MAIN PRODUCTION WAYS AND TOXIC EFFECTS OF ACROLEIN: A BRIEF SYSTEMATIC REVIEW

Clara Rodrigues Pereira [1], Lílian Lefol Nani Guarieiro [a]

[1, a] Centro Universitário SENAI CIMATEC, Brazil.

Abstract: Acrolein is a compound that can have adverse effects on human health since it has a strong toxic potential. In this context, the present study aimed to carry out a systematic review signaling other different means of acrolein formation, in addition to evaluating the toxicity of this compound. Thus, to carry out the systematic review, the VosViewer tool was used to compile the data obtained by the search and to assist in the analysis of the materials. In view of this, it was possible to detect, as results were obtained, other sources of acrolein production and its occurrence in the atmospheric environment, signaling the main means of contact with human health, in addition to the periodicity of studies focused on this theme.

Keywords: *acrolein; formation; toxicity*.

PRINCIPAIS FORMAS DE PRODUÇÃO E EFEITOS TÓXICOS DA ACROLEÍNA: UMA BREVE REVISÃO SISTEMÁTICA

Resumo: A acroleína é um composto que pode apresentar efeitos adversos à saúde humana, uma vez que, apresenta forte potencial tóxico. Neste contexto, o presente estudo teve como objetivo realizar uma revisão sistemática sinalizando outras diferentes meios de formação da acroleína, além de avaliar a toxicidade deste composto. Assim, para a realização da revisão sistemática, a ferramenta VosViewer foi utilizada para compilar os dados obtidos pela busca e auxiliar na análise dos materiais. Diante disso, foi possível detectar como resultados obtidos, outras fontes de produção de acroleína e a sua ocorrência no ambiente atmosférico, sinalizando os principais meios de contato com a saúde humana, além da periodicidade dos estudos voltados para esta temática.

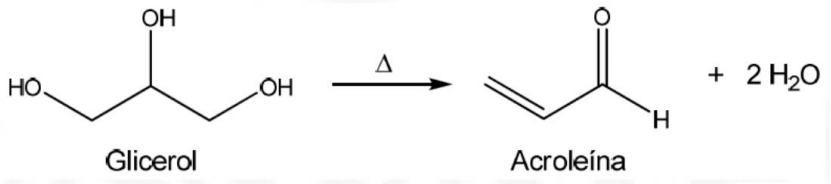
Palavras-chave: acroleína; formação, toxicidade

1. INTRODUCTION

Emissions of compounds regulated and not regulated by law, such as volatile organic compounds, may have a high carcinogenic and mutagenic potential. Among them, carbonyl compounds, light aromatic hydrocarbons, PAHs, and nitro-PAHs stand out [1]. Carbonyl compounds come mainly from anthropogenic sources, especially vehicle burning, where they play an important role as intermediate products in photochemical processes in the atmosphere [2].

In this context, among the carbonyl compounds, acrolein (C_3H_4O) can be highlighted, which consists of an unsaturated aldehyde, with high reactivity, and can be considered a strong contaminant in places such as food, water, and air [3]. In view of this, this compound can originate from processes such as the combustion of plastic, and combustion of petrochemical fuels, in addition to the overheating of vegetable oils and animal fats, causing the dehydration of glycerol, which is part of the composition of these oils, together with triglycerides with long lengths. of aliphatic carbon chains [3, 4].

Therefore, of the acrolein production processes presented, the dehydration of glycerol draws attention, since it is a renewable raw material that has been stimulating the world market for new applications, especially to produce biodiesel, as it is the main by-product from the transesterification reaction of animal fats and vegetable oils in the industrial process [5]. In this way, the formation of acrolein from glycerol dehydration draws attention, since, as mentioned earlier, glycerol is a by-product of renewable origin, however, it can originate a potentially toxic compound [5]. Thus, the formation of acrolein from glycerol can occur through double dehydration between two terminal hydroxyl groups and an intermediate hydroxyl group of glycerol (Equation 1) [6,7].



