Overall Energy Considerations for Algae Species Comparison and Selection in Algae-to-Fuels Processes

The controlled growth of microalgae as a feedstock for alternative transportation fuel continues to receive much attention. Microalgae have the characteristics of rapid growth rate, high oil (lipid) content, and ability to be grown in unconventional scenarios. Algae have also been touted as beneficial for CO_2 reuse, as algae can be grown using CO_2 emissions from fossil-based energy generation. Moreover, algae does not compete in the food chain, lessening the "food versus fuel" debate. Most often, it is assumed that either rapid production rate or high oil content should be the primary factor in algae selection for algae-to-fuels production systems. However, many important characteristics of algae growth and lipid production must be considered for species selection, growth condition, and scale-up. Under light limited, high density, photoautotrophic conditions, the inherent growth rate of an organism does not affect biomass productivity, carbon fixation rate, and energy fixation rate. However, the oil productivity is organism dependent, due to physiological differences in how the organisms allocate captured photons for growth and oil production and due to the differing conditions under which organisms accumulate oils. Therefore, many different factors must be considered when assessing the overall energy efficiency of fuel production for a given algae species.

Two species, *Chlorella vulgaris* and *Botryococcus braunii*, are popular choices when discussing algae-to-fuels systems. *Chlorella* is a very robust species, often outcompeting other species in mixed-culture systems, and produces a lipid that is composed primarily of free fatty acids and glycerides. *Botryococcus* is regarded as a slower growing species, and the lipid that it produces is characterized by high hydrocarbon content, primarily C28 – C34 botryococcenes. The difference in growth rates is often considered to be an advantage of*Chlorella*. However, the total energy captured by each algal species in the same photobioreactor system should be similar at light limited growth conditions based on photon flux. It is how the algae 'allocate' this energy captured that will vary: Data will be presented that shows that *Botryococcus* invests greater energy in oil production than *Chlorella* under these growth conditions. In essence, the *Chlorella* can grow "fast and lean" or can be slowed to grow "slow and fat". The overall energy potential between the *Chlorella* and *Botryococcus*, then, becomes much more equivalent on a per-photon basis.

This work will indicate an interesting relationship between two very different algae species, in terms of growth rate, lipid content and composition, and energy efficiency of the overall process. The presentation will indicate that in light-limited growth, it cannot be assumed that either rapid growth rate or lipid production rate can be used as stand-alone indicators of which species-lipid relationships will truly be more effective in algae-to-fuels scenarios.