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Morphology and Optical properties of (Fe-Cd) core-shell by Laser Ablation in Ethanol

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Abstract : Laser ablation in liquid has become a more important technique for the preparation of NPs. This paper report a new study on the generation of (Fe @ Cd) core-shell NPs by ablation of metal targets in aqueous environment by Q-switch Nd-YAG laser (λ=1064 nm) immersed in ethanol .Solution of NPs is found a stable in the colloidal shape for a long time. The Surface topography studied by Transmission Electron Microscopy TEM, and shape were measured by using Scanning Electron Microscope SEM, shows spherical shape , UV-Visible spectroscopy has been employed for the optical properties measurements. The absorption coefficient, refractive index and extinction index was studied. The results showed absorption of cadmium pushed towards the highest wavelengths (red shift) where any SPR pushed to (274nm) due to the effect of cadmium shell (Cd shell), which dominates on the effect of the core (Fe core). Spherical colloidal nanoparticles had showed with size less than (10nm).
Keywords: Morphology and Optical properties, Fe-Cd, core-shell, Laser Ablation.

Introduction

The development of new materials is an essential point of convergence of synthetic examination, and this consideration is ordered by headway in fields of industry and innovation. A decent case of the synergism between experimental recognition and specialized change is the gadgets producing, where disclosures of novel semiconductor materials brought about the advancement from vacuum tubes to diodes and transistors, lastly to small scale chips. The advancement of this innovation prompted the change of littler slight and littler slight electronic components, resultant in chips with a higher power of hardware and increment registering capacity. The volume of these electronic circuits and attractive dedication components is drawing nearer nanometer measurement, and as this field is entered, researchers have find that qualities of materials with nanometer measurements can transform from those of the mass material[1]. Nanoscale core-shell structures have a significant attention lately because; their physical and chemical characteristics can be tuned by controlling their chemical structure and the proportional sizes of the core and shell[2].

The solid exploration in the field of nanoparticle by scientific experts, physicists, and materials researchers is spur by the quest for novel materials keeping in mind the end goal to included scale down electronic gadget and additionally by the essential inquiry of how sub-atomic electronic attributes create with expanding size in this middle of the road area amongst sub-atomic and strong state physical science[3-9]. Probable outlook application consist of the areas of ultra fast data communication and optical data storage[6-8].Semiconductor nanoparticles are also used in building solar cells and metal nanoparticles are very important as catalysts because of their high surface-to-volume ratios[9].

Mie was the first to explain this wonder by apply traditional electrodynamics to spherical particles and understand Maxwell's condition for the reasonable limit conditions[10]. The aggregate deactivation cross part made out of ingestion and scrambling is given as a gathering through all electric and attractive various motions. The Mie hypothesis has the benefit of being hypothetically straightforward and has discovered wide application in clarifying test results[11-14]. Anyway, the majority of the material attributes are speak to by a mind boggling dielectric capacity of the absorbance metal nanoparticle along these lines darkening someway the essential tiny procedures, for example, the conceivable rot components of the strong movement of the free electrons.

The control of the size division is not extremely successful through nanoparticle framing when the metal salt decline strategy is utilized. However, this is possibly the most extensively utilized method however it doesn't deliver an exceptionally limit assignment. Ensuing size division procedure is along these lines required[15]. The search for a suitable method to narrow the size distribution for disperse aquatic solution of nanoparticle is thus required and newly laser irradiation has been propose with the report of both size reduction and shape changes of metal particles in solution[16-19]. Nevertheless, the physical mechanisms at work have not been fully elucidated although melting, photo ejection of electrons and fragmentation have been observed depending on the laser irradiation conditions Nucleation is an essential marvel that has numerous applications in science and innovation. It assumes an essential part in air and also in material sciences[20-21]. Nucleation is a first order phase transition process that can take place in vapor, liquid or solid phase. Generally, the nucleation process can be divided into two main types. The least complex and most studied is homogeneous nucleation, in which unconstrained decay of a supersaturated vapor happens by warm vacillations through the arrangement of cores or embryonic beads in the fluid phase[20-21]. In the homogeneous nucleation, the nuclei comprise of the same particles as in the consolidating vapor. In other words, homogeneous nucleation takes place in the absence of any foreign particles, surfaces, or ions. The other type of nucleation is the heterogeneous process that occurs on pre-existing surfaces, foreign particles, or ions. The homogeneous nucleation process from vapor to liquid phase has been extensively studied, both experimentally and theoretically[22,23] for different compounds. This is because of measuring techniques and theoretical models have been developed rapidly.

