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Synthesis, Ultrasonic Characterization and Scattered Intensity of Gold Nanoparticles

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ABSTRACT: ***The present paper reports the synthesis, Ultrasonic characterization & scattered intensity of Gold nano suspension with different concentration and at different temperature. Nanoparticle of gold was prepared by chemical route from Chloro auric acid ($HAuCl_4$). Trisodium citrate ($C_6H_5O_7Na_3$) was used as a capping agent. Ultrasonic characterizations of material have been playing an important role for the study of structural, intermolecular interaction and properties of matter. Ultrasonic velocity, density, viscosity measurement were carried out by Interferometer technique operated at 2 MHz for different concentration and at different temperature. It help in finding Thermo acoustic parameters such as adiabatic compressibility, acoustic impedance, free length relaxation time, etc all these are related to the surface of Nanoparticle and Nanoparticle surfactant interaction. Mismatch of density (Υ_ρ) & compressibility (Υ_k) play very important role in the study of scattered intensity of Gold nano suspension. The known values of density and compressibility of surrounding nanoparticle and surrounding liquid might be used to examine particle size determination by acoustic back scattering phenomena. The scattering of ultrasonic waves from the cluster of gold nanoparticles play very important role in medical field and in industries.***

Keywords: Nanoparticle; Gold; Ultrasonic Velocity; Thermo acoustic parameters; scattered intensity.

1. Introduction

Nanoparticle synthesis and the study of their size and properties are of fundamental importance in the advancement of recent research. It is found that the optical, electronic, magnetic, and catalytic properties of metal nano particles depend on their size, shape and chemical surroundings. In Nanoparticle synthesis it is very important to control not only the particle size but also the particle shape and morphology [1] & [2]. In the present investigation the synthesis of gold nanoparticles by chemical route is discussed, which is an easy, simple and convenient route for preparing Nanoparticles. The prepared gold nano particles have been dispersed in Methanol and then examined using X-ray diffraction (XRD) spectroscopy. These studies reveal that the prepared nano particles are of an average size of 36 nm, which indicates the importance of the present work.

In the present work we have prepared gold nano-particle and characterization by X-ray diffraction (XRD) technique. Elastic properties of nanoparticles suspension are characterized by ultrasonic testing. The method is also used for investigation of structure changes (aggregation process) under the influence of different temperature [3]-[5].

Ultrasonic velocity measurement together with density help in finding out many thermo acoustic parameters such as adiabatic compressibility, acoustic impedance, free length and relaxation time all these are related the surface of Nanoparticle and nanoparticle surfactant interaction [6]. The particle aggregation causes to increase or decrease acoustic parameters, making possible the detection of this aggregation with the ultrasonic technique. Ultrasound spectroscopy is very useful in investigation of suspensions [7] and has some advantages over many existing technologies because it is non-destructive and non-invasive. It is capable of rapid measurements and can be used to characterize systems which are optically opaque can provide useful information to higher concentration than optical methods.

2. Experimental Technique

2.1 Sample preparation

In a typical procedure for the preparation of novel gold nanoparticles 10 ml aqueous solution of 0.001 M Chloroauric acid (HAuCl4) were first prepared and stir it for 15 minutes at 80^0C. Now added 10 ml of 0.01M aqueous sodium citrate stir for 30 minute at 80^0C, clear solution turns in to red or pink colour indicating formation of gold nanoparticles. The average diameter of the gold nano spheres was around 36 nm.

The prepared sample were characterized for their phase purity and crystallinity by X-ray powder diffraction (XRD) using PAN-analytical diffractometer (Cu-Ka radiation) at a scanning step of 0.01^o, continue time 20 s, in the 2h range from 10^o to 120^o. Formation of the compound confirmed by XRD pattern matched with the standard data available in JCPDS file. From this study, average particle size has been estimated by using Debye-Scherrer formula

$$D = \frac{0.9\lambda}{WCos\theta} \;\ldots\ldots\ldots\ldots\ldots\ldots\; (1)$$

Where ‘λ’ is the wavelength of X-ray (0.15460nm), ’W’ is FWHM (full width at half maximum), ’θ’ is the diffraction angle and ‘D’ is particle diameter (size). The estimate size of gold nano particles is found to be ~ 36 nm.

