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Abstract	:	Highly efficient bio-inspired platinum nanoparticles (Pt NPs) as an electrocatalyst with superior intrinsic kinetics and high performance for methanol oxidation reaction (MOR) derived from green synthesis of bio-waste utilization is of great interest. The bio-inspired Pt NPs were examined for their kinetic parameters in terms of the Tafel plot, exchange current, square root of the scan rate, methanol diffusion coefficient, activation energy (Ea), and factors influencing current density. Bio-inspired Pt NPs exhibit a fast kinetic reaction with a low Tafel value of 179 mV dec−1 and exchange current, α = 0.33, compared to commercial Pt black (233 mV dec−1, α = 0.25). The bio-inspired Pt NPs display low activation energy, Ea, as the potential increases, indicating improved intrinsic kinetics, and the MOR catalyzed by bio-Pt NPs was discovered to be a diffusion-controlled process. The parametric effect of bio-inspired Pt NPs concentration has a crucial influence on the anisotropic morphological structure and interconnection to the current density (mA mg−1) of MOR. Central Composite Design (CCD) was applied for RSM-based modeling and analyzing the parameter effects, including bio-inspired Pt NPs concentration, methanol concentration, and electrocatalyst loading to optimize the current density. The optimized current density produced by bio-inspired Pt NPs was 640.11 mA mgPt−1 at ideal conditions of 1.5 mM bio-Pt NPs, 1.05 M CH3OH, and 2.14 mg. Ultimately, the passive DMFC single-cell powered by bio-inspired Pt NPs generates power density with Pmax of 5.70, 6.67, and 8.28 mW cm−2 at 25, 80, and 100 °C.