Formation, Characterization and Photocatalytic Activity of Orange Peel-Mediated Synthesis TiO_2 Nanoparticles

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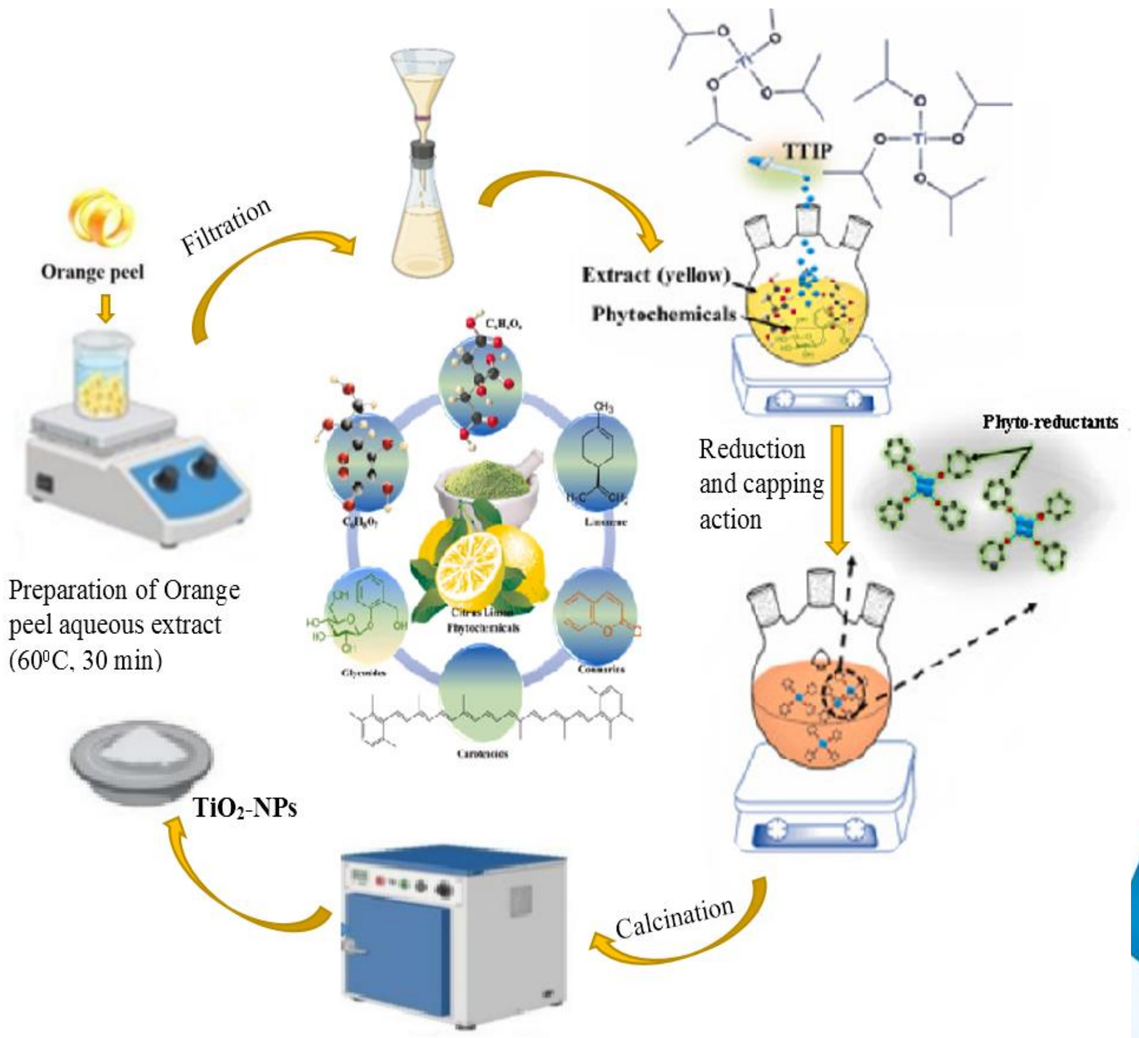
Introduction

