

Surfactant effect on nanoparticle formation by biphotonic reduction of silver ions in aqueous solution

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論文内容要旨

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論文內容要旨

Working on nanomaterials has been a hot topic for researches. It has been a crucial interest for researcher to develop an environmental friendly and simple route to synthesize them. In this study, we synthesized silver nanoparticles using ns laser light and discussed the effect of additives on synthesized photo-product.

In chapter 1, general aspects, various methods along with additives are overviewed and

then the objective of the thesis is described. In chapter 2, experimental procedure and characteristic techniques are discussed in detail.

In chapter 3, I attempted to fabricate silver nanoparticles without using additives and observed the effect of laser irradiation time and intensity on the photo-product. Silver nanocubes were fabricated and discussed the growth process in detail. Log-log plot results gave an idea, initially the process was biphotonic and later turns into single photon; however, it was complicated to explain well. The comparison between CW and UV pulsed light confirmed that silver nanocubes increased their size by single photon absorption of photo-product present in the solution.

In chapter 4, silver nanoparticles were fabricated in the presence of SDS and discussed the concentration effect on nanoparticles. Silver nanospheres were fabricated successfully which had 14 nm sizes. Various concentrations of SDS were used to discuss the effect on growth process. It was noticed that there is a lowest limit of SDS above that nanoparticles start to grow significantly. We call this lowest limit of SDS concentration as a critical growing concentration (CGC). It should be explained with the interaction between silver NS surfaces and SDS molecules as already pointed out that SDS molecules form two-dimensional aggregates (hemi-micelles) at a water and alumina interface even with a low SDS concentration.

In chapter 5, I attempted to know the individual role of each additive. It was noticed that hydrocarbon chains of molecules play an important role in growth process. Long chain hydrocarbon molecules are more effective to fabricate small sized nanoparticles; whereas small chain hydrocarbon molecules showed the opposite results. It was also confirmed that molecules with more than 10 hydrocarbon chain had CGC. This method clearly revealed the role of additives as light solely worked as a reducing agent.

In chapter 6, I attempted to change the silver salt precursor with silver acetate and discussed the effects of stabilizing agents CTAB and SDS in terms of their morphology and size distribution. It was observed that mono-dispersed silver particles had an average size diameter of spheres was 80 nm, 121 nm for SDS and CTAB, respectively.

論文審査の結果の要旨

Umair Yaqub Qazi 提出の論文は、各種の界面活性剤を含む銀塩水溶液に 355 nm のパルス光を照射することにより、生成する銀ナノ粒子の形、大きさ、成長過程について紫外可視吸収スペクトル測定、走査型電子顕微鏡 (SEM) 観測、動的光散乱 (DLS) 測定により調べたものである。特に、低濃度の界面活性剤が、ナノ粒子の生成過程に及ぼす効果を見出した意義は大きい。

銀塩としては硝酸銀および酢酸銀が用いられているが、どちらも励起波長である 355 nm の吸収が極めて小さく、さらに硝酸銀を用いた時には一定時間後に生成する銀ナノ粒子の吸光度が励起光強度の 2 乗に比例することから、ナノ粒子生成の初期過程は水の二光子吸収によって生成した溶媒和電子に起因するものと考えられた。このように化学的還元剤を使わない生成法を用いることにより、添加する界面活性剤の効果を詳細に調べることが可能となった。この結果、界面活性剤を全く含まない硝酸銀水溶液では立方体状のナノ粒子が生成すること、長鎖アルキル基を有する陰イオン性界面活性剤を比較的高濃度に含む水溶液では球形が生成すること、ある種の界面活性剤を用いると星型など特異な形のナノ粒子が生成することなど、数々の新たな知見が得られた。

界面活性剤としてドデシル硫酸ナトリウム (SDS) を用いた場合には、臨界ミセル濃度 (CMC) の 10 分の 1 程度の濃度でも立方体の成長は抑制され、生成物は球形になることが見出された。この結果を説明するため、界面活性剤の集合体が型枠として働くよりは、むしろナノ粒子表面への界面活性剤の吸着がナノ粒子の形状を制御するというモデルが妥当とされた。このような考察は、二光子還元法を用いることにより始めて可能となったものである。

これらの研究結果は、本人が自立して研究を行うのに必要な能力と学識を有することを示している。したがって、Umair Yaqub Qazi 提出の論文は博士 (理学) の学位論文として合格と認める。