(1)

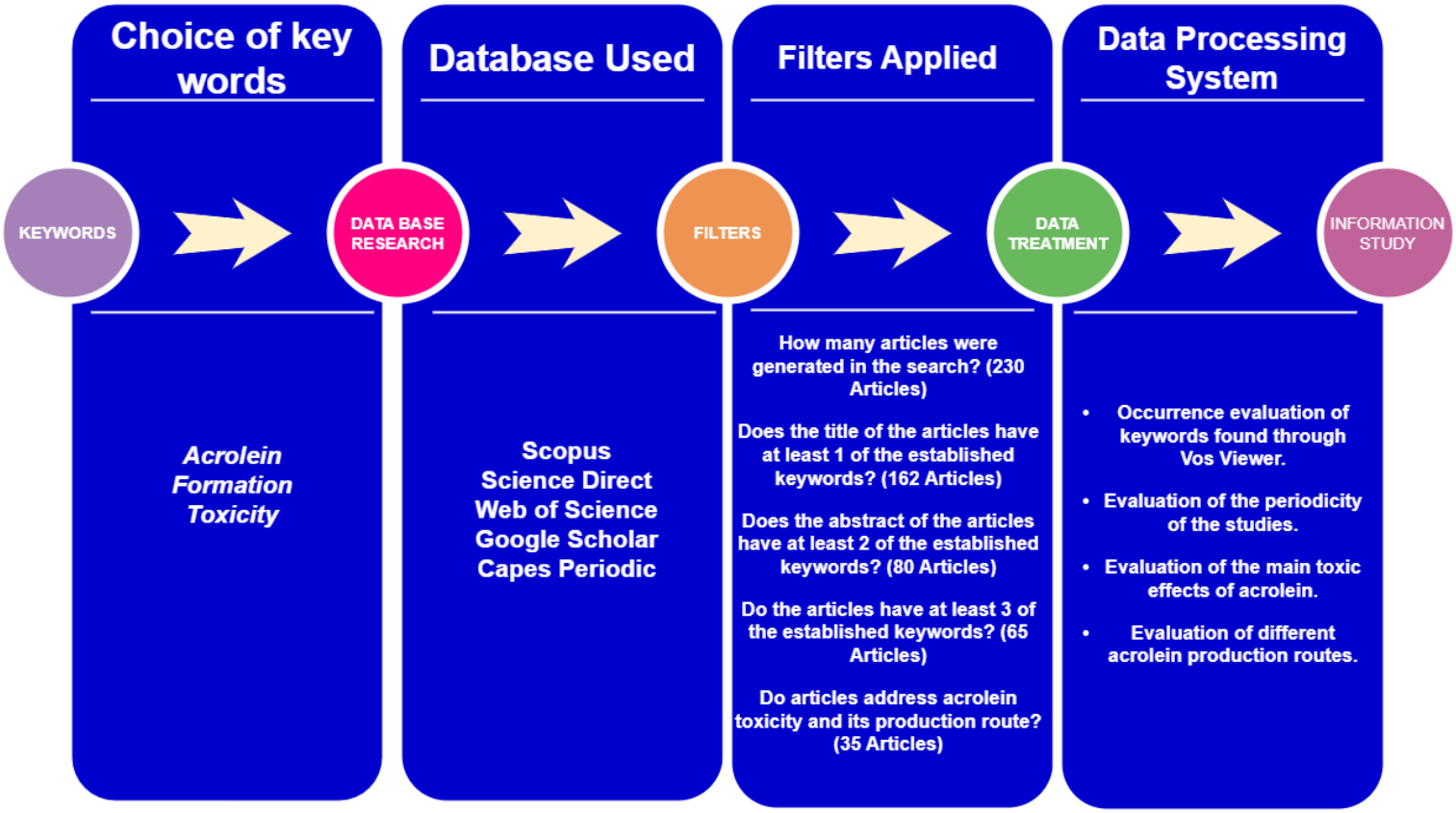
In view of this, acrolein can be considered an important chemical intermediate for the production of acrylic acid, in addition to being used in the synthesis of adhesives, paints, plastics, and rubbers and among its main applications, the production of herbicides used to control weeds in crops and algae in irrigation channels stands out, in addition to being used to synthesize polymers, amino acids, medicines, fragrances, dyes, and fuel gases [5, 8]. However, acrolein is highly reactive in such a way as to cause toxic effects such as DNA and protein adduction, oxidative stress, endoplasmic reticulum stress, immune dysfunction, and membrane damage [9]. In this way, we seek to convert acrolein into species with greater added value in relation to the oil industry, such as conversion into acrylic acid, which can be transformed into sodium polyacrylate, widely used in the manufacture of hygiene products [10].

