Proceedings of the International conference on

Advanced Materials for Clean Energy and Health Applications

March 27 & 28, 2025

AMCEHA - 2025

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Utilizing Activated Carbon from Water Filter Residues as a Counter Electrode in Dye-Sensitized Solar Cells

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Dye-sensitized solar cells (DSCs) have gained significant attention due to their efficiency and cost-effectiveness in harnessing solar energy. Selecting the material for the counter electrode (CE) greatly impacts their cost. At present, Platinum (Pt), is widely used as the CE material, that is expensive and has limited availability, prompting researchers to explore more sustainable and affordable alternatives. In this work, we investigated the potential of activated carbon derived from waste carbon which is readily available and reusable, obtained from removed carbon filter material in household water purifiers. First, dried waste filter carbon (WFC) was activated by heating at 900 °C for 20 minutes and then quenching several times. Next, dried activated filter carbon was disc-milled into a fine powder. After that, activated filter carbon (AFC) based CEs were prepared by mixing with 0.05g of Polyvinylpyrrolidone binder and 10 ml of isopropanol solvent. The resulting suspension was sprayed onto preheated Fluorine-doped Tin Oxide (FTO) glasses (2 cm × 1 cm) and sintered at 300 °C for 20 minutes using the spray pyrolysis technique. Results showed that the AFC CE-based DSC has an energy conversion efficiency of 6.14% using the standard N719 dye and liquid electrolyte (I^-/I_3^-), whereas the DSC with Pt-based CE had an efficiency of 7.81 %. AFC CE exhibited an electrical conductivity of 6.17×10^4 S m^{-1}. The open circuit voltage (V_{oc}) and short circuit current density (J_{sc}) of the AFC-based cell were 0.70 V and 12.98 mA cm^{-2} respectively. Furthermore, AFC CE and Pt CE obtained maximum IPCE values of 61 % and 57.5 % at 535 nm wavelength respectively. Although AFC CE-based DSC performs lower than the Pt-based DSC, due to its low electrocatalytic activity, the measured efficiency of 6.14 % is noteworthy, suggesting its feasibility as a Pt-free low-cost DSC.

Keywords: Activated filter carbon, Counter electrode, Dye-sensitized solar cells, Platinum