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Size Dependent Plasmonics of Chemically Grown Silver Nanoparticles

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ABSTRACT
Research on silver nanoparticles (Ag NPs) bases plasmonics is strong interest due to diverse applications within the fields of nanophotonics, biosensing and different branches of science. Here, we investigate the size dependent surface Plasmon resonance (SPR) peak of Ag NPs. In this study we synthesized different size Silver nanoparticles (Ag NPs) under different growth condition. We characterized them by UV-VIS spectroscopy and TEM analysis. The surface Plasmon resonance peaks of the Ag NPs are different for different Ag NPs and the solution color depends on the size of the Ag NPs. We observe four different color for four different sizes Ag NPs. The size of the nanoparticles is measured by TEM measurements.

***Keywords*:** Plasmonics; Silver nanoparticles; Absorption Spectrum; Visible Color; TEM

1. Introduction

Plasmonics is speedily gaining importance at intervals in the scientific and engineering analysis communities. Sweetening of the optical response of nanometric metallic systems because of their surface plasmon resonances has raised massive elementary and technological interest throughout the past decade [10-11]. Such sweetening is associated to the collective resonant electron oscillation driven by an external electromagnetic field, whose manipulation and management has led to the sphere of plasmonics. The surface plasmon band arises from the coherent existence of free electrons in the conduction band due to the little particle size [12]. This surface Plasmon resonance (SPR) absorption arises in UV-VIS region for Ag nanoparticles. This skillfulness offers a massive potential for applications such as sensing, imaging, native heating for thermal treatment, increased Raman scattering, or a lot of typically manipulation of sunshine at nanoscale [1,16]. The band shift of SPR depends on the particle size, chemical close, absorbable species on the surface, and insulator (dielectric) constant. A singular characteristic of those synthesized metal particles is that a modification within the absorbance or wavelength depends on the particle size, shape, and interparticle properties [15].Among the assorted metal nanoparticles, metallic (noble metal) element nanoparticles (Ag, Au) have attracted abundant attention, because of their glorious physical and chemical properties. Silver is FCC in phase in part below nano dimension with well crystalline in nature [6]. The silver nanoparticle (AgNP) includes a large applications in technological and in medical sectors. Nowadays, tons of researches are focused on Ag nanoparticles owing to their vital scientific and technological applications in color filters [21], optical switching, optical sensors, and particularly in surface increased Raman scattering [13]. Such properties and applications powerfully rely on the morphology, crystal structure, and dimensions of silver nanostructures. It is used wide in health, surroundings still as food and cosmetics business. Silver-nanoparticles (AgNPs) area unit utilized in cancer medical specialty, cell imaging. They're used for catalysis, transport, sensing as well as medicine and biomedical applications [9]. Ag NP is extremely effective in killing a good vary of bacteria. Silver nanoparticle primarily based gels area unit used for treating burns, gastrointrentis and infectious diseases like syphilis and gonorrhea [14,20]. Besides, functionalized, biocompatible and inert nanostructures have future applications in cancer diagnosis and medical care [20]. The target delivery of anticancer drugs has been done victimisation nanomaterials [20].

1.1. Surface plasmon resonance (SPR) of silver nanoparticles (Ag NPs)

A quantum of collective electron oscillation in a very metal, thought-about as a quantum and analogous to oscillations of a plasma consisting of stationary positive ions and a gas of electrons. Plasmons square measure the collective oscillation of the free charge (electrons) in a very conducting material (Figure 1) that confined to the surfaces of the materials and move powerfully with light [2]. Irradiating metal nanoparticles (Ag NPs, Au NPs) with light at their plasmon frequency generates intense electrical fields at the surface of the nanoparticles. This resonance will be tuned by variable the NPs size, close stuff, shape, and proximity to alternative nanoparticles [2]. Plasmonics could be a quickly developing field at the boundary of physical optics and condensed matter physics. It studies phenomena evoked by and related to surface plasmons—elementary polar excitations sure to surfaces and interfaces of fine nanostructure metals. Plasmonics takes advantage of the coupling of light to charges like electrons in metals, and permits breaking the optical phenomenon limit for the localization of light into sub wavelength dimensions sanctionative sturdy field enhancements. The sturdy interplay of the silver nanoparticles with light happens because the conduction electrons on the metal surface undergo a collective oscillation when excited through light at particular wavelengths. Known as a Surface Plasmon Resonance (SPR), this oscillation effects in unusually robust scattering and absorption residences. A unique belonging of round silver nanoparticles is this SPR peak wavelength may be tuned within broad optical seen variety by means of changing the particle length and the neighborhood refractive index near the particle floor. Even large shifts of the SPR height wavelength out into the infrared location of the electromagnetic spectrum may be done by means of generating silver nanoparticles with rod or plate shapes. This paper describes the change in the SPR spectrum of Ag NPs with different color of the Ag NPs solution. Size variation of Ag NPs and SPR is the key of this study.

