Development of an Image Processing-Based System for Microplastic Detection in Water Using Fluorescence of Rhodamine B and Silver Nanoparticles

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Abstract

Microplastics have emerged as a significant environmental concern due to their ubiquity in water, soil, and air, as well as their potential to accumulate in the human body and pose various health risks. Consequently, this project developed a microplastic detection system utilizing Surface-Enhanced Fluorescence (SEF) combined with image processing techniques. Silver nanoparticles (AgNPs) were employed to enhance the fluorescence signal of Rhodamine B solution, thereby increasing detection sensitivity. The detection system was designed as a closed unit to minimize ambient light interference, equipped with a webcam and internal UV LED lighting to stimulate fluorescence. Experiments were conducted to determine the optimal conditions by varying the Rhodamine B concentration between 10^{-5} to 10^{-3} M and adjusting the ratio of silver nanoparticles to Rhodamine B solution from 1:1 to 3:1. The results indicated that the most effective condition was Rhodamine B at a concentration of 10^{-3} M mixed with silver nanoparticles at a 2:1 ratio. This yielded the highest absorbance value of 1.85±0.01 AU, which correlated directly with the most distinct fluorescence signal, enabling the system to effectively differentiate microplastics from the background solution. Upon testing the image processing system with 5000 sample images of microplastics at concentrations of 1–10 ppm, a coefficient of determination of 0.94 was observed. This developed system facilitates a more convenient and rapid microplastic detection process, addressing the demand for effective monitoring in various environments and mitigating the current issue of discontinuous environmental surveillance.

Keywords: Microplastics; Rhodamine B; Silver Nanoparticles; Surface-Enhanced Fluorescence (SEF)