Metal colloids are well-known for their surface plasmon resonance (SPR) properties, which originate from collective oscillation of their conduction electrons in reaction to optical excitation[24-27]. The SPR frequency of a particular metal colloid sample is different from that of the corresponding metal film and has been shown to depend on particle size[28-30], shape and dielectric properties[31], aggregate morphology[32], surface modification , and refractive index of the surrounding medium[33]. The fabrication of nanostructures requires a deep understanding of the physical phenomena involved at this length – level. Low - dimension quantum structure have exposed to have individual optical and electronic characterization. In particular, the form and size of low - dimension structure are crucial parameter that determine those physical characterization. The properties of this parameter are significant number either in basic research or in technical application, cover from expansion and characterization to device processing. Among nanostructures, metallic nanoparticles are as well significant because some of their major physical characterization may be totally various from the correspond ones in either molecule or bulk solids. For example, they force suppose crystal structure that do not corresponding to those of the bulk solid[34-35]. Also, the catalytic action of a little of them depended stoutly on their size and shape. Laser ablation has shown itself as one of the most efficient physical methods for nanofabrication. The method consists in the ablation of a target (mostly solid) by an intense laser radiation, yielding to an ejection of its constituents and to the formation of nanoclusters and nanostructures[36]. The technique of pulse laser ablation in liquid PLAL has many distinct advantages[37]. These include (i) a chemically ‘simple and clean’ synthesis, the final product is usually obtained without by products and no need for further refining: (ii) low charge of experimental system and readily controlled parameter: (iii) the extreme confined condition and induced high temperature, high pressure region favoritism the shape of strange meta stable phase[38], in addition to a series of chemical reactions between solvent and solid target, and among their ions[39].

Experimental Work

Figure 1 shows the experimental settings for the Laser ablation of metal target immersed in ethanol solution to produced colloidal nanoparticles , the system consists of a laser source (Nd: YAG) laser system type (HUAFEI), wavelength (1064nm) that have been used for laser ablation.

Laser (Q-switch Nd: YAG) have maximum energy (1000mJ) per pulse, the pulse width (7ns) and the rate of recurrence (6Hz), the laser beam diameter (2mm) that has been used to laser ablation as shown in Figure (2).The absorption spectra of the colloidal solutions was measured using UV-Visible spectrophotometer, NPs size and surface morphology where examined using TEM, while the shape of NPs examined by SEM.

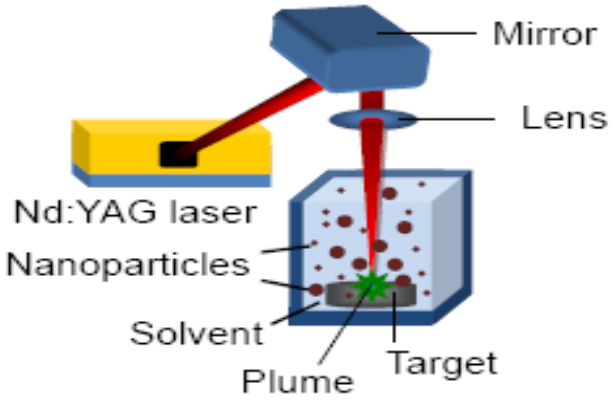


Fig.(1): Experimental set-up for colloid preparation by laser ablation.

