Thesis Project Portfolio

Optimization of Carbon-Neutral Production of Methanol Via Direct Air Carbon Capture

(Technical Report)

An Actor Network Theory and Virtue Ethics Analysis of He Jiankui's CRISPR-Cas9 Experiments on Human Embryos

(STS Research Paper)

An Undergraduate Thesis

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Bachelor of Science, School of Engineering

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Sociotechnical Synthesis

My technical work and my STS research are very different in topic. However, they both focus on the application of emerging technology. My technical work focuses on demonstrating how an emerging technology, direct air capture of CO_2, contributes to carbon reduction goals. On the other hand, my STS research focuses on analyzing the ethics behind an immoral application of another emerging technology, CRISPR-Cas9. The STS research serves as a supplement to the technical work. While the technical work illustrates how a new technology could benefit humanity, the STS research warns of the potential negative impacts of misusing a new technology.

My technical work consists of two sections: CO_2 direct air capture (DAC) and converting the captured carbon dioxide into methanol. In the DAC section, CO_2 in air contacts with a thin film of KOH solution in a cross-flow design to chemically bind with the solution and make K_2CO_3. Then the K_2CO_3 solution reacts with a slurry of $Ca(OH)_2$ in a fluidized bed reactor to make $CaCO_3$ pellets and regenerate the sorbent KOH. The pellets are sent to a calciner, where temperature is raised to 900℃ to decompose $CaCO_3$ pellets into CO_2 gas and CaO pellets. CaO pellets are then sent to a slaker, reacting with water to make $Ca(OH)_2$.

CO_2 produced from the above system is used to produce methanol. Two reactions are needed. The first reaction is reverse water-gas shift with ZnO/Al_2O_3 catalyst that partially converts CO_2 and H_2 into CO and water. The second reaction is hydrogenation with $Cu/ZnO/Al_2O_3$ catalyst that converts CO_2, H_2 and CO into methanol.

My STS research is an ethical analysis of He Jiankui's immoral application of CRISPR-Cas9 on embryos. Many authors pointed out He Jiankui's experiments were immoral because they violated regulations and guidelines, and damaged the human rights of Lulu and Nana, twin

girls born as a result of He Jiankui's experiments. On the other hand, my analysis focuses on the nature of He Jiankui and other human actors involved. Actor Network Theory is applied to reconstruct the network around the CRISPR-Cas9 experiments and evaluate the contributions of human and non-human actors. Then virtue ethics is applied to evaluate the morality of human actors in this network. My argument is that He Jiankui was not the only actor that carried moral responsibility. He could conduct these experiments without hindrance because the adversaries in this network failed to function, as he overpowered them.

My technical work gave me a better understanding of the CO_2 DAC process and methanol synthesis. I learned about chemical reactions involved, how to design equipment, economics of such a plant, which illustrated the benefits of a new technology. However, new technology could also harm society when it is misused. This is demonstrated by my STS research on He Jiankui's CRISPR-Cas9 experiments on embryos. Working on both projects allowed me to rationally examine a new technology, understanding a technology always has a bright and a dark side.