Integrated Microalgae Analysis Platform

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Research Goals

- In this proposal, we aim to develop an integrated microalgae analysis platform (iMAP), that simultaneously enabling 1) precision controls of microalgal culture conditions, 2) gene regulations of algae using photonic gene circuits, 3) ighthroughput real-time molecular imaging by embedded spectroscopic analysis and electrophysiological sensing elements for light-harvesting.

Research Contents

- Current research on microalgae has been mainly conducted by conventional large-scale microalgal culturing systems (i.e., open-air pond system, closed-loop system, and photobioreactor). Since common limitations of the large-scale culturing system are inefficiencies in high-throughput screening of the optimal strands and uniform light exposure to the crowded microalgae, there are still many challenges in the development of commercially viable photobioreactor systems. Moreover, the current optimization process is large-scale, time-consuming and labor intensive as well as the understanding of the basic cellular phenomena (or molecular mechanism) controlling microalgal oil production is still insufficient for effective light-harvesting.
- To challenge current issues, we aim to develop an integrated microalgae analysis platform (iMAP), that simultaneously enabling 1) systematic microalgal culture, and 2) development of the genetically engineered microalgal strands via photonic gene regulation, and 3) high-throughput optical/electrical analyses in real-time via embedding the new multifunctionalities (i.e., plasmonic nanostructures and electrochemical sensing capability).
- To achieve this goal, our specific aims include:
  - Specific aim 1: Development of a high-throughput optofluidic system for single-cell level trapping and culturing (for finding superior microalgal strands and culturing conditions).
  - Specific aim 2: Development of a high-efficiency microalgal transformation technology based on nanoplasmonic optical antennas for photothermal nanoporation and photonic gene circuit.
  - Specific aim 3: Development of a label-free optical/electrical microalgal monitoring platform in realtime (for understanding fundamental cellular phenomena and molecular mechanism involving microalgal oil production).
  - Specific aim 4: Maximizing a microalgal oil production via the optimized integrated microalgal analysis platform (iMAP)

Expected Effects

- In terms of research aspect,
  1. Development of new methodologies for high-throughput screening platforms enabling the versatile applications including biological and environmental monitoring as well as energy applications (e.g., micro algal oil production).
  2. Development of new methodologies for genetic engineering (e.g. cell transformation) based on optically triggered, non-invasive photonic gene circuit concept.
  3. Development of nanostructure (e.g., plasmonic nanostructures) for in-depth understanding of biological mechanism including cell signaling pathway, energy production, and cell growth.
- In terms of expected research outcomes
  (Since the proposed approach is totally different from previously developed methodologies, we expect following research outcomes)
  1. High impact research papers
  2. New intellectual properties: inventions and US/KOREA patents
  3. High-quality of research human sources