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# Fabrication of gold nanoparticles by femtosecond laser irradiation of aqueous solution in flow system

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In recent decades, metal nanoparticles (NPs) are getting interests in modern advanced material science due to their superiority of physical, chemical and biological properties, and a large potential of application prospects. However, the limitation in purity and particle size restrict its applications. Femtosecond laser irradiation is one of novel tecniques for synthesizing metal NPs and can be a solution to overcome aforementioned limitation. Metal and alloy NPs are able to be synthesized directly by applying highly-intensed laser irradiation of metal salt solution. The laser energy at the focal spot is enough to decompose water molecules producing in-situ solvated electrons and radicals to reduce metal ions simultaneously. This method is one of green routes because it does not need reducing agents to produce metal NPs. In addition, this approach has a possibility not only to fabricate pure metal NPs but also alloy NPs with tunable compositions in both aquous and organic solutions. In this work, we performed larger scale production of metal NPs using femtosecond laser irradiation of flowing aqueous solution.

Gold aqueous solution was prepared at the concentration of 2.5 x $10^{-4}$ M.  30 mL of the solution was placed in a small reservoir. By using a pristaltic-Masterflex pump and masterflex tubing, the solution was circulated in a flowing quartz glass cuvett for 2 hours. During that time, femtosecond laser pulses with the maximum energy of 5.4 mJ and the repetition rate of 100 Hz were focused in the flow-type glass cuvette perpendicularly to the side-wall. Real time measurement was also conducted to obtain absorbance spectra of the solution during the process of gold NPs synthesis by using a fiber-coupled spectrometer. Figue 1 shows a schematic diagram of the experimental setup and TEM pictures of the fabricated gold NPs in the flowing system The fabricated NPs having the average size between 4-10nm, meanwhile the laser irradiation in the flow aqueous solution improved the efficiency of gold NPs fabrication by 39 % compared to the stationary system using the same volume of the gold aqueous solution.

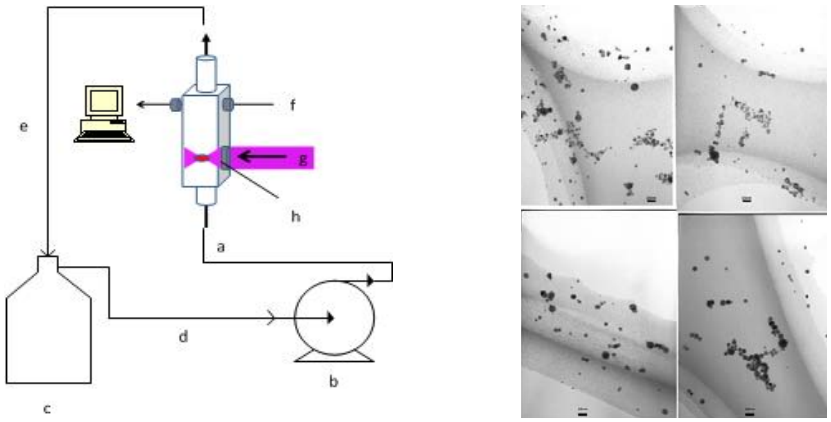


Figure 1. Schematic  diagram of the experimental setup (left), (a) flow quarzt-glass cuvette, (b) pristaltic Masterflex pump, (c) solution container, (d, e) Masterflex tubing, (f)real time absorption measurement, (g) femtosecond laser pulses, and (h) focusing lens.  TEM images of the fabricated gold nanoparticles by the flow system (right).