguished Green Chemistry. However, the so-called society of the spectacle, this philosophy can become a slogan. Today, by publicizing, or sell, the slogan of green chemistry as an absolute environmental dimension, as a synonym for environmentally friendly chemistry, which is not understood in a profound way, we contribute to the end, by engendering discrimination, exclusion, marginalization, as this 'right' that requires integration and commitment of members of the field, there is a totalitarian tendency, very similar to the use of speech "politically correct".

Marques and Machado (2014) call attention to the lack of a philosophical reflection on the relationship between GC and sustainability. That despite being a scientific movement, this should incorporate dimensions aimed at society and consider political ideas and aspects. For researchers many companies make of marketing their activities as sustainable, without making clear his intentions. According to Daly (2004, p. 198) "The SD is a cultural adaptation made by society as it becomes aware of the emerging need for zero growth." So deceive the belief that growth is still possible and desirable, labeling it *sustainable* or coloring of *green* only delays the inevitable transition and make it more painful (DALY, 2004).

Steinhäuser et al. (2004) call attention to the appropriation of concepts and their transformation into slogans, by politicians, associations, industries and companies in general. According to the authors, these groups can claim them for the care of their interests and use them as arguments in the expectation of overcoming/mask certain barriers in political conflicts without making clear their real intentions. It would be an attempt to humanize capital, make your brand/image friend of green.

For Zuin (2011) there is a whole effort and concern for the establishment of a commitment to link back to the preservation of the environment. Geared for issuing marks, certificates and hangs tags that adorn the packaging of processes, products and things individuals that serve as sales strategy, passing an image of environmentally friendly, and not for the development of an environmental design criticism.

At investigating speeches and practices on teacher GC of a certain Brazilian universities, with a view in a sociological concern on the subject, Pitanga (2015) could infer that in this context the GC presents with a propositional mechanism of change, a rationalization instrument, the way it is operated is motivated to maintain the existing dominant interests. Weber (2004) has called the rationalization of a disguised form of political domination over nature and society. Habermas (2011, p. 45) defines it as "the extension of social spheres, which are subject to the criteria of rational decision" or "adaptations to the new demands of rationality".

Even in Habermas (2011) in the capitalist environment always recorded the pressure to enhance productivity by introducing new techniques. But in the current scenario of high technological development, it intensifies the belief even more in the unlimited capacity of the development of S & T based on the substitution of natural capital for human capital. Featuring, according to the fundamentals of Habermas (2011), a disfigured rationalization in capitalist terms, leading us to infer that in the current context, the GC presents itself as greener strategy, idea that corroborated with the excerpt below:

The revolution means only a change in the institutional framework, which would not affect the productive forces as such. Keep it would, therefore, the scientific-technical progress structure would change only the regulative values. The new values would translate to technically solvable tasks; the new would be the direction of this progress, but the criterion of rationality itself remains unmodified (HABERMAS, 2011, p. 54).

Given the above scenario, the development of GC aims to forward scientific and technological alternatives order, with the word *REPLACE* order: processes and polluting products, consumers of large amounts of matter and energy (Pitanga, 2015). In this regard, Georgescu-Roegen (2005) the essentiality to understand the typical forms that technological progress may occur, highlighting the group of innovation: the replacement of innovations - that replace physical-chemical energy instead of human energy; and the spectrum of innovations - that aim to produce new consumer goods.

Another aspect is the appropriation of another's speech; the business has appropriated the ecological discourse, aiming to humanize the capital, become friends green. Not in order to meet priority to environmental sustainability, on the contrary, it seeks to improve their brand/image and persuade the consumer public with the feeling of accomplishment of a correct purchase, one that does not harm the environment.

According to Layrargues (2000), we are facing a process of technological modernization, which primarily aims to reduce costs and increase productivity, since the disposal of industries began to be questioned and regulated. But in addition, the business diagnosed opportunity to explore through marketing strategies a way to improve the industrial image, ie, in its intimate not there was an ideology transition from the economic rationale for ecological but an ownership another speech (LAYRARGUES, 2000).

In this aspect Sordi (2012), states categorically that the use of the image of a product is a form of exploitation of the green market. Also according to the studios, we are facing an *ecological makeup* characterized by two stages. At first, the ownership of the other speech industry, in this case, the environmentalist who incorporated the green to its products, carrying a strong symbolism associated with the concern to save the earth. The second stage corresponds to the manipulation of discourse, where "green is reframed as the interests, ideological and economic disputes" (SORDI, 2012, p. 29).

