DOI: 10.2478/auoc-2025-0019

Ovidius University Annals of Chemistry Volume 36, Issue 2, pp. 162 - 169, 2025

Specific capacitance and electrochemical properties of charge transfer complex of 4,4'-bipyridine with a benzoquinone derivative

Ibrahim EL-HALLAG[*],[1] Ahmad AL-OWAIS,[2] and El-Sayed EL-MOSSALAMY[3]

[1]*Chemistry Department, Faculty of Science, Tanta University, Al-Geish St., Gharbia, Tanta, Egypt*
[2]*Chemistry Department, Faculty of Science, King Saud University, Building 5, Riyadh 11451, Riyadh, Saudi Arabia*
[3]*Chemistry Department, Faculty of Science, Benha University, Fareed Nada St., Benha, Egypt*

Abstract. This study investigates the specific capacitance and electrochemical properties of a charge-transfer (CT) complex formed between 4,4′-bipyridine (BPy) and 2,3-dichloro-5,6-dicyano-1,4-benzoquinone (DDQ), focusing on its potential application as a redox-active component in advanced energy storage systems. A comprehensive series of electrochemical analyses was conducted to elucidate the electronic interactions and capacitive behavior of BPy in the presence of DDQ. Cyclic voltammetry (CV) revealed enhanced pseudocapacitive behavior, attributed to synergistic charge-transfer interactions between the nitrogen centers of BPy and the electron-deficient carbonyl groups of the nonequivalent derivative. The presence of C≡N and Cl substituents on the quinone ring was found to significantly influence the redox potentials and modulate the π–π* and n–π* charge-transfer processes, thereby affecting the electron density distribution within the molecular complex. Notably, the BPy–DDQ complex exhibited a high specific capacitance, reaching up to 114 F/g at a scan rate of 0.4 V/s, which is ascribed to enhanced charge delocalization and improved interfacial conductivity. Morphological analysis using scanning and transmission electron microscopy (SEM and TEM) further revealed the nanostructured features of the CT complex. These findings highlight the potential of BPy–DDQ complex as tunable, redox-active materials for next-generation supercapacitors and other electrochemical energy storage applications.

***Keywords*:** specific capacitance; pseudocapacitive; cyclic voltammetry; DDQ; BPy.

[*] Corresponding author. *E-mail address:* i.elhallag@yahoo.com (Ibrahim El-Hallag)