Proceedings of ICEGEE 2026 Symposuim: AI-Based Medicine and Biological Data Analysis
DOI: 10.54254/2753-8818/2026.AU33830

VOCs Emissions from Vehicles and Their Role in Secondary Pollutant Formation VOCs

Huali Mao

Zhenhai High School of Zhejiang Cambridge A-Level Center, Ningbo, China
13586222805@139.com

Abstract. In this research, this research will give the information about the VOCs from vehicle emission. This research search the figures and other information to show how the VOCs from vehicle emission will hurt us, and this research search the figures for the composition of VOCs from different vehicle emissions, and the VOCs can react to form ozone which is harmful for our health, and then this research will show the potential formation of ozone and explain how it will be harmful for our health. From this research, this research find that gasoline has the most harmful effect for our human health as it has the potential to synthesis most ozone which causes so many diseases in our body. Therefore, this research suggests that the government should make the rules that the vehicles that uses gasoline should be banned, so that this research can minimize the VOCs from the vehicle emission to reduce the ozone produced.

Keywords: composition of VOCs, photochemical reaction, OFP values

1. Introduction

In many regions, air pollution has become a serious environmental problem as there are more and more people who own vehicles in the cities so that they will release a large amount of VOCs into the atmosphere. VOCs play an important role in air pollution which is related to photochemical smog. VOCs are the acronym for volatile organic compounds VOCs and the definition of VOCs is the organic compounds whose boiling points are bet this research 50 °C and 260 °C [1]. The reason why VOCs are such a serious pollutants is that VOCs is the ingredient of producing photochemical smog under sunlight and photochemical smog contains secondary products O_3, HNO_3 and other pollutants which are harmful for human health. As for the sources of VOCs, vehicles are the major source, as modern vehicles commonly use gasoline and diesel fuels [2]. These fossil fuels will form VOCs when combusted as most of them cannot combust completely so that there will be VOCs remaining in the gas emission. Under sunshine VOCs will react with NO_x, and form ozone and HNO_3 which is quite harmful to our health. For this paper, this study summarizes the previous research about VOCs to summarize what this research have already known and discusses potential mitigation strategies to these problems. Recent studies have already shown us about the composition of the emission from different types of fuels, while some examines the mechanism of photochemical reactions between VOCs and NO_x, and some measures the ozone formation potential (OFP) separately as well as telling us how ozone will be harmful for our health. These researches, few of them relate these

© 2026 The Authors. This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (https://creativecommons.org/licenses/by/4.0/).

DOI: 10.54254/2753-8818/2026.AU33830

aspects together comprehensively. This study will summarize the chemical composition of VOCs emitted by different types of fuels during combustion and review the photochemical reaction pathway leading to the secondary products, especially ozone, and compare ozone formation potential (OFP) among different fuels and come up with policy implications to solve these problems in the cities to protect our human health. In this study, this research will illustrate the photochemical reaction pathways which is about how VOC will produce ozone at the ground level that will hurt our bodies, and try to find out the targeted control to solve these problems which is about policies about fuel transition strategies. In this research, the second section is about composition of VOCs from vehicle emission from different types of fuels diesel, gasoline and natural gases. The third section shows the photochemical reaction of VOCs and NO_x which forms ozone. The fourth section is to calculate OFP and tell how it will hurt us.

2. Composition

VOCs are the product from combustion of fossil fuels, as they come from incomplete combustion of these fossil fuels, so that the composition of the VOCs are different if this research use different types of fuels. Therefore, this research use diesel, gasoline and natural gases as examples to test the difference in composition of VOCs from combustion of different types of fuels with three main categories. The method to test the composition of different types of VOCs is to use these three fossil fuels to drive for one kilometer each and then test the VOCs from the gas emission. First of all, the composition of VOCs from diesel combustion is presented a bar graph below, which is about composition of VOCs from the combustion of diesel which is first tested.