In this context, given the information presented, the present study seeks to develop a systematic review highlighting its main production routes and the main toxic effects that acrolein can cause.

2. METHODOLOGY

The methodology of this article consisted of a systematic review of the literature, focused on studies focused on the main production routes and the main toxic effects that acrolein can cause considering a search period, the last 10 years (2013 to 2023). Thus, the steps established for carrying out this systematic review are described in Figure 1.

Figure 1. Flow of the established for the systematic review



According to the steps described above, VOSviewer was used as a tool for data processing, which consists of software used to create different types of maps based on data obtained from a search in each database. In this way, this tool can promote the construction of networks aimed at scientific publications, scientific journals, researchers, research organizations, countries, keywords, or terms, so that the items that are part of this network can be connected by links of co-authorship, co-occurrence, citation, bibliographic coupling, or co-citation. To build these maps, it is necessary to insert input files into VOSviewer, such as bibliographic database files consisting of Web of Science, Scopus, Dimensions, Lens, and PubMed files and reference manager files, such as RIS, EndNote, and RefWorks files.

The results obtained can be grouped into clusters that consist of a set of items included in the map, where in each cluster, the items obtained by the treatment line chosen in the software are linked together when there is a convergence between them, such as for example keywords, where if you have five of them in a cluster, it means that there is a relationship between them in your search occurrence.