2. Experimental

2.1. Grown of Ag NPs

The silver nanoparticles are grown by simple chemical method. We used sodium borohydride ($NaBH_4$, 99.9%) as a reducing agent for reduction of Ag from $AgNO_3$ solution. $NaBH_4$ solution (30 mM, 10 ml)) was added drop wise into 20mL of $AgNO_3$

solution (40 mM) that had been chilled in an ice bath. The reaction mixture was stirred vigorously by a magnetic stirrer. The solution turned light yellow after the addition of 1mL of $NaBH_4$, and a yellow when all of the $NaBH_4$ was added. The entire addition took ~30min, after which the stirring was stopped. After 30 min reaction time the solution color is yellow brownish. The colloidal silver was stable at room temperature and was stored in a transparent vial. Similarly three different colloidal silver was prepared by changing the reaction time. The reaction times are 40 min, 60 min and 90 min for other three Ag NPs colloidal solutions. The color of the 40 min reaction Ag NPs colloid is deep yellow brownish. The color of the 60 min and 90 min reaction colloid solutions are yellow and faint yellow respectively.

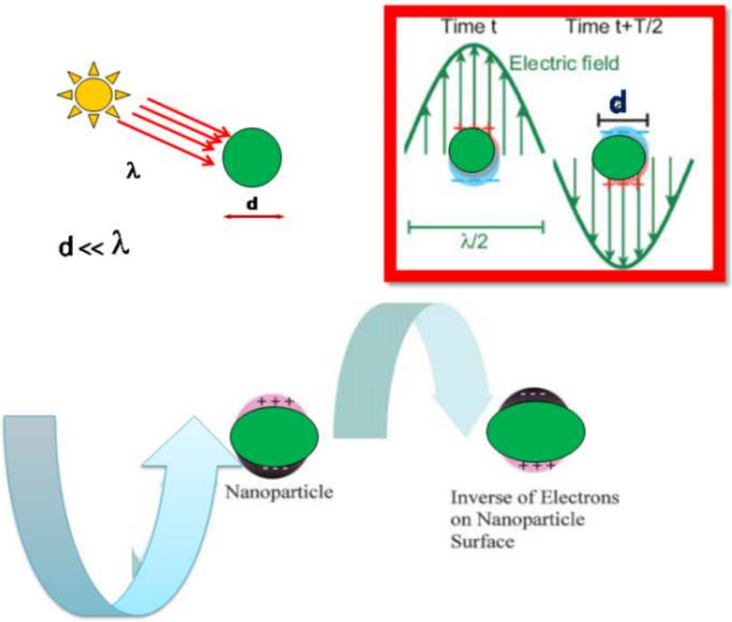

Figure 1: Illustrates the formation and propagation of localized surface plasmons.

2.2. Measurements

The optical absorption spectra of the above mentioned as-prepared samples were recorded in a ShimadzuPharmaspec-1700 UV–VIS spectrophotometer with optical wavelength 200 nm to 900 nm [8,5]. For microstructural study, a small drop of Ag NPs colloidal solution was placed on a thin carbon film supported on a copper grid and kept for some time for drying. The transmission electron micrograph (TEM) of the prepared Ag NPs was acquired using a JEOL-JEM-200operating at 200kV [7,3-4,18].

3. Results and discussion

3.1. Absorption spectroscopy

The absorption spectrum of the synthesized different Ag NPs colloids shows a surface plasmon absorption peak at different positions. The Ag NPs colloid synthesized at the reaction time of 40 min shows a peak at ~381 nm (figure 2(a)). The Ag NPs colloid synthesized at the reaction time of 30 min shows a peak at ~385 nm (figure 2(b)). The Ag NPs colloid synthesized at the reaction time of 60 min and 90 min shows a peak at ~412 nm and ~409 nm respectively (figure 2(c) and 2(d) respectively) [19].

