Fall 11-3-2015

Continuous culture and downstream processing of algae with recycle: An integrated large-scale approach for production of renewable crude oil

Matt Croughan
Amgen Bioprocessing Center, croughan@kgi.edu

CONTINUOUS CULTURE AND DOWNSTREAM PROCESSING OF ALGAE WITH RECYCLE: AN INTEGRATED LARGE-SCALE APPROACH FOR PRODUCTION OF RENEWABLE CRUDE OIL

Matt Croughan
Industry Professor and Founder of Bioprocessing Program
Amgen Bioprocessing Center at Keck Graduate Institute
535 Watson Drive, Claremont, CA, 91711, USA
T: 650-201-5039, croughan@kgi.edu
SAB Member and previous CTO, Sapphire Energy, Inc., San Diego, CA, USA

In order to have a significant impact on energy security and reduction of greenhouse gasses, the production of advanced biofuels must be increased to billions of gallons per year. Scale up of phototrophic algae bioprocessing for renewable oil production has been attempted for decades and has recently reached new levels of performance and scale. For over three years, Sapphire has successfully operated the world's largest algae farm, consisting of 100 acres of ponds in New Mexico, used to feed an integrated conversion and extraction unit based on high temperature liquefaction technology. All aspects of the process are run on a continuous basis, including the recycle of water and nutrients from the harvest and extraction units back to the ponds.

Typical oil refineries process 8 – 80 million liters of crude oil per day, on a continuous basis for up to 5 years non-stop, 24 hours per day. In order to be a significant source of crude oil to even a single refinery, productivity of an algal biorefinery must be at least 0.8 to 8 million liters of renewable crude per day. Furthermore, the manufacturing cost of the "green crude" must be at or below the current price of petroleum plus any carbon credits and/or renewable energy credits. The high productivity and low cost targets will be met only with robust, large-scale, continuous bioprocessing on an integrated basis with recycle of water and nutrients.
This talk will first introduce key aspects of biofuels bioprocessing, in contrast and comparison to biopharmaceutical bioprocessing. This includes the impact of raw material costs versus product value, and the resulting need for phototrophic culture as well as continuous integrated recycle of water and nutrients. Methods to continuously maintain a target co-culture or ecosystem, in open ponds, free of unwanted predators, competitors, and pests, will also be discussed. Challenges regarding phototrophic growth of algae, such as mixing and light penetration, will be presented in context and comparison to typical heterotrophic growth of microorganisms and animal cells in closed vessels. Trends in productivity and future prospects for the field will be presented, including the potential use of genetically-modified organisms.