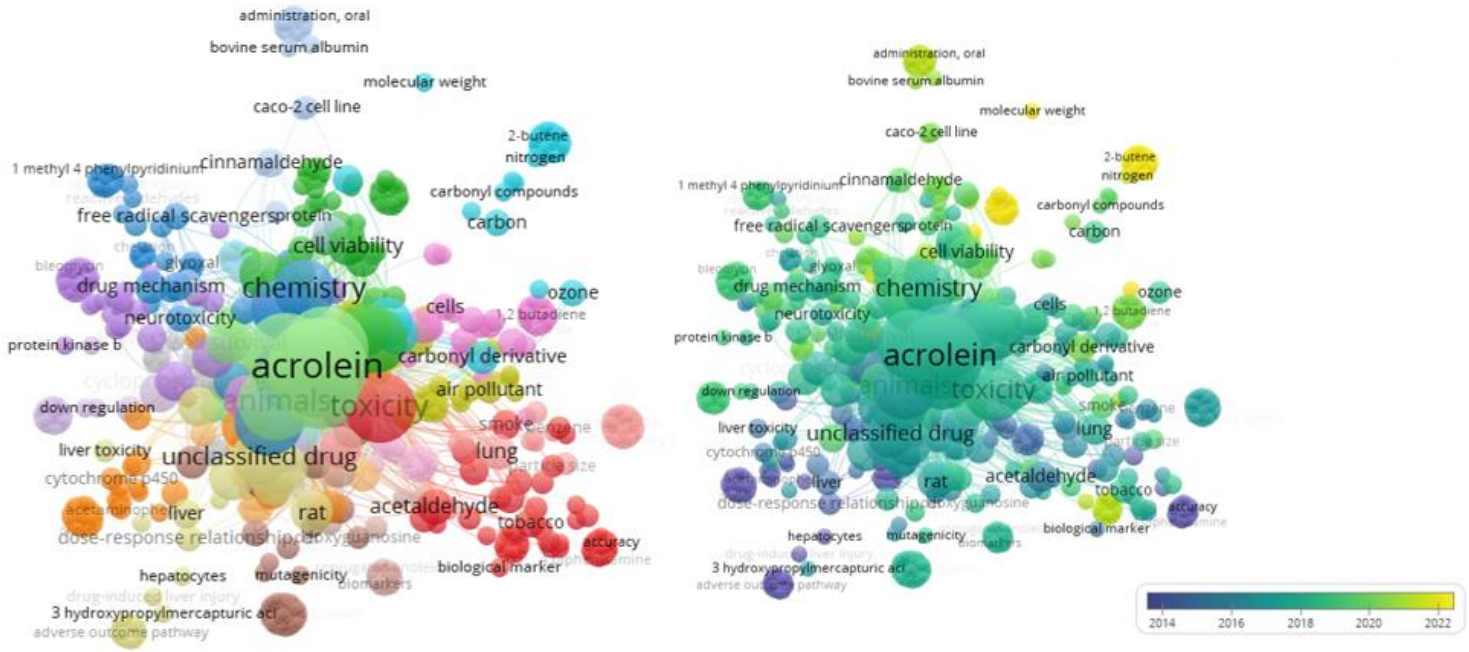
3. RESULTS AND DISCUSSION

The results of this study are divided into two parts: data processing by VosViewer and the most discussed topics related to acrolein formation and its toxicity. In view of this, figures 2 (a, b, and c) show the results from the bibliographic databases referring to the Scopus, Web of Science, and Science Direct databases, which aimed at the keywords most found by the search and their occurrence in the studies and over the years.

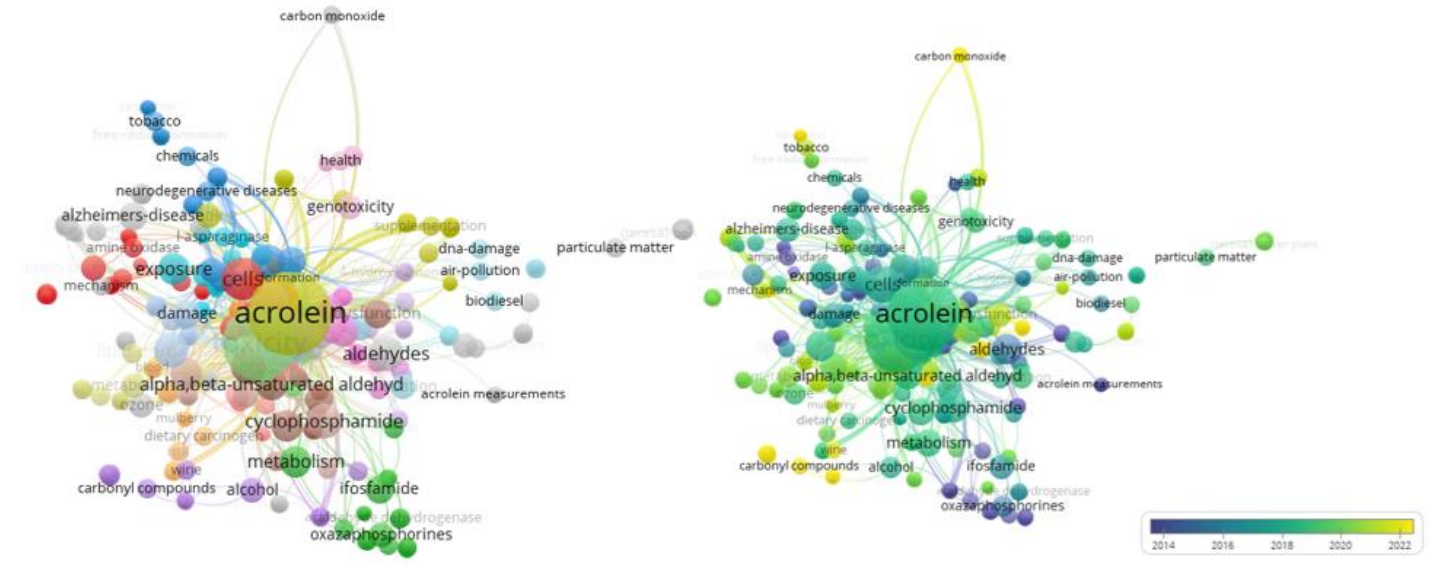
Figure 2. Occurrence of keywords in compiled studies and over the years

