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A Holistic Approach to Transportation and Energy Conversion through Chemistry and Diagnostics

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Abstract

This opinion post attempts to promote dialogue on some recent developments in the realm of combustion by highlighting their potential. It just conveys the author's ideas and makes no claim to be comprehensive. The article's topics and challenges are intended to promote improved cooperation and communication in the direction of more efficient processes and fewer combustion emissions. The author claims that because combustion science integrates the fields of chemistry, fluid dynamics, metrology and high performance computing with a variety of real world applications in energy, transportation and industrial production, it is well positioned to help with the development of technologies for an integrated, sustainable future energy system.

Keywords: ***Secondary Organic Aerosol (SOA); High energy density liquid fuels; Oxymethylene ethers; Dimethyl Ether (DME); Metrology***

Introduction

Emissions from combustion processes have a substantial impact on the environment, the climate and human health. They express worries about the heavy smog in cities and the emission of carbon dioxide by humans [1]. Fossil fuels make up more than 80% of the main energy used now in the world. High energy density liquid fuels are necessary for transportation, notwithstanding trends to introduce fuels that are not sourced from fossil fuels. A fully renewable energy source based on the sun, water and wind is shown to be technically feasible, with temporal variations being the main problem. Additionally, work in the field of chemistry is being done to capture and store renewable energy. In spite of this, CO_2 emissions grew globally from 22 Gt in 1990 to 36 Gt in 2015 [2]. The proportion of anthropogenic fossil fuels to CO_2 emissions, which was about 94% in 2015, is not expected to appreciably decline in the face of rising global energy demand. However, in addition to carbon dioxide, there are other significant problems with combustion emissions. The most important worldwide health hazard elements, such as black carbon, particulate matter or soot from controlled combustion and open burning are said to include hazards such disorders of the respiratory and cardiovascular systems [3]. Black carbon is also regarded to have a negative influence on human health and has a big impact on the climate. The existing liquid petroleum based fuels are the standard against which to compare discussions of future transportation fuels. But it's still up for debate what the best fuels of the future will be. The most appropriate solutions will be determined by a number of variables, including scientific understanding of their use and effects, energy density, toxicity, water solubility, emissions, availability, economic viability, adaptation to existing infrastructure, ease of end use and a viable lifecycle analysis, with carbon neutrality and sustainability as key variables. Biomass based fuels are commonly considered as promising beyond the first generation, but there are still challenges with resource availability, large scale energy efficiency, economic production and the availability of "green'' hydrogen for deoxygenating feedstock with too much oxygen content [4]. There have been advancements in process technology and integration; research is still needed, for instance, to increase the efficiency of catalytic conversions. Fuel additives made from biomass present opportunities to customize fuel characteristics, however problems with such multi component mixes might occur with, for instance, mixture formation, ignition timing and reaction chemistry [5]. The development of a feasible and sustainable fuel production plan should follow the pursuit of adequate propulsion and emission performance for the fuel engine system in the fuel design from biomass.

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Description

Some fossil fuel alternatives may continue to be beneficial in the medium and long term depending on the likelihood of CO_2 reactivation. At the moment, natural gas additionally, more unusual fossil fuels like shale gas and possibly methane hydrate can be added to the fuel mix. However, methane leaking could have negative consequences that need to be taken into account. In the future, liquid compounds like methanol, which can be used directly or upgraded to more useful chemicals like Dimethyl Ether (DME), ethene and fuels with a longer carbon chain, may be obtained by exploiting the waste product CO_2 as a renewable C1 building block in organic synthesis. Further potential for synthetic fuels is being explored with the help of Oxymethylene Ethers (OMEs), which can be produced from formaldehyde and methanol, both of which are C1 energy carriers [6]. An additional energy vector under consideration is ammonia. Solar and wind power will be essential for supplying electricity in a sustainable manner due to its intermittent nature, however issues with energy storage will need to be resolved: Though this does not necessarily mean that long term buffering may be performed with this capacity, it is believed that about 1% of the energy consumed globally is currently held in pump storage hydroelectricity. It might be usefully expanded by using liquid fuels high in hydrogen [7].

After treatment and emission reduction requires research

The chemical species that make up combustion emissions have so far only been partially regulated. These gaseous species, like oxides of carbon, nitrogen and sulphur can be measured to make sure that regulations are being followed. Pollutants' chemical composition is influenced by both the fuel and the combustion process [8]. Understanding and controlling emissions of particulate matter or soot related to combustion is one of the most pressing issues. Ambient Particulate Matter (PM) pollution is anticipated to have a 16%-18% impact on tracheal, bronchial and lung cancer throughout almost all of Africa and Southeast Asia in 2015, as well as a 48%-48% impact on all health hazards in the region. It is imperative to conduct more research to systematically comprehend the interactions between fuels, the combustion process and the mechanism by which soot forms, the features of the resultant particles and the characteristics of soot emission and oxidation.

Conclusion

The understanding of factors affecting soot mass and number concentration, size distribution, shape, optical characteristics, chemical composition, active surface area and reactivity is lacking pertinent information. Advances in measurement techniques are needed in order to accurately identify such attributes, particularly for particles with a diameter of less than a nanometer. Additionally, an underappreciated combustion related emission may be Secondary Organic Aerosol (SOA), an organic material that develops in the atmosphere by oxidation from gas phase precursors such as aromatics and bigger alkanes. Since combustion particles are one of the best targets to reduce the effects of climate change and human activity, there is an increased need for research concentrating on these issues.

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