Serially diluting centrifugal microfluidics for high-throughput synthesis of various shape of gold nanoparticles

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Microfluidic technology has been extensively explored for the application in the chemical synthesis of high-quality nanomaterials with high uniformity and precision that cannot be achieved using bulk-phase synthetic methods. Microfluidic devices are designed to manipulate fluids in microscale channels, microtubes, micro-interfaces, and microreactors, and narrow channel dimension provides a high surface-to-volume ratio, and fast heat and mass transfer [1-3]. In this study, we propose a fully integrated and automated centrifugal microfluidic system, which consists of a novel serially diluting centrifugal microfluidic device and a portable workstation for automated solution delivery. Our research goal is to synthesize various shapes of Au NPs by controlling the concentration of AA and search for the best morphology of the Au substrate for the SERS application. To this end, we designed a centrifugal microdevice equipped with 60 microreactors, using which 60 aliquots of the reagent solution could be prepared by combining the zigzag aliquoting microchannel and centrifugal force. To tune the concentration of the control solution (namely, AA), we developed the serially diluting microchannels by pairing the AA solution-loaded microchannel with a water-loaded microchannel, and gradually varying the depths of the two microchannels in reverse. Each of the four solutions including the Au seed solution, the growth solution, the AA solution, and water was loaded into the centrifugal microdevice by a single shot owing to the zigzag aliquoting microchannel, and after the programmed centrifugation process, 60 different synthetic mixtures were obtained in the microreactors in 30 min. Flask-based synthetic methods would require 240 manual pipetting steps and a large amount of disposable consumables to perform the same reaction procedure, so the HTP centrifugal microfluidic system saves time, labor, and cost, and eliminates contamination issues. We also constructed a portable workstation that stores the solution and automates the uptake of the target solution and the delivery of the reagent solution to the centrifugal microdevice. Therefore, in order to produce 60 different Au NPs, only one manual thing is to install the required reagent solutions, and the downstream processes such as the designated solution injection, concentration gradient of the control solution, and the division of the reagents into 60 aliquots, and synthetic reaction can be proceeded performed automatically.

References

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