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Producing Hydrogen Fuel for Fuel Cell Vehicles: Thermochemical Considerations

Due to the impending decrease in supply of easily accessible fossil-based fuels, the inherent negative environmental impact caused by fossil-fuel combustion, and the potential positive economic impact of developing sustainable/renewable energy technologies, making hydrogen a primary energy carrier has been proposed by numerous scientists and public policy leaders. However, despite the appeal of using hydrogen as a clean and renewable fuel for onboard use in automobiles, the United States is many years away from making the transition from petroleum-derived gasoline to a hydrogen-based automotive fleet. This raises many questions: 1) what are the benefits and drawbacks of using hydrogen as a fuel in automobiles and trucks; 2) what are the current technological/engineering limitations of using hydrogen fuel; and 3) is the pursuit of developing large scale use of hydrogen powered cars the right direction for the country?

Though hydrogen-powered automobiles are currently on the market, the large scale production and sale of these vehicles still faces significant challenges. This case study will focus on the problem of producing hydrogen fuel in a sustainable manner. Current industrial production of hydrogen relies on extracting hydrogen from hydrocarbon molecules. Producing hydrogen in this manner brings about the obvious problem of relying on fossil fuels for a “sustainable” fuel. Later in our general chemistry curriculum we will learn more about how photo-electrochemical processes are being developed to use water as the source of hydrogen, but in this activity you will become familiar with the advantages and disadvantages of using water as a source for hydrogen and learn how steam reforming of ethanol is being used as a hydrogen source.

You are assigned two readings to give you some background on the activity that will be done in lecture. The first is a comparison of two currently manufactured hydrogen fuel cell vehicles. This paper will provide some overview of the cost and availability of hydrogen fuel cell cars. Read the article provided at the following link.

1) Car and Driver magazine comparison of the hydrogen fuel cell vehicles manufactured by Toyota and Honda:

<https://www.caranddriver.com/reviews/honda-clarity-and-toyota-mirai-hydrogen-fuel-cell-cars-compared-comparison-test>

The second reading is a research article by a group that aimed to optimize the reaction in which ethanol is reacted with steam to produce hydrogen. This article also provides an overview of how hydrogen can be produced using different methods, as well as a more detailed discussion of the ethanol reforming process. Read Sections 1-4 of the Haryanto paper.

2) A. Haryanto, S. Fernando, N. Murali, S. Adhikari, *Energy and Fuels*, 2005, 19, pg. 2098-2106.