ISSUE BRIEF:

HUMAN HEALTH BENEFITS OF ETHANOL

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I. EXECUTIVE SUMMARY

This issue brief highlights many human health benefits of fuel ethanol. First, ethanol's history in displacing two major carcinogens from gasoline is examined. Then, ethanol's critical role in limiting harmful tailpipe emissions today is explained. This approach proves how ethanol was and is providing a cleaner, healthier alternative to conventional fuels.

II. HISTORICAL PRECEDENT

Ethanol was found to be a viable solution to transportation energy needs almost 200 years ago,[1] and was first sold commercially in the 1920s. In the last 50 years it became clear that ethanol was the safest and cleanest fuel option for providing needed octane (to prevent engine knocking), as ethanol played a major role in displacing two deadly components in fuel: lead and MTBE.

A. LEAD

In the early 1970s, the octane ratings of fuel were most often achieved through the use of lead, a carcinogen posing severe adverse health effects. After leaded gasoline was banned in 1975 due to vehicle concerns,[2] ethanol's high octane and clean-burning properties made it a natural choice to replace the octane lost with the removal of lead from gasoline. This period saw the construction of the first modern ethanol biorefineries, and culminated in the nationwide approval of E10 in 1978.[3]

B. MTBE

Throughout the 1970s-1990s, methyl tertiary-butyl ether (MTBE) was an octane booster used in gasoline. MTBE was eventually classified as a carcinogen in high doses,[4] and studies found that MTBE was contaminating ground water all over the country due to its high mobility in soil, including in some sources of drinking water. Because of this, MTBE was outlawed in 2005, thanks to the availability of ethanol as a non-toxic octane booster to replace any octane lost by the removal of MTBE.[5] Safe, clean ethanol thus filled the octane void left by both lead and MTBE.

III. TAILPIPE POLLUTANTS

Ethanol has long been known to reduce tailpipe emissions of many known human toxins. Today, while lead and MTBE are long gone from the fuel tank, ethanol is still displacing many gasoline pollutants. We will examine each of these, and it will be shown that the more ethanol added to fuel, the greater the air quality and human health benefits.

A. BTEX

BTEX are the four primary gasoline aromatics that are proven to cause adverse human health effects: benzene, toluene, ethylbenzene, and xylene.[6] BTEX comprises a fifth of every gallon of gasoline in the United States,[7] but ethanol plays a large role in reducing and displacing the effects of these pollutants: "Ethanol's high octane value has allowed refiners to significantly reduce the aromatic content of the gasoline." [8] In real numbers, "increased ethanol in gasoline allowed the United States to reduce…aromatics in gasoline from 25 percent in 2005 to 20 percent in 2016,"[9] which is 7 to 8 billion gallons of aromatics displaced annually.[10]

[1] Gustafson, C. *History of Ethanol Production and Policy*. North Dakota State University.
[2] U.S. Energy Information Administration. *Gasoline Explained: Gasoline and the environment*.
[3] U.S. Environmental Protection Agency. *Ethanol Waivers (E15 and E10)*.
[4] U.S. Environmental Protection Agency. *Methyl Tertiary Butyl Ether (MTBE)*.
[5] Office of Transportation and Air Quality (2017). *Fuel Trends Report: Gasoline 2006 – 2016*. U.S. Environmental Protection Agency.
[6] Bertrand, S. (2022). *Ethanol Can Help Reduce Toxic Gasoline Aromatics.* Environmental and Energy Study
[7] Environmental and Energy Study Institute (2014). *Gasoline Aromatics – A Toxic Brew that Surrounds Us All.*
[8] Ibid. note 5.
[9] Ibid. note 7.
[10] Vander Griend, S. (2020). *Making a Cleaner Fuel for Today & Tomorrow's Vehicles*. Urban Air Initiative.