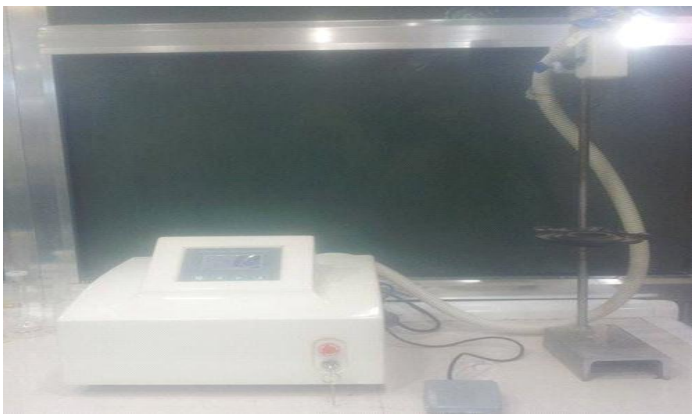
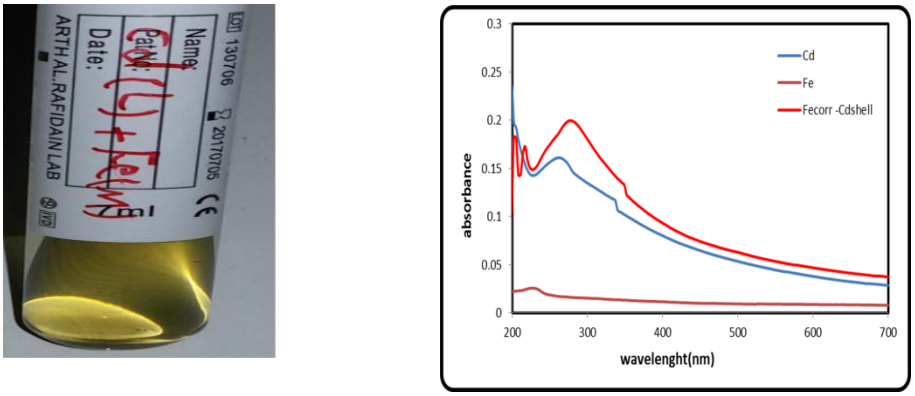


Figure (2) : (Q-Switch Nd:YAG) system

Results and Discussion

(Fe_{core} –Cd_{shell}) Nanoparticles collide have been synthesized by laser ablation of pure metal iron plate submerged into ethanol solution. These plates were irradiating with laser pulses emitted by an IR high-power nanosecond laser system equipped. Then irradiating Cd plate submerged into Fe nanoparticles collide solution by laser Nd: YAG at a wavelength (1064nm) and the rate of recurrence is (6Hz).

The resulting solution Nano scale (Fe_{core} –Cd_{shell}), its bright yellow color due to the fluctuation of electrons free delivery caused by the interaction of electromagnetic field and this is what is called (SPR). The formation of nanoparticles (core-shell) is an important in the classification structures of nanoparticles as the outer shell (shell) determines the properties of the surface of the particles, while core is responsible for the optical and magnetic properties of the system and this agreement with[40-42].



Fig(3): a) Absorbance spectra for NPS of (Cd, Fe, Fe core - Cd shell), in ethanol, when using the wavelength (λ = 1064 nm). b) Colloidal solution photograph.

Figure (3) shows the absorbance spectra of each of collide NPs (Fecore-Cdshell, Fe, Cd) with SPR peaks (274, 220, 256) nm respectively. Since the peak of (Fe core-Cd shell) containing NPs of pure iron and cadmium. Notes that the absorption peak of cadmium is (256nm), But when it produces in the form of (core-shell) pushed towards high wavelengths (red shift) which means that the peak of SPR will be pushed to the (274nm) due to the effect of the cadmium shell (Cd shell), which dominates the effect of the shell (Cd shell) and has been interpreted due to dampening of core, i.e. Fe SPR by Cd. The formation of Fe @ Cd leads to the disappearance of SPR peak of Fe and Cd nanoparticles and appearance new peak relates to Core –shell formation at 274 nm. Since the atomic size of Fe is dissimilar to that of Cd, the inter diffusion between Fe atoms and Cd atoms is not easy and thus the surface layer of core stay don't oxidase rather than the pure Cadmium.