3.2. Color effect

The color of the 30 min reaction colloidal solution is yellow brownish (Fig 3(b)). The color of the 40 min reaction Ag NPs colloid is deep yellow brownish (Fig 3(a)). The color of the 60 min and 90 min reaction colloid solutions are yellow and faint yellow respectively (Fig. 3(c) and Fig. 3(d) respectively) [17]. The different color is mainly due to different size Ag NPs colloidal plasmonically generated colors, which are unique in that the optical properties of metal nanoparticles can be tuned by changing size, shape.

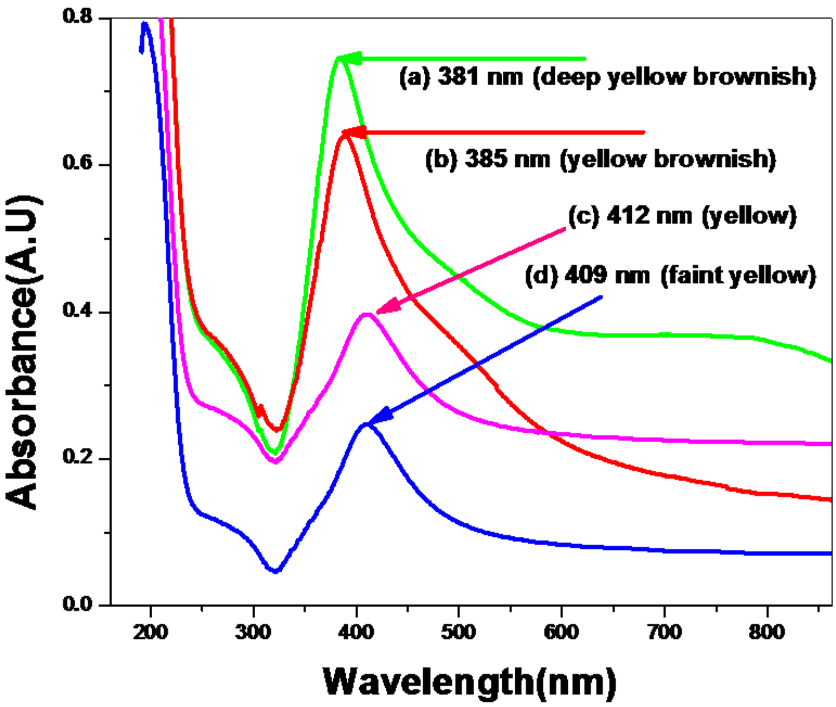

Figure 2: UV-VIS absorption spectra of Ag NPs colloid solutions prepared with reaction time (a) 40 min, (b) 30 min, (c) 60 min,(d)90 min .