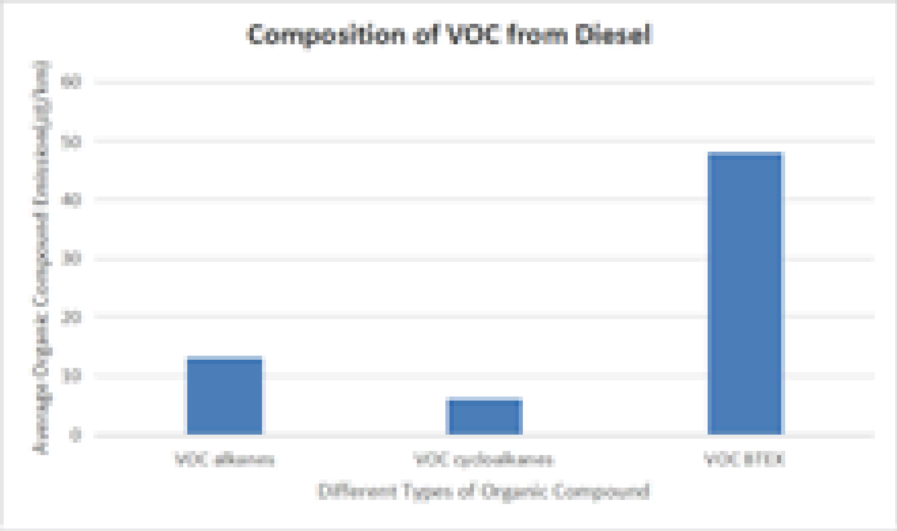


Figure 1. The y-axis shows the amount of emission of the compounds when driving per kilometer using the fuel, diesel (estimation, graph is not so clear) [3]

Figure1 shows that Alkane emissions are approximately 13 μg km^{-1} when driving 1 kilometer with diesel which takes a percentage of 19.4 percent over all these gas emission, and the VOCs cycloalkane has the emission of 6 microgram per kilometer which only holds a proportion of about 9.0 percent, while the BTEX (aromatics organic compound) has the emission of 48 microgram per kilometer which is the rest apart from the two types VOCs mentioned before and this type of VOCs, BTEX, is the most abundant in the mixture of the vehicle emission released from diesel.

Then, this research will illustrate the information about gasoline from the bar graph shown below.

DOI: 10.54254/2753-8818/2026.AU33830

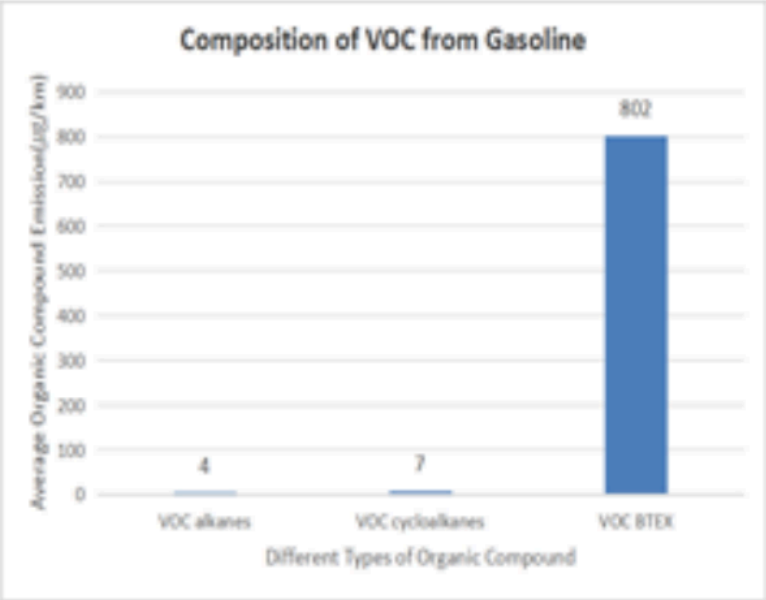


Figure 2. The y-axis shows the amount of emission of the compounds when driving per kilometre using the fuel, gasoline (estimation, graph is not so clear) [3]

Figure2 shows that gasoline emissions show a notable feature which is the emission of BTEX was 802 microgram per kilometre, which is much higher than the 4 microgram for alkane and 7 micrograms for cycloalkane. This means that nearly all the VOCs in the vehicle emission produced by gasoline is BTEX from this bar graph.

After that, this research will show the bar graph about types of organic emission from natural gas which is quite similar but seems to be at even more extreme conditions than gasoline.

