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RESEARCH ARTICLE

# Isotherms, kinetics and thermodynamic sorption of paranitroaniline on *Cocos nucifera* shell activated carbon@$TiO_2$ composite

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**Abstract**

A comparative study was conducted on the adsorption capacity of *Cocos nucifera* shell-activated carbon (CNSA) and *Cocos nucifera* shell-activated carbon@$TiO_2$ composite (CNSA-$TiO_2$) for para-nitroaniline in an aqueous medium. The CNSA was carbonized at 500 °C and activated with 1 M $HNO_3$ while the CNSA-$TiO_2$ composite was prepared by wet impregnation method. The prepared adsorbents were characterized through Brunauer–Emmett–Teller (BET), energy dispersive X-ray (EDX) spectroscopy, Fourier-transform infrared (FTIR) spectroscopy, and scanning electron microscopy (SEM). The BET-surface area of CNSA-$TiO_2$ (748.96 $m^2$/g) was established to be larger than CNSA (574.21 $m^2$/g), however both materials are mesoporous. The effects of initial *p*-NA concentration, pH, adsorbent dosage, contact time, and temperature, were explored for both adsorbents. The results showed that the adsorption operating parameters influenced the adsorption process except for temperature, with maximum adsorption of 38.26 and 38.36 mg/g for CNSA and CNSA-$TiO_2$, respectively. Freundlich, Langmuir, Temkin, and Dubinin-Radushkevich isotherms were tested on the adsorption data, and the adsorption process of both adsorbents followed the Freundlich isotherm model ($R^2 > 0.988$). Among the kinetic models studied, the pseudo-second-order model ($R^2 = 1$) best described both processes. The thermodynamic parameters such as $\Delta G°$, $\Delta H°$ and $\Delta S°$ were calculated. The process was exothermic, spontaneous and feasible.

**KEYWORDS**
adsorption, *Cocos nucifera* shell-activated carbon, isotherm, *p*-nitroaniline, $TiO_2$

## 1 | INTRODUCTION

The growing global concern about water pollution caused by synthetic organic pollutants is largely driven by the hazardous effects on the environment and the negative health risks associated with them.[1] Among this group of synthetic organic pollutants, aniline-based organic compounds have emerged as major pollutants due to their significant release from various industries. An aniline-based organic compound such as paranitroaniline (*p*-NA) is one of the most important chemical precursors in the world.[2] and is commonly used in the manufacturing of antioxidants, dyes, corrosion inhibitors, pesticides, petrochemicals, and pharmaceuticals.[3,4] The wastewater generated from these industries poses significant health concerns, such as cancer and hemolytic anemia, triggered by the toxicity of *p*-NA due to its pollution of the environment.[2,5] The occurrence of *p*-NA in water, even at very low quantities, causes extreme harm to both humans and aquatic life. Furthermore, *p*-NA resists chemical and biological oxidative destruction and has been described as one of the significant and prioritized contaminants in water by the US Environmental Protection

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