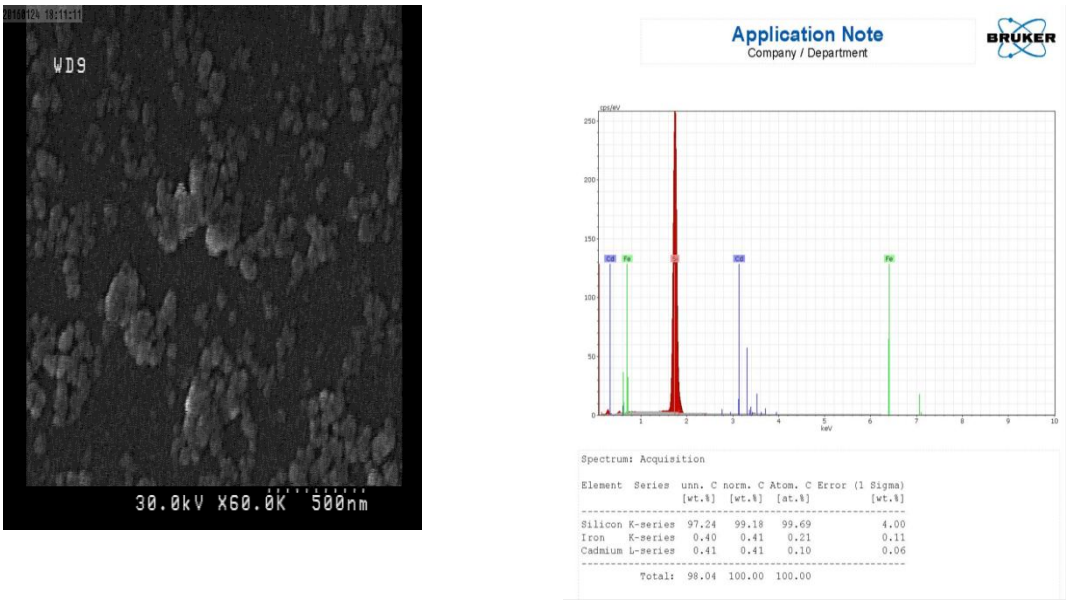


Fig. (4) Shows the image of SEM and EDX scheme of nanoparticles (Fe core - Cd shell) in ethanol and when using (λ = 1064 nm) and (f = 6 HZ).

Figure (4) shows the image of SEM and EDX scheme for the solution of colloidal nanoparticles (Fe core-Cd shell) with (1064nm) wavelength in ethanol solution as it shows EDX scheme purity nanoparticles of iron and cadmium particles.

We think that in our present UV–Vis study the decrease in Fe SPR intensity and the gradual red shift of SPR band is due to the damping of Fe SPR by the surface Cd atoms. This dampening of Iron SPR with increasing concentration of cadmium also confirms the formation of Fe @ Cd nanoparticles.

Figure (5) represent the TEM image and statistical distribution colloidal nanoparticles (Fe core-Cd shell) prepared in ethanol solution with ablation by basic wavelength (1064nm) Nd: YAG Laser and shows the SEM micrograph of Fe nanoparticles which are being used as core particle in the present core @ shell nanoparticle synthesis. Particles are mostly spherical in shape with an average diameter ~ 10 nm. The resolution of transmission electron microscopy images in Figs. (5) illustrate the formation of Fe@ Cd nanoparticles of different shell thickness. TEM images show the core, i.e. Iron particles with high density and the core is surrounded by the shell of Cd with thinner density. Similar to the observation of other research groups but for Au@Ag system.

