CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)

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Project Number

S1503

Project Title

Accumulation of the Biodiesel Precursor Triacylglycerol Offsets Oxidative Stress in Chlamydomonas reinhardtii

Abstract

Objectives/Goals

Microalgae accumulate the biodiesel precursor triacylglycerol (TAG) when subjected to nutrient stress, a phenomenon that has become the basis for the field of algal biodiesel. Despite the promise of this technology as a carbon neutral alternative to fossil fuels, low oil yields have constrained adoption. This research seeks to increase oil yield by identifying the process that directly instigates TAG synthesis, which would allow oil accumulation to be induced without starving cells. The putative safety valve function of TAG in relieving electron buildups in the photosynthetic apparatus is evaluated.

Methods/Materials

Thin-layer chromatography (TLC) and Gas Chromatography Flame Ionization Detection (GCFID) were used to identify four redox-defective strains, three of which also demonstrated high growth kinetics. Chlorophyll fluorescence showed that photosynthetic electron transport rate and photosystem II yield were enhanced at low light intensities in the high-TAG mutants and provided evidence of excessive electron accumulation in the photosynthetic apparatus when TAG synthesis was halted.

Results

Blocking fatty acid synthesis caused the photosynthetic electron carrier plastoquinone to become highly reduced. This result demonstrates for the first time a causative link between reduction pressure and TAG accumulation, and indicates that offset of electron accumulation is a major physiological role of TAG. Four knockout strains that are defective in putative electron carriers where identified and shown to produce up to 30% more TAG than wild-type, as well as higher growth.

Conclusions/Discussion

The elucidation of this major physiological role of TAG accumulation in microalgae opens avenues for genetic engineering to enhance biodiesel yields. The four strains identified by this study simultaneously demonstrate high growth and TAG hyper-accumulation, and thus hold significant promise for industrial applications. By specifically activating the pathway that senses abnormal electron accumulation in the photosynthetic apparatus and signals TAG accumulation, biodiesel production can be achieved with no growth constraints.

Summary Statement

This clean energy project demonstrated that biodiesel synthesis in algae protects the cell from deadly electron buildups, and used this phenomenon to identify new algal lines that produce up to 30% more oil than existing strains.

Help Received

I used resources and lab equipment at the Carnegie Institution for Science (Department of Plant Biology) at Stanford under the supervision of Dr. Xiaobo Li and Dr. Martin Jonikas.