2a) Scopus, 7b) Web of Science, 3c) Science Direct

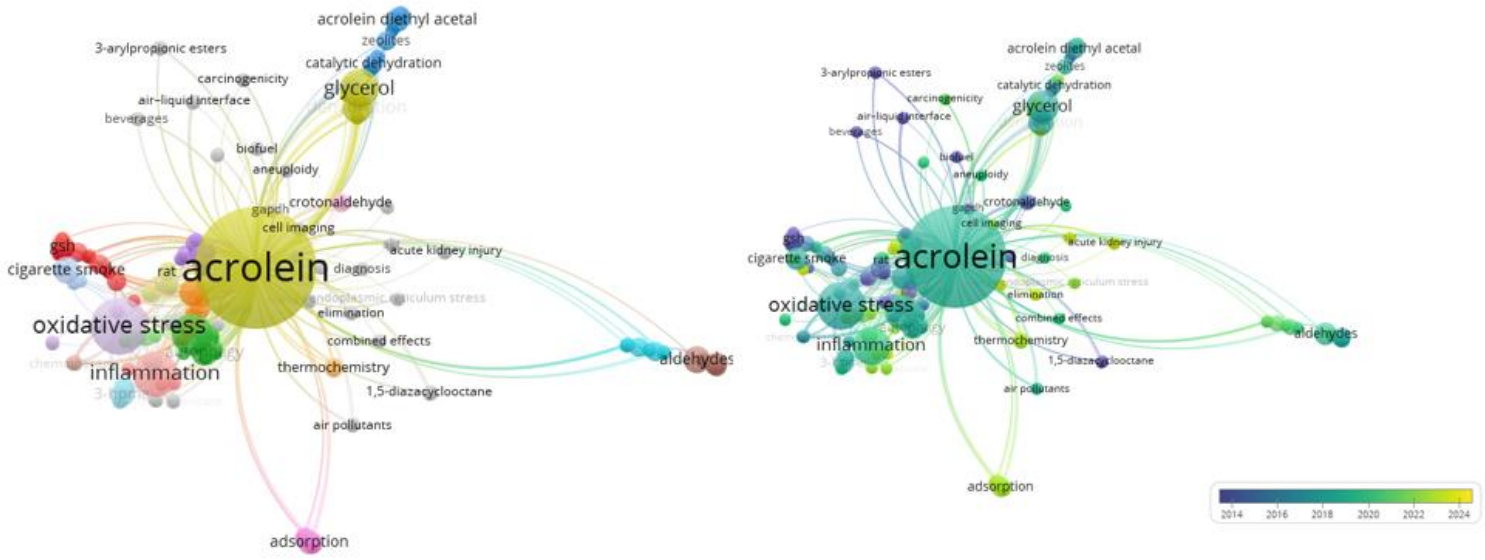
a)



b)



c)



In view of the results obtained by VosViewer, it was possible to obtain the following sequence of the number of clusters: Scopus (20 Clusters), Web of Science (27 Clusters), and Science Direct (46 Clusters). In this way, it was possible to observe that the group of selected keywords promoted a high occurrence of words, in addition to the connection between them, so that for the three databases analyzed, the keyword *"acrolein"* obtained a higher occurrence and the how much she connected with so many other words. In addition, it was possible to detect the evolution of research over the years, for the analyzed databases, highlighting the year 2020 as the largest publication in the researched area, but highlighting the continuation of studies in the area over the years.

Therefore, after analyzing the materials selected according to the research criterion, it was possible to detect the main sources of acrolein production, as well as its main toxic effects. Thus, Table 1 presents a compilation of the different routes in which acrolein can be formed, its form of contact with the human body, and its main toxic effects.