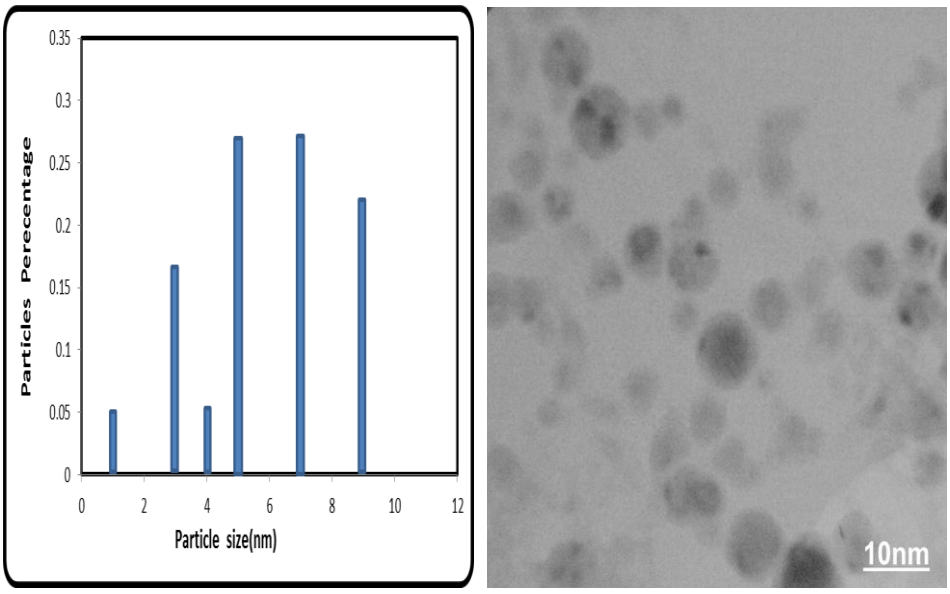
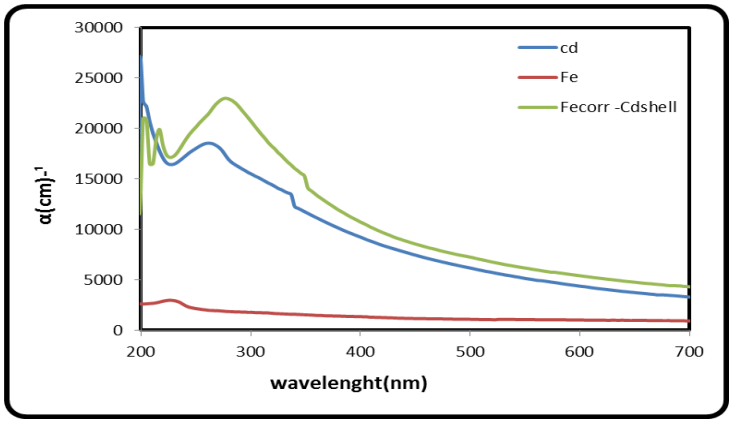


Fig. (5) TEM image and the statistical distribution of nanoparticles (Fe core - Cd shell) in ethanol and when using (λ = 1064 nm), (f = 6 HZ).

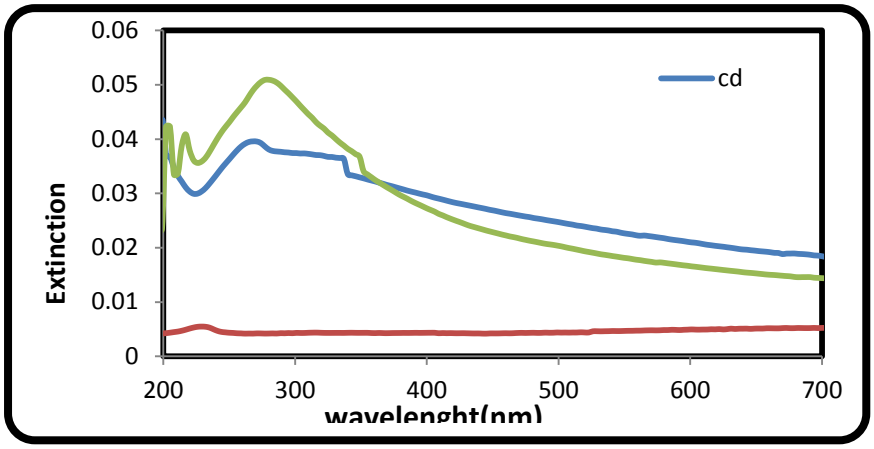
Figures (6)&(7) shows the relationship of the absorption coefficient and Extinction Coefficient as a function of wavelength respectively of the (Fe core - Cd shell) colloidal nanoparticles in ethanol solution with (1064nm) wavelength of Nd:YAG laser ,as it had been noted (red shift) due to the effect of cadmium shell which has the same behavior for Absorbance.

