Membrane Biofilm Reactors (MBfRs) for High Volumetric Production Rate of Valuable Products

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Invention Description

High petroleum costs coupled with major environmental concerns have pushed researchers to search for alternative and renewable sources of energy. Biomass represents an abundant, sustainable resource for energy production. Bio- and thermo-chemical conversion schemes often result in formation of energy-dense gases from biomass. Since as much as 30% of our energy consumption is in the form of liquid transportation fuels, high value is achieved by producing liquid fuels these from gaseous feedstock in a renewable way, such as with microorganisms. Current biotechnological practices that focus on making liquid fuels using gases are plagued by very low gas transfer rates, low catalyst (microorganisms) concentration, and the inability to achieve productivities that are commercially feasible.

Researchers at the Biodesign Institute of Arizona State University have developed a novel membrane biofilm reactor (MBfR) that can be fed with a variety of gaseous substrates to produce valuable chemicals, including fuels or fuel precursors. The design includes superior hollow fiber membranes, innovative options for supply of gas mixtures, optimization of the biofilm on the fiber surface (containing the microorganisms of choice), and an advanced separation system to extract the desired chemical product. This MBfR design overcomes two key challenges in other systems: first, achieve superior rates from direct gas transfer to the reaction zone (i.e., the microorganisms) and, second, have high catalyst density via retention of the microorganisms of interest in biofilms.

This novel MBfR strategy provides an effective solution for overcoming challenges of using gaseous substrates to produce liquid biofuels at commercially relevant production rates.

Potential Applications

- Production of valuable products from gaseous substrates using biofilms
    - Gaseous substrates include hydrogen, methane, carbon monoxide, carbon dioxide, and oxygen, or combinations (e.g. syngas, natural gas)
    - Chemical products formed include volatile fatty acids such as acetate and formate, alcohols such as methanol, ethanol and butanol, and other products such as formaldehyde

Benefits and Advantages

- Volumetric mass transfer coefficients (Ka) that are superior to those possible with current commercial microbial technologies producing liquid fuels from gases, with decreased operational energy consumption
- High catalyst densities in biofilms without requiring a large footprint – results in very high chemical/biofuel productivity
- Versatile scalability of the system for a variety of products
- Effective pH and microbial community management for optimal growth conditions
- Flexibility in operating temperatures – higher temperatures maximize the liquid-gas transfer rate and also allow growth of thermophilic microorganisms capable of novel metabolisms