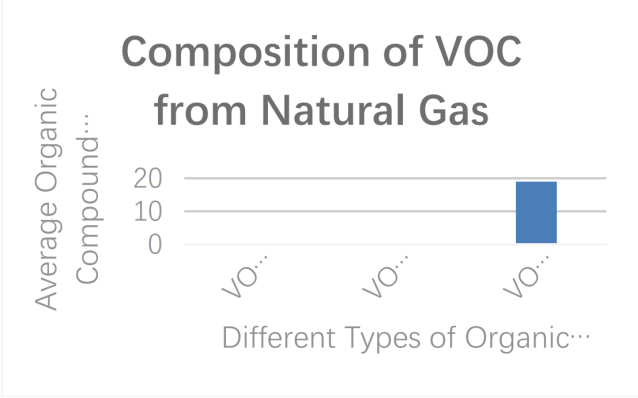


Figure 3. The y-axis shows the amount of emission of the compounds when driving per kilometre using the fuel, natural gas(estimation, graph is not so clear) [3]

Figure3 shows that the distribution of composition of VOCs from natural gas is quite similar to that of gasoline. The emission of BTEX is 19 microgram per kilometre, while emissions are negligible for alkane and cycloalkane which means that nearly all the VOCs are BTEX and this is quite similar to gasoline as the author has mentioned before.

Overall, there is another bar graph which shows the total amount of VOCs emission from these three types of fuels to identify which one produces the largest amount of VOCs.

DOI: 10.54254/2753-8818/2026.AU33830

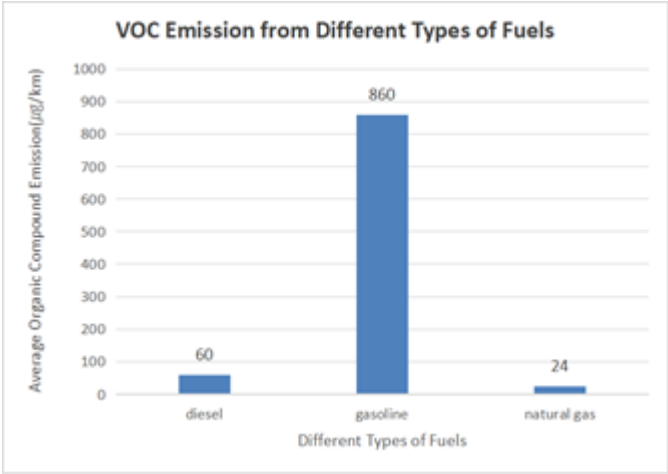


Figure 4. The graph compares the total VOCs emission from combustion of different types of fuels (estimation, graph is not so clear) [3]

Figure4 shows that overall comparison indicates that among these three types of fuels, gasoline is the one which produces most VOCs emission, and BTEX occupies most of the emission.

The reason why gasoline produces most VOCs is that VOCs are usually hydrocarbon with the number of carbons from 5 to 11, and gasoline is usually alkane with short carbon chains which remain due to incomplete combustion [4].

Then the author will talk about the reasons in detail with the bar graph shown below to discuss this trend.

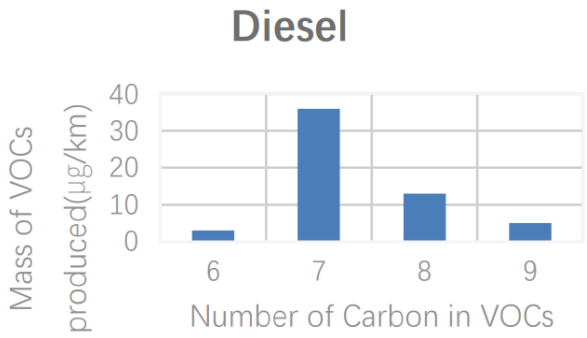


Figure 5. The graph compares the total VOCs emission of different number of carbons from the incomplete combustion of diesel (estimation, graph is not so clear) [3]

From figure 5, we can see that the most abundant VOCs remaining is the one with 7 carbons in the compound, which is only 36 microgram when the vehicle is driving for 1 kilometer. Even the sum of the rest VOCs produced from diesel to drive for 1 kilometer cannot reach 20 microgram.

After that the author will talk about gasoline in the same method.

DOI: 10.54254/2753-8818/2026.AU33830

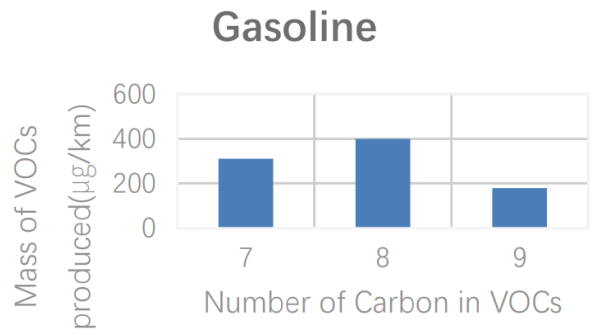


Figure 6. The graph compares the total VOCs emission of different number of carbons from the incomplete combustion of gasoline (estimation, graph is not so clear) [3]

For gasoline, it is apparent that it produces much more VOCs than diesel. The amount of 7 carbon VOCs produced is over 300 microgram per kilometer, and the amount of 8 carbon VOCs produced is even more which is nearly 400 microgram per kilometer. For the last one 9 carbon VOCs, this one produced is a little less than the two types mentioned before which is only 180 microgram per kilometer. Overall, all the VOCs produced from the emission from gasoline is about 900 microgram per kilometer which is much larger than the VOCs produced by diesel.

