In this work, Y-doped ZnO nanoparticles were precipitately synthesized for different various yttrium molar percentages—percentage values of 0.5%, and the nanoparticles were then demonstrated as photocatalysts for methylene blue degradation. Morphology shows that the particle size of pure ZnO is 113.77±33.26 nm, which decreases to the minimum value of over one-third for the Y-doped ZnO samples. This decrease in particle size is consistent with the small crystalline size, primarily due to low crystallization in the presence of yttrium dopants. However, the expansion of the crystal structure is observed. Chemical surface structures point to the major vibration of ZnO, however, some carbon-relating groups are still remain in the surface. Optical property reveals similar trends for all Y-doped ZnO samples. The estimated band gap energy (E_g) was reduced to the minimum value for the 4 mol.% condition. For use as a photocatalyst, the appropriate Y-doped ZnO for yttrium dopants of 4 mol.% presents the best optimal degradation efficiency of 61.19%. This improvement in photocatalytic degradation is caused by the synergy of decreased particle size and reduced E_g. Therefore, yttrium plays the role to decrease particle size and reduce E_g of Y-doped ZnO materials, which thus leads to improved photocatalytic performance.

1. Introduction

Pollutions in water resources are a concerning issue that has had negative potential effects on both human health and the surrounding environmental systems. Toxic chemicals have been made by human activity; activities are the major pollutants that have continue to contaminate in the soil, air and water in the surrounding environments such as soil, air, and water. Especially, in water, the chemicals have causes wastewater, which is a worrying issue and because it has a large-scale impact on the environment, in large scales due to especially if it is transportation of water in to natural rivers. To reduce chemical residues, the photocatalytic degradation is one of the an interesting effective methods to reduce chemical residues, due to its simple and flexible uses [1]. The photodegradation is based on two fundamental processes, including namely, photoactivation and degradation processes. The photodegradation has occurred when photocatalysts absorb energy from incident light for generating electron-hole pairs, which are continuously transferred to the photocatalyst’s surfaces. Then, the pairs have reacted with chemical residues for mineral transformation in during the degradation process.

Several semiconducting semiconductor materials such as TiO_2, CuO, SnO_2, and ZnO have been investigated for applying as photocatalysts [2,3,4]. Among these, ZnO is an interesting one, primarily due to its stability and unique in-opto-electronic properties, and stability. ZnO has a large band gap (E_g) of around 3.70 eV that can specifically be activated by ultra-violet (UV) light; a high carrier mobility for rapidly transferring electron-hole pairs to the material’s surfaces; and a relatively stable chemical structure [4]. Moreover, ZnO also has advantages in the various nano-structural fabrications. To improve the photocatalytic activity of ZnO, it has been demonstrated in several developments such as with several improvements in charge separations, lifetimes, and surface areas. Phopayu et al. [5] modified ZnO by using graphene quantum dots (GQDs) dopant for extending the crystalline structure of the GQDs-ZnO nanocomposites [5]. The extended structure has reducing grain boundary density, which thus causes a lower electron-hole pair recombination at the grain boundary. This behavior plays the role to increase the lifetime...
for electron-hole pair movement at surfaces of the GQDs-ZnO, which resulted in high photocatalytic performance for commercial glyphosate degradation. Bozetine et al. \(^1\) presented the simple and green synthesis of ZnO/carbon quantum dots (CQDs)/Ag nanoparticles (NPs) nanocomposites for photocatalytic application. The nanocomposites exhibited excellent photocatalytic performance due to the improved charge separation efficiency and increased surface areas \(^4\). The charge separation was improved because electrons can easily be transferred in the nanocomposites which caused by the energy level adjustment for heterojunction interfaces. This result agrees in line with in several composite structures reported elsewhere \(^6\)-\(^8\). For the increased surface areas, it was described by the attachment of small CQDs or Ag NPs on the ZnO surfaces. The improved charge separation efficiency and increased surface areas of ZnO/CQDs/Ag NPs nanocomposites was synergistically enhanced the photocatalytic degradation of methylene blue (MB). Yu et al. \(^1\) developed ZnO/biochar nanocomposites using a facile ball-milling method for applying as a photocatalyst \(^9\). The nanocomposites exhibited the increased mesopore and macropore structures in comparison to pure ZnO. In photocatalyst applications, the degradation efficiency of MB was peaked at to 95.19% under visible light activation. The improvement in degradation efficiency was caused by the combination of adsorption and photocatalysis processes. Wang et al. \(^1\) prepared Ce-doped ZnO using a simple solution method \(^10\). They found that Ce-dopant has affected the decrease in particle size and \(E_g\) values. These results synergistically function to improve photocatalytic activity, which subsequently enhanced the degradation efficiency of MB.

In the current work, Y-doped ZnO photocatalysts were synthesized from a mixture of zinc nitrate and yttrium nitrate. The yttrium nitrate was varied in the molar percentage range of 0-5% to investigate the influence of yttrium on structural, chemical, and optical properties. The characteristics of Y-doped ZnO were investigated and analyzed. Then, The Y-doped ZnO were use as a photocatalyst for MB degradation. The photocatalytic degradation efficiencies were calculated based on the absorbance measurement. In order to evaluate the appropriate yttrium content of Y-doped ZnO for the best optimum MB degradation.