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# Green synthesis of $TiO_2$ nanoparticles prepared from *Phyllanthus niruri* leaf extract for dye adsorption and their isotherm and kinetic studies

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**Abstract**

Herein, the green synthesis of $TiO_2$ nanoparticles using *Phyllanthus niruri* leaf extract was accomplished by the sol-gel method. The structure and particle size of the synthesised $TiO_2$ nanoparticles were characterised by X-ray diffraction (XRD) analysis and the size was found to be 20 nm. The Fourier-transform infrared spectra determined the existence of carboxyl and hydroxyl functional groups. The images from SEM analysis recommended a porous and heterogeneous surface. The methyl orange (MO) dye removal was examined using different parameters such as pH, time, dose, temperature and dye concentration. Maximum dye elimination percentage was achieved at pH 6.0 and 0.02 g as the optimum adsorbent dose. The kinetic analysis suggested that the pseudo-second-order kinetic model finely defines adsorption dynamics. Langmuir adsorption isotherm studies revealed endothermic monolayer adsorption of the methyl Orange dye. The negative value of $\Delta G°$ and positive value of $\Delta H°$ showed the spontaneous and endothermic adsorption method.

## 1 | INTRODUCTION

In the present scenario, water pollution is a severe threat to the eco-system, so it has become essential to remove the contaminants from the effluents before it is discharged into the natural water resources. Directly or indirectly, fresh water is polluted by the untreated industrial effluents from various production units and industries. Aquatic bodies and aquatic organisms are affected harmfully by one of the major contaminants that is organic aromatic dye discharged from the industries. Dyes possess a complex aromatic structure, which are difficult to be degraded and also have carcinogenic and mutagenic effects on human beings [1–3]. Anionic dyes are lethal, as they not only pollute the environment but also affect the entire food chain resulting in biomagnification. Methyl Orange (MO) is an anionic dye, which is used as a colouring agent for dying various materials and it is necessary to remove methyl orange from the industrial discharge before it flows into the sewage thereby ensuring environmental safety.

Nanotechnology is an emerging field of science and it creates impact in solving many issues related to health and energy towards the need of the society. Currently, the biosynthesis of nanoparticles has been considered as environmentally sound and safer and more cost-effective alternative for chemical and physical production methods [4]. Plant extracts are mainly promising for 'green' production since they are freely available, cheap, and offer simplicity of use and scalability. Various methods including chemical and physical means, chemical reduction, sol–gel, solvothermal, hydrothermal and electrochemical reduction techniques are widely employed for the synthesis of nanomaterials. But, the above methods are costly, requires high energy, difficult to separate and potentially hazardous.

Numerous conventional techniques including coagulation [5–7], electrochemical destruction [8], ozonation [9], and ion exchange [10, 11] are examined to treat the dye contaminated waste water. Of all these, adsorption is considered as an effective technique because of its simple design, high-level efficiency and its convenience in operating. Among physical, chemical and biological conventional methods of dye removal, physical adsorption is an effective method for fast removal of dyes from the effluents [12, 13]. Many adsorbents such as activated carbon [14], peat [15], silica [16], clay [17],