Finally, the author will talk about these about natural gases.

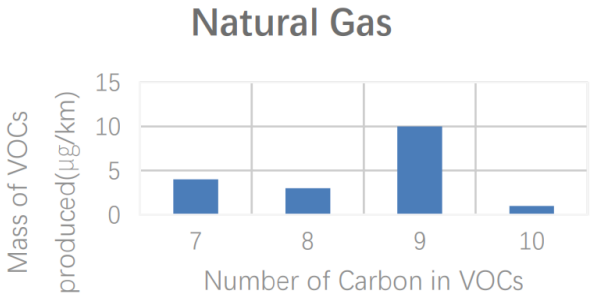


Figure 7. The graph compares the total VOCs emission of different number of carbons from the incomplete combustion of natural gas (estimation, graph is not so clear) [3]

For the last one, natural gases, which produces the least amount of VOCs from driving for one kilometer. The 7 carbon VOCs only takes an amount of 4 microgram per kilometer, and the VOCs with 8 carbons is even less as it is only produced 3 microgram per kilometer, but the amount of VOCs with nine carbons is a little larger which is 10 microgram per kilometer. In addition, the amount of VOCs with ten carbons is the least which is produced only one microgram per kilometer. Overall, the total amount of short chain VOCs produced by natural gas is only 18 microgram per kilometer.

With figure 5,6 and 7 shown above, it is apparent that the gasoline produced the most amount of VOCs as the short chain compound produced from the incomplete combustion of gasoline is about 900 microgram per kilometer, while the other two, diesel and natural gas only produce a small amount of VOCs which are only less than 100 microgram per kilometer and 18 microgram per kilometer. Following this trend, as VOCs are the compound with short chains, so that as gasoline has

DOI: 10.54254/2753-8818/2026.AU33830

more short chains organic compounds with less than 10 carbons so that after incomplete combustion, there will be more VOCs remain there and released from vehicle emission.

The reason why BTEX is the major of VOCs is that BTEX compounds have aromatic structures which is more stable than other organic compound so it is more difficult to burn it, which means that it has the incomplete combustion which is remained and emitted into the atmosphere. This is because that the conjugated bonding system will distribute the electrons to the whole compound so that the covalent bonds in the compound are stronger, which has higher bond energy and more difficult to break down.

Overall, the author get a conclusion from all the graphs above. First of all, the type of fossil fuels that produces the most amount of VOCs is gasoline. At the same time, the author finds that most of the VOCs from the vehicle emission is BTEX which is aromatic structure.

3. Photochemical reaction

The main reason why VOCs are considered a significant problem is that they undergo photochemical reactions in the atmosphere to form secondary products, which are harmful to human health; among these products, ozone is of particular concern due to its adverse effects when inhaled. The overall reaction can be expressed as VOCs + NO + O_2 + sunlight → mixture of O_3, HNO_3, and organic compounds [1]. Ozone is formed through the photolysis of NO_2, which generates atomic oxygen, and this atomic oxygen reacts rapidly with molecular oxygen to form ozone. Meanwhile, VOCs react with hydroxyl (OH) radicals to produce peroxyl radicals, such as HOO and ROO, which subsequently react with NO to form NO_2, thereby accelerating the production of ozone [5].

4. OFP calculation and ozone

OFP (ozone formation potential) refers to the capacity of VOCs to generate ozone in the atmosphere. It can be calculated using the formula OFP = [VOCs] × MIR, where [VOCs] represents the concentration of VOCs and MIR is the maximum incremental reactivity coefficient. Representative MIR values for different VOC species are summarized in Table 1 [6].

