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Fibrous nanocomposite materials as a cathode catalyst for improved power production in microbial fuel cells

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The energy development based on fossil fuels is creating major problems because the sweltering of fossil fuels leads to the generation of gases linked to global warming. The reduction of these natural resources is also an important issue of concern which has stimulated scientists to search for green and economic energy production method to meet growing demands. Microbial fuel cells (MFCs) have attracted great scientific attention because they can produce clean energy from a variety of waste materials using microorganisms as the catalyst. The controlling factor for power generation in MFCs depends on the design and efficacy of the electrode material, which provides the active sites for the cathodic oxygen reduction reaction. Most electrodes used in MFCs to enhance the performance were generally platinum-based, which has limited their large scale applications. Therefore, it is important to fabricate efficient and economically viable cathodes for MFCs using alternative inexpensive conductive materials which provide the catalyst with improved kinetics oxygen reduction reaction at the working cathode. In the present study, a fibrous PANI-MnO_2 nanocomposite was prepared using a scalable in situ chemical oxidative polymerization method. The electrochemical capacitive behavior of the as-synthesized fibrous PANI-MnO_2 nanocomposite was evaluated further by cyclic voltammetry (CV) and galvanostatic charge-discharge (GCD) measurements. The fibrous PANI-MnO_2 nanocomposite showed a better electrochemical specific capacitance with excellent cyclic stability. In addition, the fibrous PANI-MnO_2 nanocomposite was also assessed as a cathode catalyst for improved power generation in MFCs and showed much better performance than either PANI or plain carbon paper.

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Caffeine and coffee waste: Lot of utility for these feedstock due to recent discovery of caffeine degrading genes from *Pseudomonas*

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Problem Statement: In recent years, biofuel has emerged as a sustainable solution to the ever-growing demand of clean energy in the 21st century. Utilization of food crops as feedstock for bioethanol production, although a quick solution, is not the best, particularly with fast-growing global population, high global hunger index and a steep competition from feed industry for meat and dairy production. Consequently, utilization of sugar/carbon-rich domestic/agricultural wastes and forest products are gaining popularity as alternate feedstock, which also address issues related to waste management and pollution.

Methodology & Theoretical Orientation: In 2009, Mahula flower (an untapped sugar-rich forest product) was successfully demonstrated as a better alternative feedstock for bioethanol production. Given, coffee is the second-most traded commodity in the whole world; coffee waste has gained popularity as an untapped carbon-rich feedstock. The idea is to utilize caffeine, a key carbon-rich component of coffee waste generated from domestic, commercial, or agricultural sources for bioethanol, enzyme, pharmaceutical production and other applications such as soil-bioremediation.

Findings: We have isolated and studied several strains of soil-bacteria that degrade caffeine either via N-demethylationor C-8 oxidation pathway. Genetic maps of both these pathways have been fully characterized. These genes are the only characterized bacterial caffeine-degrading genes and offer great value from a biofuel production perspective via metabolic engineering. At this time, we have been able to show reconstitution of demethylation caffeine-degrading pathway in *E. coli* to produce high value products such as theobromine, 3-methylxanthine, 7-methylxanthine and xanthine. Interestingly, a caffeine-addicted *E. coli* was also developed using these genes.

Conclusion & Significance: In future, via rigorous metabolic re-wiring in organisms such as *E. coli* and yeast, we expect to generate biofuel, high value chemicals, remediation of coffee-waste for potting soil, and enzyme-based diagnostic test for caffeine detection for medical and food applications.

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