Microalgae-microbial fuel cell (m-MFC): an integrated process for removal of pharmaceuticals in sewage and simultaneous electricity generation

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The scarcity of resources has changed the global production and management system and shifted worldwide attention from residual treatment towards resource recovery to building a self-sufficient bio-based economy and sustainable technological community. The recovery of resources from different waste streams has been considered a prominent solution to deal with the paucity and to enhance the economic and environmental performance of wastewater treatment. The biotechnological processes offer a versatile and economical pathway to transform and concentrate constituents of wastewater into valuable products for the development of a circular economy. Therefore globally, researchers are focussing on the assessment and application of environment-friendly technologies and energy sources to tackle burning issues such as increased disposal of untreated effluents, rising level of GHGs, and escalating energy demand.

In this regard, the bio-electrochemical System (BES) and microalgal biofuel have shown great potential and emerged as a sustainable and efficient technology for the treatment of emerging contaminants and to meet the future energy demand. For biofuel production, algal biomass is a future attractive source because of its potential to produce up to 10 times more oil per acre than traditional biofuel crops and it has been suggested that the utilization of this source as fuel feedstock in relation to various processes such as the production of biodiesel connected with hexane extraction, production of bioethanol by fermentation, biohydrogen, and biomethane production. On the other hand, BESs is gaining significant attention because of their prominence for electricity generation and in wastewater treatment efficiency, remediation of contaminants, nutrient recovery, and value-added products generation.

Microalgae has huge potential in bioremediation of waste, carbon dioxide sequestration, and as a renewable fuel source. They are currently used to bioremediate numerous pollutants of different characteristics and properties. Also, they show great potential for biofuel production. Pharmaceuticals and personal care products (PPCPs) are a group of xenobiotics present in the environment, mainly due to their stable structure and the inefficiency of conventional wastewater treatment plants to remove them. Microbial fuel cell (MFC) is a BES technology that utilizes microorganisms to convert biochemical or light energy into electricity through metabolic reaction and photosynthesis. Microalgae-Microbial fuel cell systems have recently gained increasing attention as a flourishing technology of wastewater treatment and energy recovery.

In m-MFC systems, a syntrophic interaction happens between bacterial populations and algal biomass, and this system functions with minimal net energy input. By incorporating microalgae into MFC, microalgae-microbial fuel cell (mMFC) integrates electricity generation, wastewater treatment, CO_2 sequestration, and biomass production in a single, self-sustainable technology. Our research group has been studying the degradation of pharmaceuticals in both the anode and cathode chambers of mMFC. Started the study by comparing the effect of antibiotics in the anode and cathode chambers of m-MFC. A 90% removal efficiency could be observed for the antibiotic. The antibiotic degradation is efficiently done in 1-2 days. The maximum power density obtained was 70-140 mW/m^{3}which is comparable with the existing microbial fuel cell reactors.

Currently, a mixture of pharmaceuticals is trying to degrade using m-MFC while generating bioelectricity. The effluent from the anode chamber will be recirculated to the cathode chamber for more efficient removal of the pollutants. CO2 generating from the anode chamber wiCO_2 e recirculated in the cathode chamber (Fig. 1). Also, the microalgae biomass collected from the cathode chamber will be used as a substrate in the anode chamber and also as an electrode material and will be explored for the potential of biofuel generation. This integrated mMFC can be a breakthrough in the field of algal-mediated removal of PPCPs in waste water treatment processes.

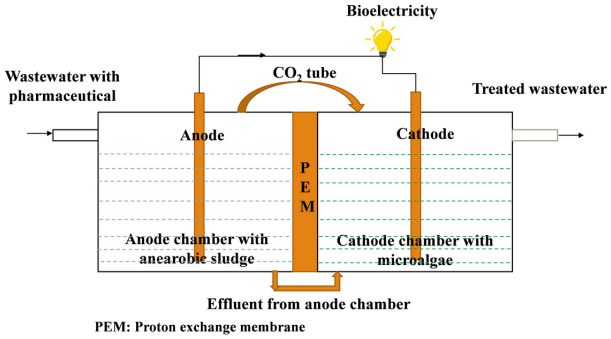

Fig. 1: Schematic of microalgae microbial fuel cell for pharmaceutical treatment and bioelectricity generation

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