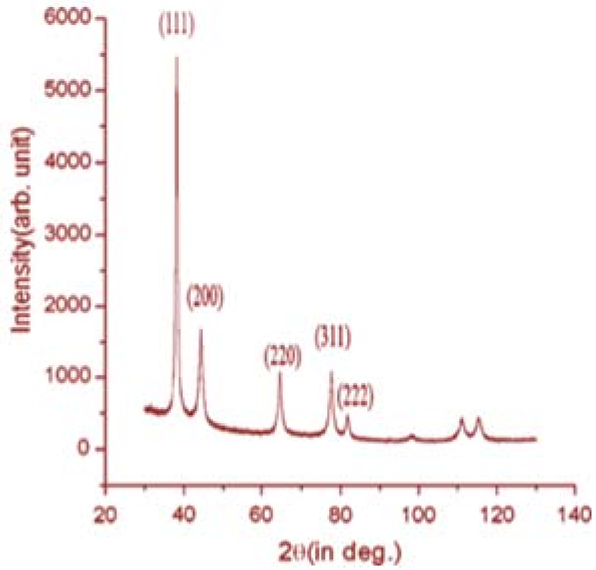

Figure 1: XRD Pattern of gold nano particles

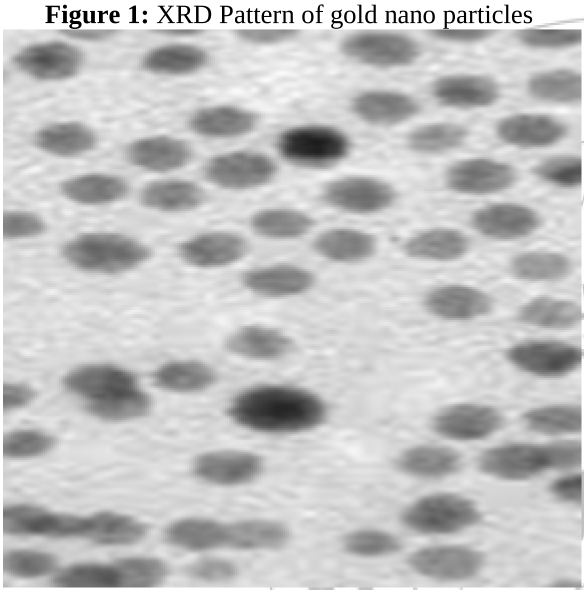

Figure 2: TEM images of gold nano particles

2.2 Measurement

The X-ray diffraction of the nano sized calcium carbonate is obtained by using a Philips Holland, PW-1710 x-ray diffractometer having Cu k_α x-ray radiation of wavelength λ=1.5405 A^0 and a continuous scan of 2^0/ min at 35 KV and at 20 mA as shown in figure (1). Ultrasonic velocity measurements were carried out using pulse echo techniques operated at 2MHz. A Thermostat (Lab Slab) controls the temperature of the liquid to an accuracy of ± 0.1° C. Density measurement was carried out using specific gravity bottles and digital mono pan-balance with accuracy of 0.001mg.

3. Result and Discussion

Gold is generally regarded as an inert metal showing a low electro catalytic activity. Recently, it was found that gold in the form of nano-sized particles exhibits an unusually high electro catalytic activity Initial results showed that gold could be a promising candidate for some applications, such as electro catalytic oxidation of methanol

Nanoparticle suspension forms an interesting bridge between molecular liquids and colloidal solution. There is a reasonably good understanding of the dynamics of simple molecular liquids on one side and macro colloids on other sides. Little is still known as there dynamical behavior and how they can be controlled during processing. Associations collides are substances whose molecules aggregates spontaneously in a given solvent to form thermodynamically stable particles of colloidal dimensions.