Figure (8) show the refraction coefficient as a function of wavelength of colloidal nanoparticles (Fe core - Cd shell) in ethanol solution.

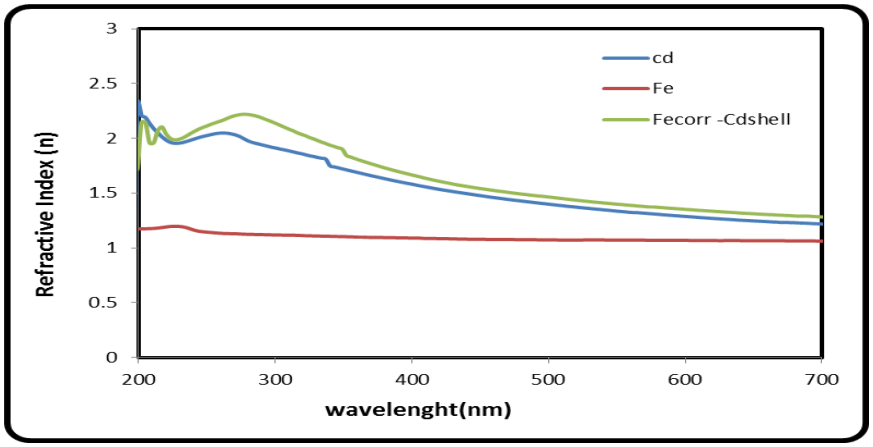


Fig(6): Shows the relationship between the absorption coefficient and the wavelength of the colloidal nanoparticles.

where it was noted that the reflectivity of the core-shell solution much higher than the reflectivity iron ,cadmium solutions respectively, because of the increased density of colloidal nanoparticles for core-shell and therefore increasing the refractive index ,which depends on the coefficient density t.



Fig(7) Shows the relationship between the Extinction coefficient and the wavelength of the colloidal nanoparticles



Fig(8) Shows the relationship between the refractive index and the wavelength of the colloidal nanoparticles.

Nanoparticles have SPR peak maximum due to the aggregate excitation of electrons which are coupled to the transverse electromagnetic field. The electron vibrate with respect to the positive ionic cores, and it is the surface polarization that provides a restoring force. Mie theory requests that the dielectric function of the particle and the embedding medium be restricted and specified. This theory is phenomenological in character since it provides no physical insight into material properties other than what is specified by the input dielectric function.

Conclusions:

In summary, this research has successfully produced spherical Fe@Cd NPs colloidal by using a simple method of nanosecond pulsed laser ablation in ethanol. Measurements UV-Visible showed that the SPR absorption of cadmium pushed towards the highest wavelengths (red shift) that any SPR peak will pushed into (274nm) due to the effect of cadmium shell (Cd shell), which dominates the effect of the shell (Cd_{shell}). Spherical colloidal nanoparticles as picture showed TEM be the shape and a size less than (10nm) with narrow statistical distribution. The refractive index of Core-shell is higher than of Fe and Cd alone.

Important feature of a useful synthetic procedure is that the particles should be stable, and it is desirable for processes such as bio functionalization, i.e. preparation should be carried out in aqueous environment.