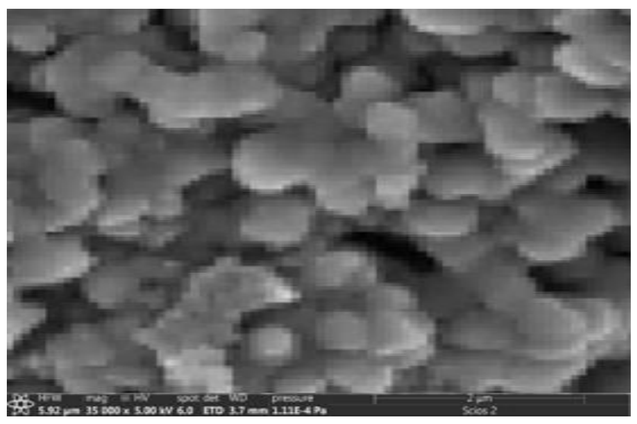
Nanotechnology has emerged as a powerful tool in environmental remediation, especially through the development of metal oxide nanoparticles like titanium dioxide (TiO_2). Green synthesis methods using plant extracts offer an eco-friendly alternative to conventional chemical synthesis. In this study, TiO_2 nanoparticles were synthesized using orange (Citrus sinensis L.) peel extract, leveraging its rich phytochemical content as a natural reducing and stabilizing agent. The synthesized nanoparticles were characterized and evaluated for their photocatalytic efficiency in degrading malachite green dye under sunlight, demonstrating strong potential for wastewater treatment applications.

Biosynthesis of TiO_2 Nanoparticles:



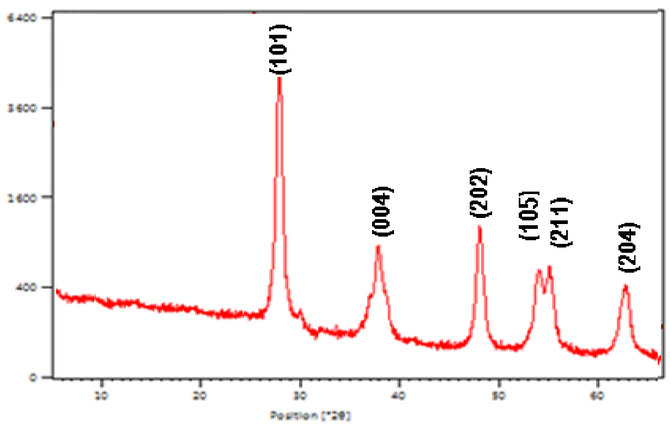
TiO_2 nanoparticles were synthesized via a green method using orange peel extract. Fresh peels were boiled in distilled water to obtain the extract. This was then mixed with a 5 mM TiO_2 solution and stirred at room temperature. The resulting mixture was centrifuged, washed, and dried at 50–60 °C for 48 hours and than calcinated at 600 °C to obtain fine TiO_2 nanopowder

Characterization of TiO_2 NPs



SEM images revealed spherical particles with sizes ranging from 50 to 150 nm, showing some agglomeration.

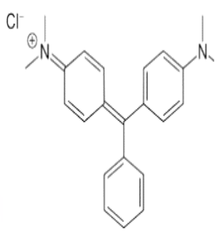
XRD analysis confirmed the anatase crystalline phase, indicating high purity and crystallinity of the nanoparticles.



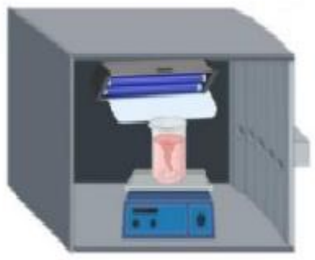
Photocatalytic activity

The photocatalytic performance of the TiO_2 nanoparticles was evaluated by degrading malachite green dye under natural sunlight.

