Executive Summary

Next-Generation High Throughput Plasmonic Nanotweezers for Nanoplastics Analysis

The contamination of the environment by plastic waste has become a pressing global challenge, with an alarming projection that there will be more plastics in the ocean than fishes by 2050. Understanding the properties and potential health impacts of plastic nanomaterials, specifically nanoplastics (1 nm to 100 nm), is crucial. However, analyzing nanoplastics remains a significant challenge due to their small size. Current analytical tools are limited, hindering our comprehensive understanding of nanoplastic exposure and its consequences.
To address this critical need, this research project aims to develop a groundbreaking technology for the rapid characterization of nanoplastics with single-particle resolution. We propose a high throughput plasmonic nanotweezers approach, merging plasmon-nano-optics and microfluidics, to enable stable trapping and enhanced Raman spectroscopy of individual nanoplastic particles.

Our research objectives are to develop plasmonic optical nanotweezers for high throughput nano-optical trapping (within seconds) and enhanced Raman spectroscopy of single nanoplastics. By controlling the nanogap spacing of the central plasmonic cavities, we will stably trap and analyze a wide range of nanoplastic sizes, from 5 nm to 100 nm.
We will also utilize engineered and natural nanoplastics to experimentally validate the technology's ability to trap and perform enhanced Raman nanoplastics at various concentrations. By analyzing the enhanced Raman signals, we will determine the chemical composition of trapped nanoplastics.

The completion of this research will yield a transformative technology that overcomes the limitations of conventional optical tweezers and current nanoplastic analysis methods. It will allow for rapid and precise characterization of nanoplastics, enabling more comprehensive assessments of nanoplastic pollution levels and potential impacts on ecosystems and human health. The research findings will be shared through scientific publications in leading journals and conferences, facilitating knowledge dissemination, and encouraging the adoption of this technology by other researchers. Moreover, the technology will help offer new insights into nanoplastic degradation and breakdown processes, contributing to effective strategies and policies to combat plastic contamination.

The potential impacts of this research are significant, and they include:
Environmental monitoring: The technology could be adapted to detect nanoplastics at extremely low concentrations, making it ideal for identifying leaching from infant plastic feeding bottles and evaluating suitable materials. It will aid in assessing nanoplastic pollution in water bodies, and air, supporting targeted cleanup efforts.
Industry motivation: The accurate measurement of nanoplastic pollution will incentivize industries to develop sustainable alternatives, fostering innovation in eco-friendly materials and packaging solutions.
Ecological consequences: The high-throughput detection technology can help assess the ecological impact of nanoplastic pollution, helping conservationists and biologists design appropriate conservation strategies.
In conclusion, our research project holds significant promise for advancing nanoplastic analysis, addressing an important timely grand challenge, and contributing significantly to global efforts to combat plastic pollution and safeguard the health of our planet and its inhabitants.