The most dangerous aromatic of BTEX is benzene, a known carcinogen that increases the risk of leukemia and causes blood disorders. Benzene is found in gasoline at a rate of about 1%,[11] and even just breathing in benzene fumes can affect the nervous system.[12] The use of higher blends of ethanol, specifically E85, lead to significant benzene emissions reductions "at a rate…proportional to the amount of ethanol in the fuel."[13] This fact—increasing ethanol content causes a proportional decrease in benzene emissions—has been proven again and again over the years.[14, 15, 16] The TEX of BTEX are also displaced when higher blends of ethanol are used, at a rate of 50% - 95% as the percentage of ethanol in the fuel grows.[17]

B. 1,3-BUTADIENE

A carcinogen associated with leukemia, 1,3-butadiene is found in gasoline and vehicle exhaust. Ethanol is a major factor in reducing emissions from 1,3-butadiene, particularly for higher blends. 1,3-butadiene emissions are markedly reduced via blends at E30 and above, to the tune of a 75% reduction.[18]

C. OXIDES OF NITROGEN (NOx)

NOx is highly pollutant and dangerous to human health; among other effects, it causes damage to respiratory airways.[19] Ethanol reduces NOx emissions when blended with gasoline, and the effect only increases with greater ethanol content. NOx emissions decrease by as much as 70% for midlevel blends like E20 and E30 compared to E0,[20] and E27 has lower NOx emission rates than E10.[21] The widespread adoption of E15 would help lower atmospheric NOx emissions,[22] as E15 provides a reduction in NOx emissions compared to E10.[23]

D. PARTICULATE MATTER (PM)

Particulate matter is the mixture of solid particles and liquid droplets found in the air, and "can aggravate asthma, emphysema, bronchitis, heart disease, and lung disease."[24] Increasing ethanol content results in lower PM emissions,[25] and the use of even E15 results in 18% PM emissions reductions compared to E10.[26]

E. CARBON EMISSIONS

Ethanol reduces emissions of harmful greenhouse gases (GHGs). Emissions from carbon monoxide (CO), which can damage the cardiovascular and central nervous systems, are significantly reduced with higher blends.[27]Simply by switching from E10 to E15, CO emissions are reduced by 17%.[28] And emissions of ozone (O_3), which can reduce lung function and aggravate asthma and other respiratory issues, trend lower for E15 compared to E10.[29]

FOR FURTHER INFORMATION

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[11] U.S. Environmental Protection Agency. *Gasoline Mobile Source Air Toxics*.
[12] American Cancer Society. *Benzene and Cancer Risk*.
[13] Yanowitz, J. and McCormick, R. L. (2009). *Effect of E85 on Tailpipe Emissions from Light-Duty Vehicles*. Journal of the Air & Waste Management Association.
[14] Hubbard, C. P. et al. (2014). *Ethanol and Air Quality: Influence of Fuel Ethanol Content on Emissions and Fuel Economy of Flexible Fuel Vehicles*. Environmental Science & Technology.
[15] Mohammed, M. K. et al. (2021). *Effect of ethanol-gasoline blends on SI engine performance and emissions*. Case Studies in Thermal Engineering.
[16] Yang, J. et al. (2019). *Emissions from a flex fuel GDI vehicle operating on ethanol fuels show marked contrasts in chemical, physical and toxicological characteristics as a function of ethanol content.* Science of the Total Environment.
[17] Ibid. note 16.
[18] Ibid. note 16.
[19] Alternative Fuels Data Center. Pollutants and Health. U.S. Department of Energy.
[20] Hubbard, C. et al. (2013). Ethanol and Air Quality: Influence of Fuel Ethanol Content on Emissions and Fuel Economy of Flexible Fuel Vehicles. *Env. Sci. & Tech.*
[21] Ibid. note 3.
[22] Tang, T. et al. (2023). Expanding the ethanol blend wall in California: emissions comparison between E10 and E15. *Fuel*.
[23] Ibid note 7.
[24] Ibid. note 9.
[25] Stein, R. et al. (2013). An Overview of the Effects of Ethanol-Gasoline Blends on SI Engine Performance, Fuel Efficiency, and Emissions. *SAE Int. J. Engines.*
[26] Ibid note 7.
[27] Ibid. note 3.
[28] Tang, T. et al. (2023). Expanding the ethanol blend wall in California: emissions comparison between E10 and E15. *Fuel*.
[29] Ibid. note 4.