UNIVERSITI TEKNOLOGI MARA

SYNTHESIS AND CHARACTERIZATION OF BISMUTH MAGNETIC MICROSWIMMER FOR DEGRADATION OF POLYSTYRENE MICROPLASTICS

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ABSTRACT

Microplastics ranged from 1 μm to 5 mm but the occurrence of smaller microplastics (micron-sized) has become a major concern due to their larger surface area, which can accumulate and transport other contaminants such as heavy metals and chemical additives and pose potential risks to humans and marine systems. However, microplastics with sizes ranging from 1 μm to 10 μm were found in water treatment plant effluent, indicating that they did not settle through sedimentation and passed through the filtration system. Light-driven microswimmers are one of the promising new technologies for microscale environmental remediation. Hence, this study proposes photocatalytic degradation of 1.1 μm polystyrene latex (PSL) beads microplastics using bismuth magnetic microswimmer. In this study the bismuth magnetic microswimmer was synthesized via facile hydrothermal method and the microswimmer's motion and photocatalytic degradation of PSL were performed under visible light in an aqueous solution. The self-propelled bismuth magnetic microswimmer with average particle size of 3.913 μm was observed to collect the PSL microplastics at a reasonable speed of 3.0498 μm/s in 5 wt% H_2O_2 under low light intensity (i.e., 7.02×10^{-2} W/cm^2) white light irradiation. Moreover, the mesoporous bismuth magnetic microswimmer with surface area of 5.4775 m^2/g successfully degraded 64% PSL microplastics in 120 hours. Furthermore, the decrease in total organic carbon concentration in the PSL solution and the concentration of carbon dioxide (CO_2) produced prove demineralization of the PSL microplastics into CO_2 and water molecule. In addition, the appearance of carbonyl and hydroxyl functional group peaks in the Fourier Transform Infrared (FTIR) spectrum of degraded PSL provides mechanistic insight into the photocatalytic degradation of the PSL microplastics. The stability of the bismuth magnetic microswimmer was relatively good, with 73 %, 65 %, 60 %, and 40 % PSL microplastics degraded from first cycle to last cycle. Very low concentration of Bi^{3+} (i.e., 0.0327-0.0712 mg/L) and Fe^{3+} (i.e., 0.0200-0.0633 mg/L) was observed after each cycle of bismuth magnetic microswimmer, which is environmentally safe. Finally, it is economically feasible to implement the photocatalytic degradation of the PSL microplastics using bismuth magnetic microswimmer since the microswimmer can be recycled.

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Sincerely,

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