References

1. Brian L. Cushing,* Vladimir L. Kolesnichenko, and Charles J. O'Connor. Recent Advances in the Liquid-Phase Syntheses of Inorganic Nanoparticles Chemical Reviews, Vol. 104, No. 9, 2004.
2. Yuping Bao, Hector Calderon, and Kannan M. Krishnan, Synthesis and Characterization of Magnetic-Optical Co-Au Core-Shell Nanoparticles.J. Phys. Chem. C, 111, 1941-1944 1941, 2007.
3. P.Mulvaney, M.Giersig, Henglein, A., Electrochemistry of Multilayer Colloids: Preparation and Absorption Spectrum of Gold-Coated Silver Particles,J. Phys. Chem. 1993, 97, 7061-7064.
4. Henglein, A., Small-particle research: physicochemical properties of extremely small colloidal metal and semiconductor particles, Chem. ReV. 1989, 89, 1861.
5. Alivisatos, A. P., Perspectives on the Physical Chemistry of Semiconductor Nanocrystals , J. Phys. Chem. 1996, 100, 13226.
6. Schmid, G. Clusters & Colloids: From Theory to Application; VCH: Weinheim 1994.
7. Kamat, P. V.; Meisel, D. Studies in Surface Science and Catalysis,Vol. 103; Semiconductor Nanoclusters - Physical, Chemical, and Catalytic Aspects; Elsevier: Amsterdam, 1997.
8. Edelstein, A. S.; Cammarata, R. C. Nanoparticles: Synthesis, Properties and Applications; Institute of Physics Publishing: Bristol, 1996.
9. Graetzel, M. In Electrochemistry in Colloids and Dispersions; Mackay, R. A., Texter, J., Eds.; VCH: Weinheim, 1992.
10. Mie, G., Beiträge zur Optik trüber Medien, speziell kolloidaler Metallösungen , Ann. Phys. 1908, 25, 377
11. Kreibig, U.; Vollmer, M. ,Optical Properties of Metal Clusters;Springer: Berlin, 1995.
12. Papavassiliou, G. C. Prog. Solid State Chem. 1980, 12, 185.
13. Creighton, J. A.; Eadon, D. G., Ultraviolet–visible absorption spectra of the colloidal metallic elements , J. Chem. Soc., Faraday Trans. 1991,87, 3881.
14. Mulvaney, Surface Plasmon Spectroscopy of Nanosized Metal Particles ,P. Langmuir 1996, 12, 788.
15. T. G. Schaaf, M. N. Shafigullin, J. T. Khoury, I. Vezmar, R. L. Whetten, W. G. Cullen and P. N. First, J. Phys. Chem. B, 1997, 101, 7885.
16. H. Fujiwara, S. Yanagida and P. V. Kamat, J. Phys. Chem. B, 1999, 103,2589.
17. A. Takami, H. Kurita and S. Koda, Isolation of Smaller Nanocrystal Au Molecules: Robust Quantum Effects in Optical Spectra, J. Phys. Chem. B, 1999, 103,1226.
18. P. V. Kamat, M. Flumiani and G. V. Hartland, J. Phys. Chem. B, Picosecond Dynamics of Silver Nanoclusters. Photoejection of Electrons and Fragmentation,1998,102, 3123.
19. S. Link, C. Burda, B. Nikoobakht and M. A. El-Sayed, Laser-Induced Shape Changes of Colloidal Gold Nanorods Using Femtosecond and Nanosecond Laser Pulses, J. Phys. Chem.B, 2000, 104, 6152.
20. Abraham, F. F. "Homogeneous Nucleation Theory" (Academic, New York, 1974).
21. Kashchiev, D. "Nucleation: Basic Theory with Applications" (Academic, New York, 1974).
22. Oxtoby, D. W. "Homogeneous nucleation: theory and experiment" J.Phys. Condens. Matter 1992, 4, 7627.
23. Laaksonen, A.; Talanquer, V.; Oxtoby, D. W. "Nucleation: Measurements, theory, and atmospheric applications" Annual Review of Physical Chemistry 1995, 46,489.
24. P.N. Prasad, Nanophotonics, Wiley-Interscience, New York, 2004.
25. H. Itoh, K. Naka, Y. Chujo, Synthesis of gold nanoparticles modified with ionic liquid based on the imidazolium cation, J. Am. Chem. Soc. 126 (2004)3026–3027.
26. S. Magdassi, A. Bassa, Y. Vinetsky, A. Kamyshny, Silver nanoparticles as pigments for water-based ink-jet inks, Chem. Mater. 15 (2003) 2208–2217.
27. D.G. Duff, A. Baiker, I. Gameson, P.P. Edwards, A new hydrosol of gold cluster. 1. Formation and particle-size variation, Langmuir 9 (1993) 2301–2309.
28. S. Link, M.B. Mohamed, M.A. El-Sayed, Simulation of the optical absorption spectra of gold nanorods as a function of their aspect ratio and the effect of the medium dielectric constant, J. Phys. Chem.B103 (1999) 3073–3077.
29. S. Link, Z.L. Wang, M.A. El-Sayed, Alloy formation of gold-silver nanoparticles and the dependence of the plasmon absorption on their composition, J. Phys. Chem. B 103 (1999) 3529–3533.