To Loureiro (2012), companies began to mobilize with the intention of achieving environmentally acceptable standards, as a phenomenon more associated with market strategies that even the ethical principles or defense of nature. The environment has become an item of extreme importance in the quest to define which companies operate in the world market. "The goal of companies, whether national or international, is to obtain competitive advantages, and investments are made to expand the consumer market for green goods" (LOUREIRO, 2012, p. 31).

Finally, Leff (2010, p. 69) warns us to ideological formulations within the environmental field, "which is generating interest speeches with the function of neutralizing the consciousness of the subject the conflict of interests that are at stake." Thus, data and dialogue with the literature that deals

with GC, leads us to infer that this philosophy is a simulacrum, according to the sayings of Leff (2006), as it seeks to internalize the environmental dimension in the economic perspectives.

### 3 Considering the importance of Green Chemistry Education

The irruption of environmental complexity induces an epistemological and societal change - "passing the mechanistic paradigm to a thermodynamic-ecological - contrary to the fragmentation of the sciences and walking in a holistic building a world understood as an inter-relations system, interdependencies and feedback" (LEFF, 2006, p. 306), where only the adoption of a complex thought, interdisciplinarity and changes in values and practices of people can lead to a proposal for coexistence less uncertain over time (PITANGA, 2015a).

The environmental problems are, in its main feature, the increasing complexity, the endeavor to meet them and offer referrals for possible solutions, it is known the need to deconstruct and reorient society in another direction, for this, it is necessary to think them holistic and systemic (PITANGA, 2015a). For Huesemman (2001), the reductionist mechanisms of science are inherently limiting to solve environmental problems, as this paradigmatic model considers the workings of nature as a machine, and thus ends up ignoring their complexity, by investigating the properties as isolated parts.

Many of the researchers in the environmental area are not aware of the inherent limitations of their research methodologies in solving environmental problems, because they carry strong elements of mechanistic thought which are themselves reductionist. For Huesemann (2001, p. 273), "the methodologies to successfully deal with these new problems cannot be the same that helped create them."

Because the scientific mainstream is reductionist while the environment is an interconnected and complex system, much of modern science and technology can be inherently unsuitable for the successful confrontation of ecological crisis ... Ultimately, therefore, that science reductionist and its technological consequences can save us from ecological crises should be viewed with skepticism (SAREWITZ, 1996 apud, HUESEMANN, 2001, p. 274).

The thermodynamic-ecological paradigm has its founding foundation in theoretical assumptions proposed by Georgescu-Roegen (2005). Seen as visionary (CECHIN; VEIGA, 2010), he proposes a reformatting the mechanistic basis of the dominant economic paradigm. Even though his remarks reproved by the leading economists in activity, it is assigned an epistemological reformulation of economic fundamentals, when it presents the law of entropy as the root of economic scarcity (MAYUMI, 1995).

His epistemological question attachment to the mechanistic theories and understanding of economic and physical processes as a mechanical analogue. And so, just considering that economic cycles do not affect the environment in any way in terms of matter and energy. It breaks with the prevailing thoughts in that it considers qualitative aspects in discussions involving the production processes, when for it presents an analysis on the basis of thermodynamics postulates.

He claims that the entropy law is the only natural law that does not make quantitative predictions. Recognizing that even the material universe are subject to a number of irreversible qualitative changes. That is, in general, all types of energy are gradually transformed into heat, and the heat dissipated becomes useless energy (GEORGESCU-ROEGEN, 2005). Thus, "in all closed system, like the earth, the usable material is irrevocably degrades into non-usable material. That is, the useable energy is not transformed into usable energy until it reaches a maximum. The fourth law of

thermodynamics" (GEORGESCU-ROEGEN, 1986, p. 7). In practical terms from his law drops some myths, as presented above are: The fallacy of endless substitution and limitless technology.

The environmental knowledge presents the conceptual category proposed by Enrique Leff, this is characterized by the prospect of creating a paradigm that can guide civilization not only in regard to economic aspects. Encourages an epistemic break with the current models, a continuous process of deconstruction and reconstruction of thought aiming to bring humanity into a new order, taking into account gnosiological aspects, ontological, axiological and epistemological, because as stated Leff (2010) *the environmental problem is a problem of knowledge*.