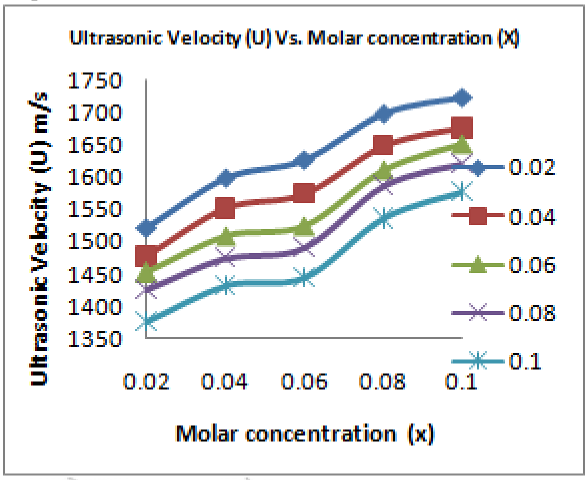

Figure 3: U versus conc. of gold nano particle in methanol

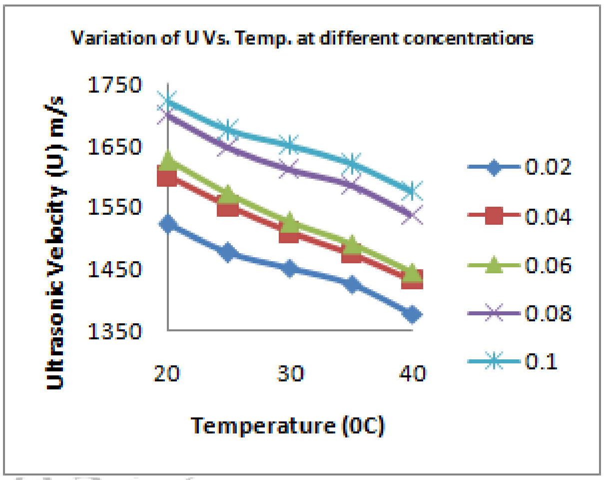

Figure 4: U with temperature of gold nano particle in methanol

Fig.3 shows the variation of ultrasonic velocity versus concentration of gold nanoparticle suspension in methanol. Fig. 4 shows the variation of ultrasonic velocity with temperature. The variation in ultrasonic propagation shows analogous behavior with increase in concentration of gold nanoparticle in methanol. The non linear variation of ultrasonic velocity versus concentration of gold nanoparticle suspension in methanol shows strong interaction between the constituents. It is observed that as concentration of gold nano particle suspension in methanol increases heteromolecular interactions in the constituents becomes stronger [8]. The ultrasonic velocity decreases with increase in temperature because gold nanoparticles and thermo-elastic loss arises due to the Brownian motion of nanoparticles at nanoscale level is a key mechanism governing the thermal behavior of nanoparticles colloidal-fluid suspension.