30. U. Kreibig, L. Genzel, Optical-absorption of small metallic particles, Surf. Sci. 156 (1985) 678–700.
31. S.J. Oldenburg, R.D. Averitt, S.L. Westcott, N.J. Halas, Nanoengineering of optical resonances, Chem. Phys. Lett. 288 (1998) 243–247.
32. J.P.Novak, C. Nickerson, S. Franzen, D.L. Feldheim, Purification of molecularly bridged metal nanoparticle arrays by centrifugation and size exclusion chromatography, Anal. Chem. 73 (2001) 5758–5761.
33. M.D. Malinsky, K.L. Kelly, G.C. Schatz, R.P. Van Duyne, Chain length dependence and sensing capabilities of the localized surface plasmon resonance of silver nanoparticles chemically modified with alkanethiol selfassembled monolayers, J. Am. Chem. Soc. 123 (2001) 1471–1482.
34. J. Fournier, W. DeSisto, R. Brusasco, M. Sosnowski, R. Kershaw, J. Baglio, K. Dwight, A. Wold ,Preparation and characterization of thin films of alumina by metal-organic chemical vapor deposition ,Mater. Res. Bull. 1998, 23, 31.
35. M. Jos´e Yacam´an, J.A. Ascencio, H.B. Liu, J. Gardea-Torresdey, Structure shape and stability of nanometric sized particles, J. Vac. Sci. Technol.B 2001, 19 , 1091.
36. Perrier J., Millon E., Fogarassy E., Recent Advances In Laser Processing Of Materials , 2006.
37. Ghaleb AL-Dahash, Sahib N. Abdul Wahid, W. Mubdir , Study the Effect of the Aqueous Media on the Properties of Produced Copper Nanoparticles Colloidal by Using Laser Ablation Technique, Eng. & Tech.Journal,Vol.33 ,Part(B), No.5 2015
38. Ogale, S.B.; Patil, P.P.; Phase, D.M.; Brandarkar Y.V.; Kulkarni S.K.; Kulkarni, S.; Ghaisas, S.V.; Kanetkar, S.M.; Bhide, V.G. and Ghua, S., Synthesis of metastable phases via pulsed-laser-induced reactive quenching at liquid-solid interfaces , Phys. Rev. B, 1987, 36, 8237.
39. Scalisi, A.; Compagnini, G. and Puglisi O., Production of gold nanoparticles by laser ablation in liquid alkanes , J. Appl. Phys., 94, 7874, 2003.
40. Santanu Pyne , Priyanka Sarkar , Samita Basu , Gobinda Prasad Sahoo , Dipak Kumar Bhui ,Harekrishna Bar , Ajay Misra., Synthesis and photo physical properties of Au @ Ag (core @ shell) nanoparticles disperse in poly vinyl alcohol Matrix . J Nanopart Res 13:1759–1767 (2011).
41. Wasan Mubdir Khilkal, Ghaleb A. Al-Dahash, Sahib Ne'ma, Preparation of Gold NPs Colloidal by Laser Ablation Under the Effects of Magnetic Field, Australian Journal of Basic and Applied Sciences, 8(18) December 2014, Pages: 159-162.
42. Wasan Mubdir Khilkal, Ghaleb A. Al-Dahash, Sahib Ne'ma, Preparation and Characterization of Cu nanoparticles by Laser Ablation in NaOH Aqueous Solution International Journal of Current Engineering and Technology, Vol.4, No.4 (Aug 2014)2577.

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