Table 1. Main sources of acrolein formation and its toxic effects

Main Means of Acrolein Formation	Main means of contact	Main Toxic Effects
Burning Fossil Fuels	Inhalation	Increases vascular permeability, leukocyte, extravasation, and induced pain, causing apnea, shortness of breath, cough, airway obstruction, and mucous secretion.
Cigarette Burning		
Burning wood or plastic	Ingestion	
Cooking or frying foods with fats		

In this context, in addition to the information presented in the table, it was possible to observe from the analysis of the materials that the greatest exposure to acrolein in humans comes from air pollution, in a way that, a chronic exposure to acrolein can lead to myocyte dysfunction, to a dilated cardiomyopathy and heart failure

[11, 12, 13]. These health impacts could be evaluated through in vivo tests in rats, proving such effects in addition to signaling them.

4. CONCLUSION

Therefore, the present study presented the main results of a systematic review using VosViewer as a research treatment tool and it was possible to observe the main keywords that guide this work, its main connections, and the evolution of studies over the years.

In addition, it was possible to detect other forms of occurrence and production of acrolein, in addition to harmful effects on human health, such as cardiorespiratory problems that could be proven through in vivo tests, showing the importance of this topic and the increase in analyzes and studies signaling greater attention to this topic.

5. REFERENCES

[1]GUARIEIRO, Lílian Lefol Nani et al. Carbonyl compounds emitted by a diesel engine fuelled with diesel and biodiesel–diesel blends: Sampling optimization and emissions profile. **Atmospheric Environment**, v. 42, n. 35, p. 8211-8218, 2008.

[2]GUO, S. J. Carbon isotopic signatures of carbonyls from roadside air observation. **Journal of Atmospheric Chemistry**, v. 78, n. 4, p. 239-250, 2021.

[3]ALFARHAN, Moaddey; JAFARI, Eissa; NARAYANAN, S. Priya. Acrolein: a potential mediator of oxidative damage in diabetic retinopathy. **Biomolecules**, v. 10, n. 11, p. 1579, 2020.

[4]PETERS, Morenike A. et al. Subcritical Water Hydrolysis of Fresh and Waste Cooking Oils to Fatty Acids Followed by Esterification to Fatty Acid Methyl Esters: Detailed Characterization of Feedstocks and Products. **ACS omega**, v. 7, n. 50, p. 46870-46883, 2022.

[5]MONTEIRO, Marcos Roberto et al. Glycerol from biodiesel production: Technological paths for sustainability. **Renewable and Sustainable Energy Reviews**, v. 88, p. 109-122, 2018.

[6]SHEN, Lingqin et al. Liquid phase catalytic dehydration of glycerol to acrolein over Brønsted acidic ionic liquid catalysts. **Journal of Industrial and Engineering Chemistry**, v. 20, n. 3, p. 759-766, 2014.

[7]BOBBIO, F. O.; BOBBIO, P. A. **Introdução à química de alimentos.** 3ª Ed. São Paulo: Varela, 2003.

[8]LIMA, Paula Jéssyca Morais et al. An overview on the conversion of glycerol to value-added industrial products via chemical and biochemical routes. **Biotechnology and Applied Biochemistry**, v. 69, n. 6, p. 2794-2818, 2022.

[9]ZHANG, Jianbo et al. Gut microbial glycerol metabolism as an endogenous acrolein source. **MBio**, v. 9, n. 1, p. e01947-17, 2018.

[10]FERNANDES BARBOSA, Felipe; PINHEIRO BRAGA, Tiago. Catalytic Conversion of Glycerol to Acetol and Acrolein Using Metal Oxides: Surface Reactions, Prospects and Challenges. **ChemCatChem**, v. 15, n. 2, p. e202200950, 2023.

[11]HENNING, Robert J. et al. Acrolein can cause cardiovascular disease: a review. **Cardiovascular toxicology**, v. 17, n. 3, p. 227-236, 2017.

[12]ABDULLAH, Anas et al. A review on recent developments and progress in sustainable acrolein production through catalytic dehydration of bio-renewable glycerol. **Journal of Cleaner Production**, v. 341, p. 130876, 2022.

[13]CROWLEY, Liana N. et al. Acrolein, an environmental toxicant and its applications to in vivo and in vitro atherosclerosis models: An update. **Environmental Toxicology and Pharmacology**, v. 93, p. 103890, 2022.