Table 1. It shows the MIR value of different VOCs [6]

VOCs	MIR(gO_3/gVOCs)
Ethylene	6.7 - 8.0
Propylene	9.3 - 10.5
Toluene	5.5 - 7.0
Xylene	6.0 - 6.5
Formaldehyde	5.2 - 6.0
Acetaldehyde	5.5 - 6.5
Benzene	1.8 - 2.5
Isoprene	10.0 - 12.0
n-Hexane	1.0 - 1.5
Cyclohexane	1.2 - 1.8

Table1 show considerable variation in their ozone formation potential, indicating that different VOC species contribute differently to ozone production. Ground-level ozone poses multiple risks to human health. It is associated with cardiorespiratory effects, including changes in heart rate

DOI: 10.54254/2753-8818/2026.AU33830

variability, blood pressure, pulmonary function, and lung inflammation. It is also linked to skin-related effects such as lesions and microbiome imbalance, and in severe cases may contribute to premature mortality and economic loss. In addition, secondary reaction products, including ketones and aldehydes, may further affect physiological functions such as blood pressure regulation and skin aging processes [7-10].

5. Results

The results indicate that among the three types of fuels considered, gasoline produces the highest VOC emissions from vehicles, likely related to its fuel composition and combustion characteristics. Meanwhile, VOCs can react with NO_x and oxygen under sunlight to form ozone. In addition, the analysis of OFP shows that different VOC species exhibit varying potentials for ozone formation, further highlighting their contribution to secondary pollution. The adverse effects of ozone on human health are also evident from the Revie this research evidence.

6. Conclusion

This study shows that VOCs from vehicle emissions pose significant risks to human health. Therefore, reducing vehicle usage, particularly gasoline-pot his researched vehicles with higher VOC emissions, is an important approach to mitigating air pollution. Such measures can contribute to lot his researching pollutant levels and improving public health.

References

[1] C. Baird, M. Cann, Environmental chemistry (W. H. Freeman and Company, New York, 2012), pp. 77–78
[2] Y. Liu, M. Shao, L. Fu, S. Lu, L. Zeng, D. Tang, Source profiles of volatile organic compounds (VOCs) measured in China: Part I. Atmos. Environ. 42, 6247–6260 (2008). https: //doi.org/10.1016/j.atmosenv.2008.01.070
[3] B. Vansevenant, A. S. Vishnoi, A. De Filippis, L. Beillon, G. Toïc, Y. Azizi, B. Guiot, C. Ferronato, L. Fine, P. Tassel, S. Serindat, Y. Liu, Unregulated particle and VOC emissions from comparable diesel, gasoline and natural gas vehicles. Atmos. Environ. X 28, 100390 (2025). https: //doi.org/10.1016/j.aeaoa.2025.100390
[4] Y. Zhao, M. Wang, R. Zhu, Y. This researchi, L. He, J. Hu, Y. Lai, S. Su, Volatile organic compound emissions from light-duty vehicles: Effects of aromatic and olefin compositions in gasoline. Fuel 407, 137388 (2026). https: //doi.org/10.1016/j.fuel.2025.137388
[5] X. Liu, D. Li, W. Zhang, J. Wang, D. Liu, W. Li, Y. Zhao, Y. Zhou, L. Sheng, The impact of photochemical loss of VOCs from anthropogenic and biogenic emissions on ozone formation mechanisms. Environ. Pollut. 391, 127571 (2026). https: //doi.org/10.1016/j.envpol.2025.127571
[6] W. P. L. Carter, Development of maximum incremental reactivity scales for use in ozone air quality management, U.S. Environmental Protection Agency, EPA/600/R-09/137 (2010)
[7] Y. Li, X. Jian, Y. Guo, F. Deng, J. Zhang, Y. Li, F. Feng, Indoor ozone and ozone reaction products: An emerging health threat. Environ. Pollut. 389, 127416 (2026). https: //doi.org/10.1016/j.envpol.2025.127416
[8] W. P. L. Carter, Development of ozone reactivity scales for volatile organic compounds. Air Waste 44, 881–899 (1994). https: //doi.org/10.1080/1073161X.1994.10467290
[9] Y. Zhang, L. Xue, W. P. L. Carter, C. Pei, T. Chen, J. Mu, Y. Wang, Q. Zhang, W. Wang, Development of ozone reactivity scales for volatile organic compounds in a Chinese megacity. Atmos. Chem. Phys. 21, 11053–11073 (2021). https: //doi.org/10.5194/acp-21-11053-2021
[10] J. Zhan, Y. Liu, W. Ma, X. Zhang, X. Wang, F. Bi, Y. Zhang, Z. Wu, H. Li, Ozone formation sensitivity study using machine learning coupled with the reactivity of volatile organic compound species. Atmos. Meas. Tech. 15, 1511–1520 (2022). https: //doi.org/10.5194/amt-15-1511-2022