Malachite green dye

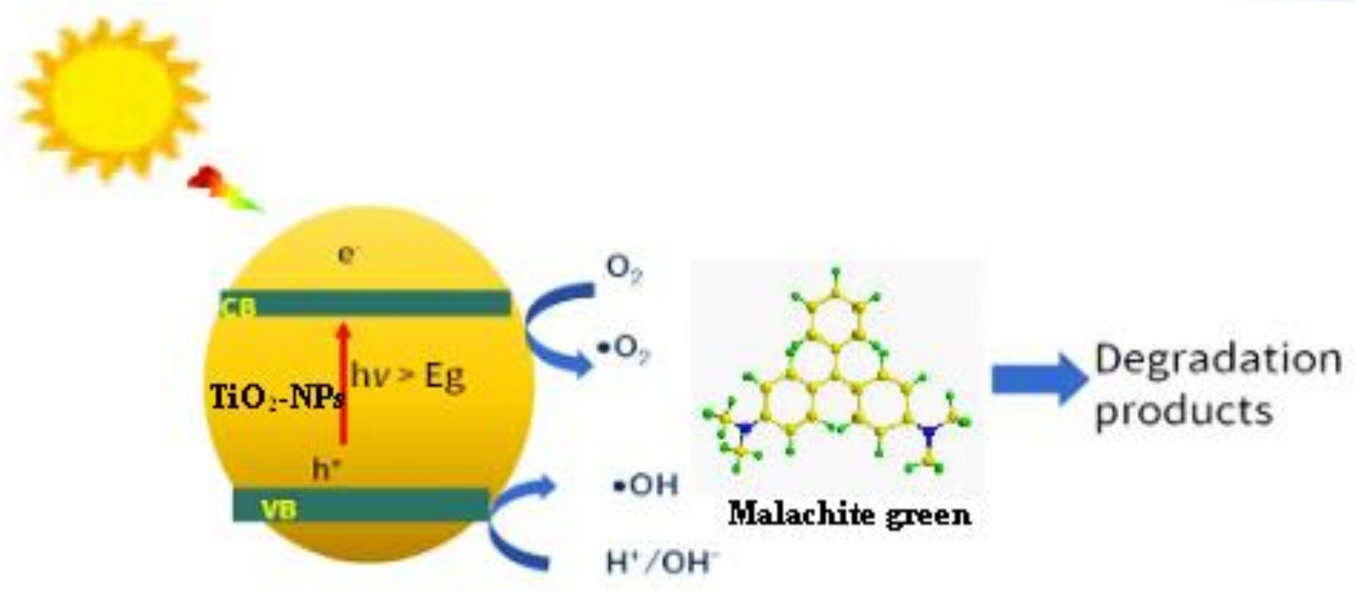


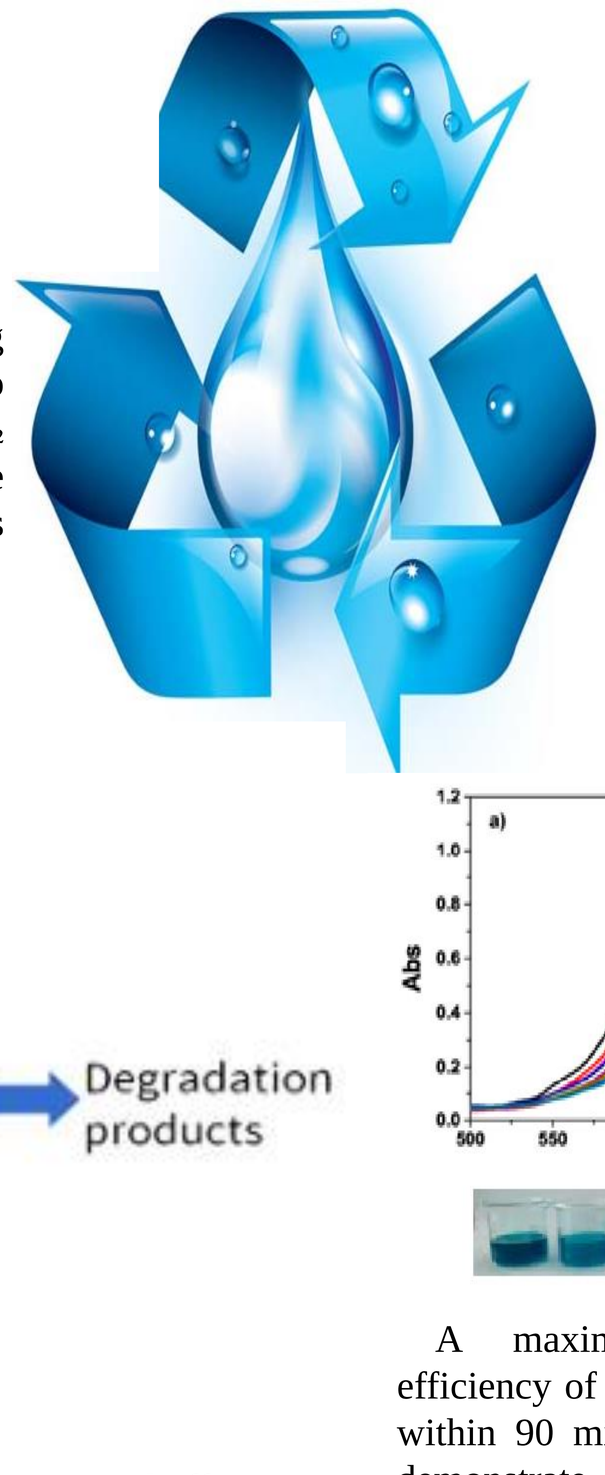
$$R(\%) = \frac{C0 - Ce}{C0} \times 100$$

