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Optimization of Activation Process for Application of Silver Nanoparticles in SERS

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Extended Abstract

Raman spectroscopy represents a useful analytical method for identification of many types of molecules which is unlike infrared spectroscopy applicable also for studying of aqueous systems. Unfortunately, the low sensitivity of this spectroscopic method represents big complication in analysis of diluted samples, mainly in the case of biomolecules analysis. However, the Raman signal can be significantly enhanced by the adsorption of the molecules on the curved metallic surface – Surface Enhanced Raman Spectroscopy (SERS). The enhancement could be in this case so high that only one molecule adsorbed on the metallic surface could be detected. However, the level of enhancement is strongly dependent on the particle size or degree of particles aggregation if metal nanoparticles are used as substrate for SERS. Additionally, the surface properties of the used metal nanoparticles play an important role in the activation process as is demonstrated in the presented study.

The efficiency of both activation methods (aggregation and recrystallization) have been studied using four types of the silver nanoparticles (AgNPs) prepared using different chemical reduction processes. Along to the AgNPs colloids prepared by the classical borohydride and citrate methods two other colloids prepared by modified Tollens process with maltose and glucose as reducing agents were tested. Aggregation of the AgNPs dispersions was induced by addition of small amount of NaCl to obtain final concentration of 10 mM; recrystallization was going in the solution with final concentration of NaCl at value of 400 mM. After activation process the Raman spectra were measured using adenine as probe molecule. In the case of aggregation activation all tested dispersions were efficient in Raman signal enhancement. The highest enhancement (about $7 \cdot 10^4$) was observed in the case of the AgNPs prepared by borohydride method. Enhancement factors obtained with the other dispersions were comparable and their values were less than half the value obtained with borohydride AgNPs. In the case of recrystallization activation procedure the citrate prepared AgNPs wasn't active in SERS. The highest enhancement was obtained with AgNPs prepared by the modified Tollens process with glucose as reducing agent. The observed enhancement factor was about 2.5•105 and it was stable for about 15 minutes after starting of activation process. In the case of borohydride prepared AgNPs the obtained enhancement factor was lower in comparison with aggregation procedure and the system wasn't stable. The obtained results confirmed the efficiency of the activation process based on the recrystallization of the AgNPs but revealed that this activation procedure isn't suitable for AgNPs prepared by the classical reduction methods.

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