The postmodern critique of logocentrism of science implies a problem of (dis)/reconstruction of the dominant model of paradigmatic scientific as a prerequisite to be able to translate the principles of environmental complexity in scientific and educational policies explicit in fields which follow predominating the institutional arrangements the Napoleonic university and modern science (LEFF, 2010). It's like says Leff himself, live a deep crisis in the forms of knowledge production. In the meantime Coimbra (2000, p. 53) leads to shrewd reflection:

Undoubtedly, the high degree of specialization in knowledge and theoretical life stems from a paradigm, identifying with this or that philosophical or scientific school. But the dissection of the world and spirits, driven by civilizing fever reached such a point that it created a malaise unbearable. Of them suffer from universities, research institutes, centers generation and transmission of knowledge: the construction of knowledge that comes into play. His suffering, also the institutions political, social, economic and even religious, behold, culture and civilization are at stake. The planetary society is fragmented: the human species, in bad relations with the rest of the natural world; humans create difficulties for their mutual understanding; finally, the natural world presents new puzzles - perhaps as a result of anthropogenic interventions - so that the management of the land ecosystem has become difficult, complex and without defined prospects.

The formation of the chemical in universities and other institutions has been carried out in recent times within a framework of specialization and increasing segmentation of the various materials that make up the chemical. And it ends up developing in the minds of trainees, the reductionist component, which brings as consequences, difficulties in addressing environmental problems in a systemic way - this facilitates global visions and detection of interrelationships within the system and its casing (MACHADO, 2014).

To Zoller (2004), there is around the world a reform phenomenon in chemistry education, which proposes significant changes in the dominant paradigm marked by algorithmic concerns and transmission of scientific concepts to teaching aimed at obtaining higher cognitive skills. To do so, requires profound changes in the ways in environmental chemistry is taught, moving away from close relationships with approaches in - analyzes, ecotoxicology and environmental engineering - and approaching interdisciplinary approaches.

In essence, such changes should involve skills that allow dealing with complex global systems, involving science activities, technology, research and education focused on social responsibility to respect the unlimited cultural perspectives. This model requires systemic thinking, which can deal with the complex and open systems; interdisciplinary and transversal education; teaching-learning process focused on students with projects and research on real global problems; integration of scientific, technological and environmental aspects, with education aimed at the CTS approach (ZOLLER, 2004).

Given the complexity involved in environmental issues, and thinking of them as well as an understanding of the biological, it is necessary to incorporate a holistic and systemic thinking. And in this sense cannot treat GC as another area or sub-area of chemistry, you cannot associate it as a further specialization of chemistry, on the contrary, the historical moment in which it came to an emerging conclamation for retotalization of knowledge. Thus, education in GC is shown as an instrument which aims to reduce and facilitate global understanding and integrating on the complexity of the operation of systems.

And in that sense, interdisciplinarity and transversality are presented as sufficient theoretical contributions to such an undertaking - that is to face the problems as complex of contemporary society which spread in its various externalities. Marques et al. (2013, p. 914) deal about the importance of GC and point-in "as a kind of unifying and cross slope of the different areas of chemistry" way of thinking that goes against the instrumental rationality model so present in courses forming chemicals.

For Bernardes and Prieto (2010), environmental issues must be approaches in an interdisciplinary manner, with respect to the epistemological dimension, and transversely on the didactic dimension. Thus, content and associated concepts such as sustainable development, environmental conservation, carbon credits, population growth, sustainability, is meaningless without an approach that encompasses the historical, political, sociological and philosophical. These ideas are in line with what is proposed by Zuin (2011) in his studies on GC when alerts us to the need for a deeper understanding and that does not lead us to understand GC as the absolute environmental dimension.

Sjöström, Eilks and Zuin (2016), point to the importance of the environmentalization of the formative curricula, especially the category that they classify as: Strong Environmentalization. Starting from an understanding of the reflection of the development of chemistry as a multidimensional socio-scientific issue, and the chemical education with objectives of a transforming practice. These in turn involve epistemological issues, politics and democracy, positions based on values, from which students can develop decision-making skills and thus contribute to the less uncertain future of the planet.

The transversality is presented as a guiding theoretical support for GC in that it proposes major changes in the organizational structures of the curriculum components. Based on the understanding that GC should not be treated as a field/subfield of chemistry, because of their cohesive and cross-cutting nature, allows thus break the barriers of over-specialization, which distance knowledge so close, allowing to overcome the specialist view (ZUIN, 2011), and is thinking seen as an obstacle in the formation of the chemical.

