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Subject: CHEN 3810, Chemical Engineering Lab

Final Assessment: Chemical Looping Technology for Combustion, Gasification, Reforming, and Chemical Syntheses

Out of all the common fossil fuels used on Earth, coal is the dirtiest, as it contributes to global warming and climate change, such that the carbon dioxide (CO_2) emitted into the atmosphere traps heat and warms up the globe. According to the U.S. Energy Information Administration, a ton of coal creates 4,172 pounds of CO_2 when burned, and in 2014, the electric utility industry burned 851 million tons of coal[1]. What's worse was that in 2018, 6,677 million metric tons of CO_2 was emitted globally[2]. Therefore, it is important to invest in the performance optimization of renewable energies, such as solar cells, electrolyzers, and hydrogen fuel cells, to curb coal production and to conserve the Earth's natural resources. However, even though our experimental findings revealed that the electrolyzer was the most energy-efficient, the solar PV and fuel cell have to be further developed to reduce ohmic losses and to optimize electrical conductivity, so that we can increase the solar to fuel (SF) cell energy efficiency for meeting grid requirements.

Now, what if I told you that there was a cleaner way to use coal, in addition to using renewable energies. I had the pleasure to meet and listen to one of the leaders in clean energy research, Dr. Liang-Shih Fan, who spoke about his chemical looping technology for generating electricity from coal without air pollution. In typical coal plants, coal is pulverized into powder and then burned in a boiler to produce steam, which at very high pressure flows into a turbine, which is connected to a generator that produces electricity. Now, the problem with this process is that it creates exhaust gases, such as nitrogen oxide and carbon dioxide, that is difficult to isolate and capture. With the chemical looping technology, the coal does not react with air, rather it is exposed to oxygen-bearing materials such as iron oxide[3]. This is important because as the energy bounded in the coal breaks the bond between oxygen and iron, the reaction produces a stream of pure carbon dioxide and iron metal that is easy to capture, up to 99 percent efficiency, which can then be recycled or stored. What's better is that the burning of iron does not produce nitrogen oxide since it can take place at lower temperatures. An alternative approach to producing the same type of output stream is burning coal in pure oxygen, which is expensive. Dr. Fan has developed a reactor that enhances the practical oxygen-carrying capacity of iron oxide, while decreasing the amount of material needed. Additionally, his team is also looking into gasifying coal and using syngas to create cheaper options for chemical looping.

Overall, chemical looping is the future for reducing our carbon footprint. Once the cost of clean coal technology is more economical than producing coal in a traditional manner, we can curb the emissions of toxic air pollutants, and companies can begin generating products in an environmentally, sustainable manner.

References: (1) Hong, B D, and E R Slatick. "Carbon Dioxide Emission Factors for Coal," Energy Information Administration, Aug. 1994. (2) "Overview of Greenhouse Gases." EPA, Environmental Protection Agency, 10 Apr. 2020. (3) Zeng, L.; Luo, S.; Li, F.; Fan, L.S.; "Chemical Looping Technology and Its Applications in Fossil Fuel Conversion and CO2 Capture", Scientia Sinica Chimica, 42(3), 260 – 281, 2012.