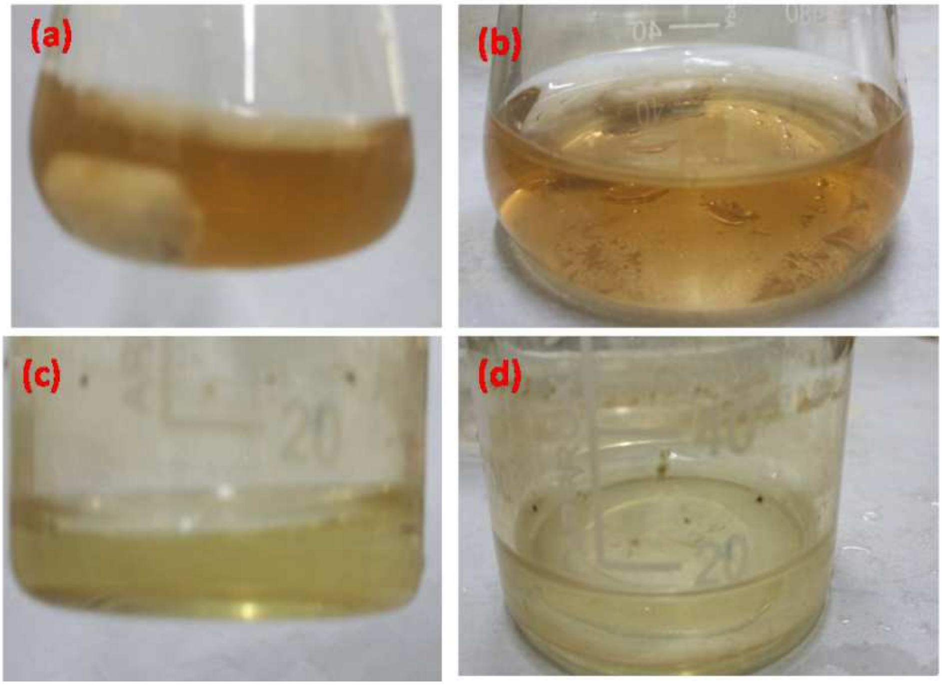

Figure 3: The color of the (a) 40 min reaction Ag NPs colloid (b) 30 min reaction Ag NPs colloid,(c) The color of the 60 min and (d) 90 min reaction colloid solutions.

3.3. TEM analysis

The TEM analysis easily indicated the size of the synthesized Ag NPs. It is clear (Figure 4) that the average size of the 40 min reaction Ag NPs is 7 nm and 30 min reaction Ag NPs is 10 nm. The average size of the 60 min reaction and 90 min reaction Ag NPs are 16 nm and 20 nm respectively. All the silver nanoparticles are almost spherical nature.

Table 1: Characteristic parameters

Name	Average Size	Plasmonic peak	Color
Ag NPs	7 nm	at 381 nm	Deep yellow-brownish
Ag NPs	10 nm	at 385 nnm	Yellow brownish
Ag NPs	16 nm	at 409 nm	Faint yellow
Ag NPs	20 nm	at 412 nm	Yellow

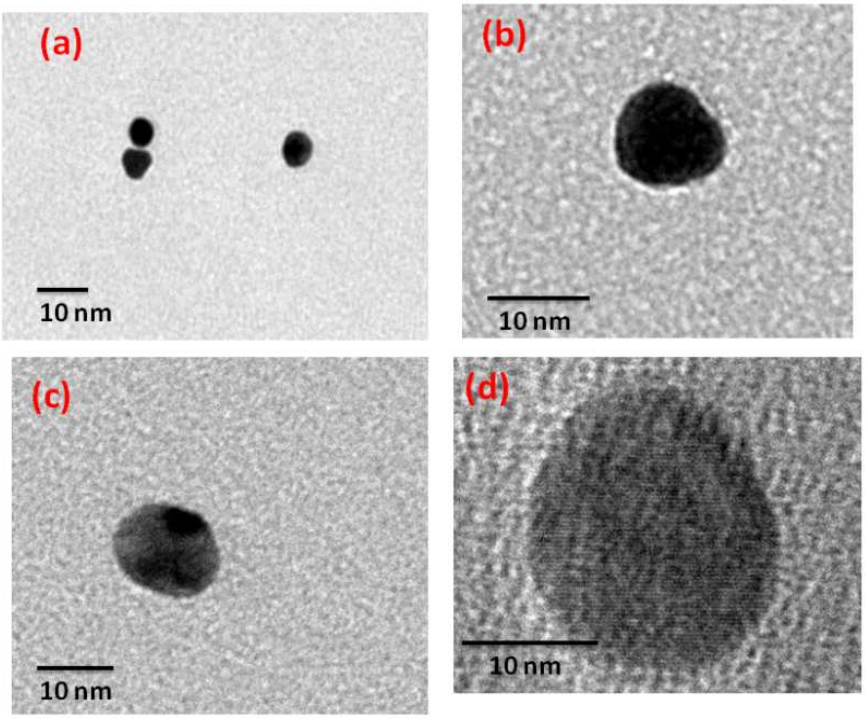

Figure 4: TEM images of the (a) 40 min reaction Ag NPs, (b) 30 min reaction Ag NPs ,(c) 60 min reaction Ag NPs, (d) 90 min reaction Ag NPs .

4. Conclusion

The size variation tunes the Localized surface plasmon resonance (LSPR) and the color of the Ag NPs. Our results are important for size tuning Plasmon based bio-sensing and surface-enhanced Raman scattering (SERS). This study is important for the field of interaction of light with metallic nanostructure particularly in biomedical and Bio-phonics including quantum optics.

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