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Effects of Humic Acid and Natural Sunlight Irradiation on the Behaviour of Zinc Oxide Nanoparticles in the Aqueous Environment

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Abstract: The unique properties of ZnO nanoparticles have attracted scientists' interest to produce on a large-scale. Household items, cosmetics, consumer products, and electric sensors are some products that utilize these ZnO nanomaterials. Eventually, ZnO nanoparticles will be released into the environment in various ways. Once released, ZnO nanoparticles would dissociate into Zn^{2+} ions, which are toxic to aquatic organisms. The presence of humic acid and exposure to sunlight could affect the dissolution of ZnO nanoparticles. Two sizes of commercial ZnO nanoparticles (< 50 nm and < 100 nm) were chosen to study the influence of humic acid and sunlight on the dissolution. In the presence of humic acid, the dissolution of both sizes is higher, with 67 % and 39 % Zn^{2+} dissolved for < 50 nm and < 100 nm, respectively. The concentration of Zn^{2+} ions seems to be consistent or stable when exposed to sunlight. However, the humic acid enhanced the release of Zn^{2+} ions. Langmuir isotherm model best fitted for the humic acid's sorption onto the ZnO nanoparticles with the process been favorable.

Keywords: ZnO nanoparticles; humic acid; sunlight; dissolution; aggregation.

1. Introduction

Applications of nanotechnology in daily usage are already well known [1-6]. To date, nanomaterials' production has become more rapid and on a large scale by years, which consequently increased the amount released to the environment [7-10]. For instance, nanoscale materials' production is expected to exceed $125 billion by 2024 [11]. These nanoscale metal oxides exhibit unique physical and chemical properties essential for their applications [12-14]. For example, zinc oxide and titanium dioxide were used in cosmetic and sunscreen products due to their ability to absorb UV light [15-16] and antibacterial activity [17-19]. ZnO and TiO_2 nanoparticles were also widely used as catalysts in water treatment [20], removing pollutants such as dye and humic acid [21-22].

Climate change and hydrological processes could affect the biodegradable activity of dead plants, determining the concentration of organic matter released into the aquatic ecosystem. According to [23], natural organic matters are present in almost all aquatics ecosystems. The concentration is ranging from 0.1 – 10.0 ppm depending on biogeochemical conditions and climate. Natural organic matter consists of fractions of humic substances such