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# Rapid photocatalytic degradation of nitrobenzene under the simultaneous illumination of UV and microwave radiation fields with a $TiO_2$ ball catalyst

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ABSTRACT

To use the microwave/ML/$TiO_2$ hybrid system as an advanced treatment of nitrobenzene (NB), a series of experiments were performed to examine the effects of microwave irradiation and auxiliary oxidants. The degradation of NB was carried out using different combinations of five-unit treatment techniques. The NB degradation rate increased with increasing microwave intensity. The circulation fluid velocity, concentration of $H_2O_2$, and the rate of $O_2$ gas injection showed the highest rate of degradation under optimal conditions. A significant synergistic effect was observed when $H_2O_2$ addition was combined with the microwave/ML/$TiO_2$ hybrid process.



## 1. Introduction

Owing to the advances in industry, many organic compounds have been produced as organic solvents, which are contaminating soil and underground water [1,2]. A large portion of these organic compounds are volatile organic solvents and hydrophobic materials, whose specific gravity is larger than water. In addition, they are poisonous and mutagenic derivative materials, and are very difficult to decompose chemically and biologically, giving them significantly long half-life [3]. Nitrobenzene (NB) is used widely in areas, such as aniline synthesis, dyes, rubber making, textile, synthetic resins, pesticide, explosives, cosmetic, and drugs [4,5]. NB, which exists in the environment, is emitted mainly from the manufacturing process of chemical products or the use of products that contain these materials [6,7]. Even at low concentrations, NB can damage the reproductive cells of rodents, and the World Health Organization (WHO) defined NB as an animal carcinogenesis chemical compound [8–10]. For these reasons, this study assessed the decomposition of NB as a model pollutant.

Conventionally, NB in aqueous media is processed using physical, chemical, and biological techniques. The general treatments is composed of adsorption [11,12] and biodegradation [13,14]. These techniques can be effective but it occurs secondary pollution, resulting in high processing cost. Advanced oxidation processes (AOPs) have been shown to be effective in the destruction of aromatic wastewater pollutants [15,16]. Basically, the AOP process uses oxidizing hydroxyl radicals to oxidize pollutants using $O_3$, $H_2O_2$, UV, and photocatalysts [17–21]. Among these methods, photocatalysis has been applied frequently for the advanced degradation of aromatic wastewater pollutants [22,23]. In particular, the $TiO_2$ photocatalytic process has significant advantages, such as available at room temperature, applicable under atmospheric pressure, complete mineralization, and low cost compared to the conventional treatments [24–26].

On the other hand, the use of $TiO_2$ as a photocatalyst has been limited by its high band gap (3.2 eV), meaning that it can be only activated by ultraviolet (UV) light. In addition, it has a low photo quantum efficiency and a high rate of electron–hole pair recombination [27,28]. Therefore, a method to enhance the processing efficiency is needed to decompose aromatic wastewater pollutants at high speed. Recently the effects of the microwave irradiation on the treatment of non-biodegradable materials in water using $TiO_2$

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