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RESEARCH ARTICLE

# Visible Light Assisted Photocatalytic Degradation of Methylene Blue Dye and Mixture of Dyes Using $ZrO_2$-$TiO_2$ Nanocomposites

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**Abstract:** ***Background:*** Different photocatalysts such as $TiO_2$, ZnO and $WO_3$ have been used for the degradation of organic pollutants. However, these materials have some limitations, which have been affected the catalytic efficiency in the various transformations. The composites of these materials with other oxides can produce better results by tuning structural as well as optoelectrical properties. The composite of $TiO_2$ with $ZrO_2$ has attracted attention due to its use in different areas, as $ZrO_2$ and $TiO_2$ have similar physicochemical features.

***Methods:*** This research contains the preparation of $ZrO_2$-$TiO_2$ nanocomposites by hydrothermal method and analysis of photocatalytic activity for the degradation of methylene blue and a mixture of dyes under visible light irradiation.

***Results:*** Physicochemical characterization of $ZrO_2$-$TiO_2$ nanocomposites has been studied by using different techniques. Prepared catalysts has shown anatase phase of $TiO_2$ and tetragonal phase of $ZrO_2$. XRD, FESEM and HRTEM have supported the nanocrystalline nature of the composites. The photocatalytic activity of composites and bare $TiO_2$ samples were demonstrated for the degradation of methylene blue dye. Enhanced activity has been shown by composite having Ti:Zr 3:1 molar proportion, i.e., $Ti_3Zr$. Effect of concentration of methylene blue, pH of the solution and catalyst loading have been studied by using $Ti_3Zr$. In addition, the degradation of a mixture of three dyes, namely methylene blue, rhodamine B and methyl orange, has been studied.

***Conclusion:*** In summary, prepared $ZrO_2$-$TiO_2$ composites found to be nanocrystalline and visible light active. These catalysts have shown activity for photocatalytic degradation of methylene blue and a mixture of dyes.

**Keywords:** Nanocomposite, photocatalysts, hydrothermal, dye degradation, visible light irradiation, $TiO_2$.

## 1. INTRODUCTION

As water pollution is attracting much attention of the globe due to its diverse effects on mankind and other living organisms, the management, controlling and treatment of many natural and synthetic man-made pollutants are very significant. Day-by-day, amounts of disposal and organic load from the textile industries are gradually increasing and contribute to a larger extent to water pollution [1]. An organic compound that causes an increasing environmental danger is mostly textile dyes and other industrial dyestuff. During the dyeing process, more than 20% of dyes are illuminated as waste [2, 3] and these dyes are very toxic and may be responsible for several skin infections, diseases like cancer and also significantly affect an aquatic life [4-6]. The use of a heterogeneous semiconductor photocatalyst is a most conventional method for the treatment of wastewater purification by reduction and oxidation reactions accelerated by oxygen molecules, hydroxyl anions, or other organic molecules and radicals [7-9].

Semiconductor photocatalysts such as $TiO_2$, ZnO and $WO_3$ have been used for photocatalytic degradation of organic pollutants and dyes [10]. However, these bare materials suffer from various constraints such as active in UV-region only, fast recombination of the charge carriers, improper charge separation as well as transport, etc, which have been reflected through their lesser extent of catalytic efficiency in the various transformations. These constraints are to be overcome, making their composites with other supportive materials so as to tune their structural, optoelectrical properties for potential applications [11-13] The combination of $TiO_2$ and $ZrO_2$ as a composite has attracted much attention from the last two decades [14-16] and has been employed for several purposes, such as gas sensors, photoconductive thin films, ceramic technologies and in the fuel cell. $ZrO_2$ is an n-type semiconductor with similar physico-chemical features to that of $TiO_2$. It is established in the literature that the $ZrO_2$

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