Techno-Economic Assessment of a Cost and Quality-Based Algal Biodiesel Production Process

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Biodiesel fuel is an environmentally friendly replacement for petroleum-based diesel fuel. Energy-dense algae are more suitable feedstocks for biodiesel than current food crops and animal fats. Algae circumvents many of the current problems that limit biodiesel's expansion, mainly the requirement for arable land. However, existing production processes for algal biodiesel are not cost-effective, and quality was not considered in previous studies. To overcome both challenges, I developed a novel Cost and Quality-based Algal Biodiesel Process (abbreviated as CQ-Biodiesel), which produces cost-effective biodiesel while exceeding the minimum biodiesel quality defined by ASTM. CQ-Biodiesel is modeled using the process simulator SuperPro Designer. Here, I shift the focus from product retention (as in previous studies) to overall cost-effectiveness. This enables minor sacrifices in productivity for maximal energy efficiency. While product is lost through each stage, a significant portion of energy from the waste is recovered in the residue treatment stage, leading to 95% total energy efficiency. A hybrid cultivation method is introduced to harvest flue gas from power plants and maximize lipid productivity at 0.13 g/L/day, which is a 10% increase compared to previous studies. A closed-loop hexane extraction method is developed to reduce pollution by 99% compared to previous studies. In the US, the effective production cost is 10% less than petroleum-based diesel when including federal tax credits. The present study reveals that the CQ-Biodiesel model significantly improves upon existing algal biodiesel production processes in three key aspects—cost, quality, and reduced environmental impact. Moreover, it is less expensive than both existing biodiesel and petroleum-based diesel.

Awards Won:
Second Award of $2,000
King Abdulaziz &amp
his Companions Foundation for Giftedness and Creativity: Full Scholarship from King Fahd University of Petroleum and Minerals(KFUPM) (and a $400 cash prize)
King Abdulaziz &amp
his Companions Foundation for Giftedness and Creativity: NOT TO BE READ -- $400 cash prize for each Full Scholarship from King Fahd University award recipient
Air Force Research Laboratory on behalf of the United States Air Force: Glass trophy and USAF medal for each recipient
Air Force Research Laboratory on behalf of the United States Air Force: First Award of $750 in each Regeneron ISEF Category