The GC must be inserted from themes and beyond the only concern with acquisition of definitions/concepts. His guiding principles carry the integrator and transverse characters, and thus appear as a mechanism to overcome the barriers of educational processes. It is, therefore, an obstacle so that GC is seen as another new field of the chemical on the contrary, its forward bias causes it to be seen as a guidance tool for forming chemicals having multiple thoughts and parallel as is proposed Machado (2014).

Jickling (1992) drew attention to the dark around the term sustainable development, due to the lack of philosophical and sociological analysis. Pitanga (2015) with reference to the author sometimes cited also has similar concerns when dealing with GC, understanding that the lack of these components can turn it into a rationalization instrument due to the appropriation of ecological discourse by the chemical industry. And so the GC emerging as a prospective proposal of the chemical on the planetary scenario would become an industrial slogan reduced to technological optimism.

In this sense, education in green chemistry seeks to provide a reformatting in the formation of chemical seeking to reconcile an integrated environmental vision, thinking it in a broad sense, where aspects: physical environment, biosphere, human health, etc., can be incorporated. So GC comes up with a way to help the chemicals to the adoption of a holistic approach foundations in mainstreaming as a way to address and discuss issues; interdisciplinarity as needed in the north search (re)totalization of knowledge, and the assumptions that allow incorporate the philosophical and sociological dimensions beyond the biological and technical dimensions.

#### 4 Final Considerations

Researchers notably recognized, including Kirchhoff (2005) point to the green chemistry as a tool for sustainability. Notable contributions and advances emerged from the progress of GC, especially in concerns about waste reduction and control of emissions of substances in the environment, however, such alerts Marques and Machado (2014) lack analysis of the relationship between GC and sustainability .

We know that sustainability is not a concept of chemistry, on the contrary it arises and manifests itself as political speech. And around the term several discussions have taken place over time. Sauv e (2005) calls attention to the idea that the term sustainability emerges as an enriched reading of Sustainable Development, pointing out that the philosophical and epistemological limitations were not remedied. And in this sense it is necessary to discuss, warn regarding appropriations and circulation to possible approaches between DS and GC, and they end up keeping at its core, arguments seeking to maintain the operating conditions of capitalist modes of production.

The technological optimism accepts a clear limitation of the technical dimension. The lesson is that it is not a safe path through technological innovation based on product substitutions and chemical processes. The laws of thermodynamics are inexorable. From the physical point of view, the planet Earth has a maximum carrying capacity, both in the supply of matter and energy, and in the purification of waste, few will be the contributions of technological innovations continue with a social organization that aims to expand limitlessly the economy. Contrary to what proposes the classical theories of economics are the laws of thermodynamics that limit its expansion process and not the markets.

Thus, we believe that readings and discussions that address these issues can contribute to green chemistry do not end up becoming a rationalization tool, appropriating the most competent human capital that this area can provide. We are concerned that the GC does not become a thought - stopping slogan, an empty slogan second Daly (2004), that does not lead anywhere. For, as our investigations indicate there is an asymmetry in basic tripod of sustainability, where economic approach, aiming to market growth and large corporations has excelled when compared to the environmental and social dimensions.

Based on the following assumptions: 1) GC is one of the ways of dealing with environmental issues; 2) environmental problems are complex and present themselves as a social category of analysis; 3) as it was in the mechanistic paradigm that we historically built the social organization that come to this unsustainable point. So it is paradoxical, understanding GC as a contributor strand of environmental sciences, sustain their models of teaching and research along the lines of the mechanistic paradigm.

Taking as reference to the above assumptions, and away from incurring the pitfalls of this possible paradox, GC cannot be seen as another discipline, as already points to IUPAC, as this type of division

is the product of the current paradigm of elements that are in crisis. The epistemological path which emerges GC, the disciplining is seen as an outdated way to build knowledge, and limited as whether to seek solutions to environmental issues.

For Leff, Capra, Huesemann, Boaventura Santos and some other scholars, environmental issues are problems in how knowledge is produced: that is, fragmented, specialized, sterile, dogmatic. Thus, GC cannot be limited to chemistry and the environment, their epistemological foundations require that in addition to technical approaches, economic, political, social should be part of their discussions. And by promoting inserts such those in these lines, GC is able to overcome misconceptions of the salvationist myth of technological determinism, and not to become another slogan to reinforce business interests.

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