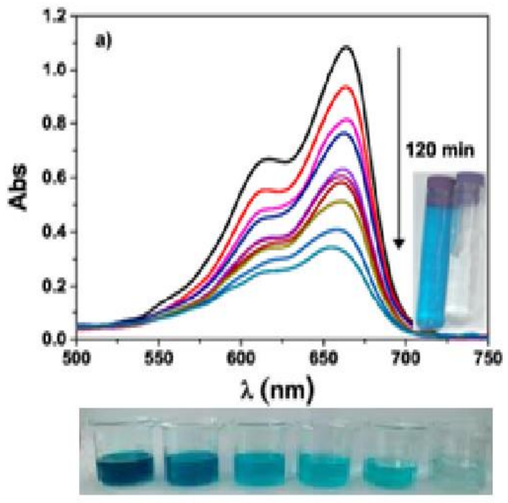


Photocatalytic setup

Mechanism of Malachite Green Dye Degradation

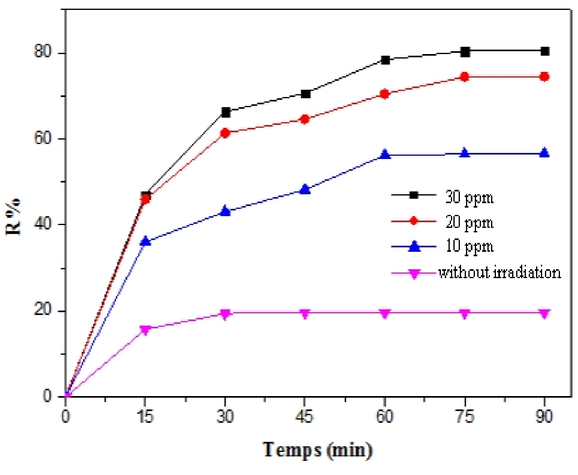






The UV-Vis spectra show a steady decrease in the absorbance peak of malachite green over time, showing the solution changing from deep blue to nearly colorless, consistent with ~95% dye degradation, and this indicating MG degradation.

A maximum degradation efficiency of 95% was achieved within 90 minutes. The results demonstrate strong photocatalytic activity, highlighting the potential of these green-synthesized nanoparticles for wastewater treatment.



Conclusion

TiO_2 nanoparticles synthesized using orange peel extract demonstrated effective photocatalytic activity for degrading malachite green dye under natural sunlight. The green synthesis method proved to be eco-friendly, cost-effective, and efficient. These results highlight the potential of plant-mediated TiO_2 nanoparticles in sustainable environmental remediation, particularly for treating dye-contaminated wastewater.