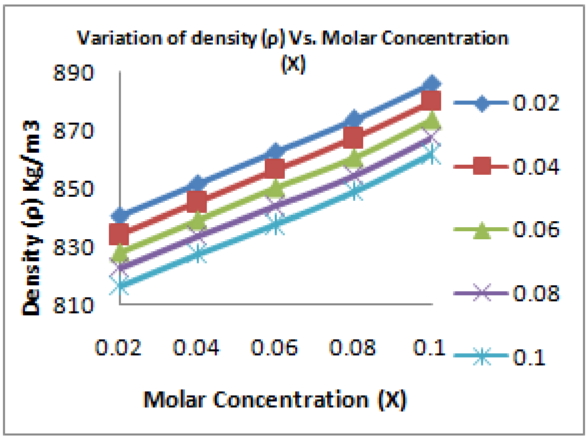

Figure 5: Variation of ρ with conc. of gold nano particle in methanol

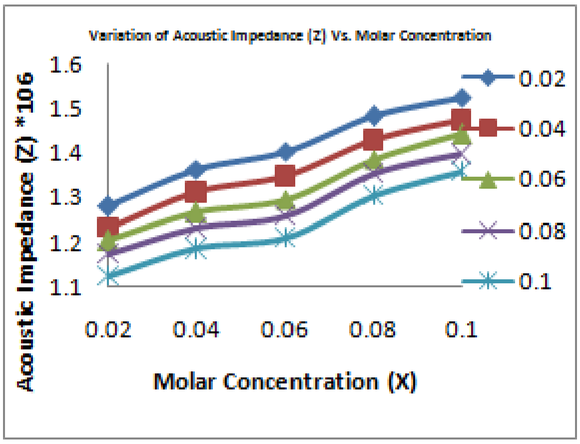

Figure 7: Z Vs. conc. gold nano particle in methanol

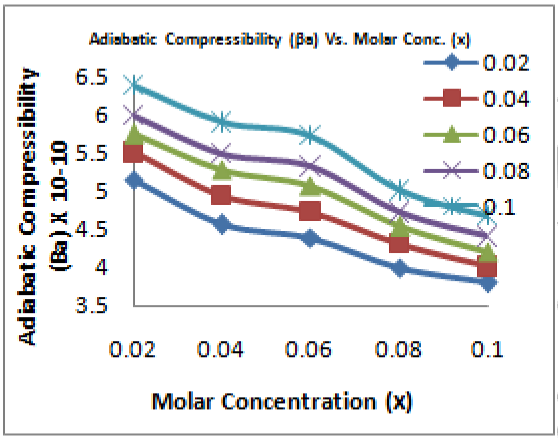

Figure 6: βa with conc. of gold nano particle in methanol

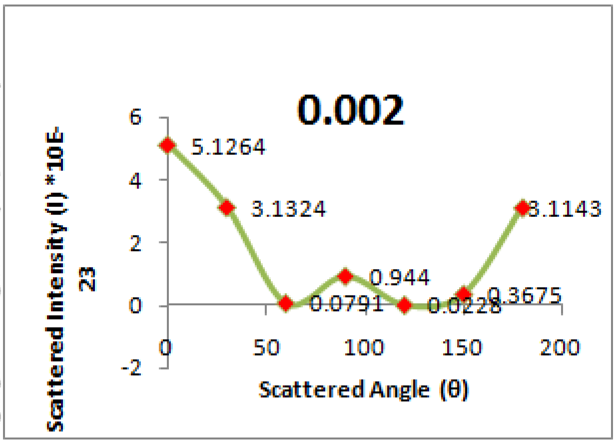

Figure 8: Variation of scattered intensity vs. scattered angle

Fig.5 shows the variation of density with molar concentration of gold nanoparticles in methanol. Density of gold nano suspension increases with increase in molar concentration of gold nanoparticles in methanol. This indicates the close packing between the constituents in the nano material suspension.

Fig.6 shows the variation of adiabatic compressibility with molar concentration of gold nanoparticles in methanol. The adiabatic compressibility of a liquid is a thermodynamic parameter of fundamental significance [9] & [10]. It enables direct access to the liquid structure in terms of the particle packing density and the inter particle forces. The adiabatic compressibility of a fluid is related to its density ρ and sound velocity v. The adiabatic compressibility shows the reverse trends as that of ultrasonic velocity which is theoretically accepted. The non-linear variation of adiabatic compressibility with molar concentration indicates the presence of phase separation in nano suspension.

Fig.7 shows the variation of acoustic impedance with increase in gold nano particles in methanol. Increase in acoustic impedance shows the association and decrease in acoustic impedance shows the dissociation of nanoparticles in nano suspension [12].

Fig.8 contains the plot of scattered intensity versus scattered angle at molar concentration 0.002. It is observed that there is back scattering at 70^0 & at 130^0. It is due to mismatch of compressibility of scatterer. Decrease in compressibility of scattering nanoparticle as compared to surround medium methanol decreases the scattered intensity [13-15].

Fig.9 contains the plot of scattered intensity versus scattered angle at molar concentration 0.004. It is observed that there is back scattering at 90^0. It is due to mismatch of compressibility of scatterer. Fig.10 contains the plot of scattered intensity versus scattered angle at molar concentration 0.006. It is observed that scattered intensity decreases with increase in scattered angle and shows back scattering at 100^0 [16-18]. It is due to mismatch of compressibility of scatterer. Scattered intensity is maximum for scattered angle 0^0 and decreases at 180^0.

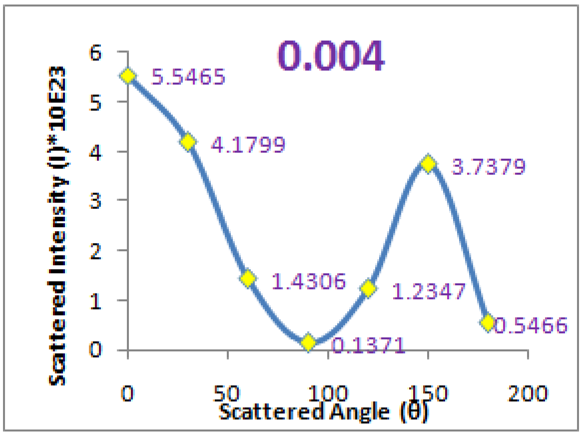

Figure 9: Variation of scattered intensity versus scattered angle

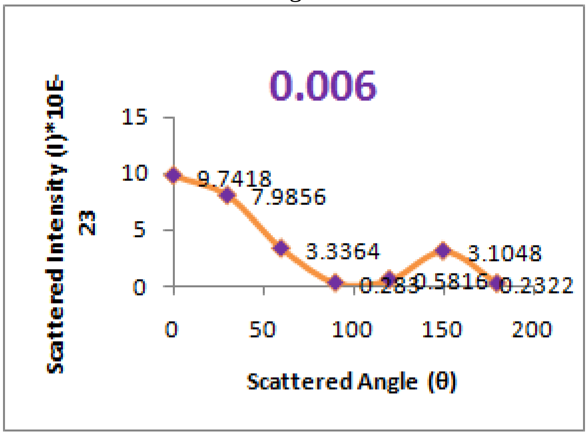

Figure 10: Variation of scattered intensity verses scattered angle

Fig.11 contains the plot of scattered intensity versus scattered angle at molar concentration 0.008. It shows back scattering at 75^0 & 150^0. Fig.12 contains the plot of scattered intensity versus scattered angle at molar concentration 0.01. It is observed that scattered intensity decreases for all ranges of scattering angle except 150^0. There is back scattering at 120^0. Mismatch of compressibility and density play very important for such behavior of scattered intensity [19 & 20].

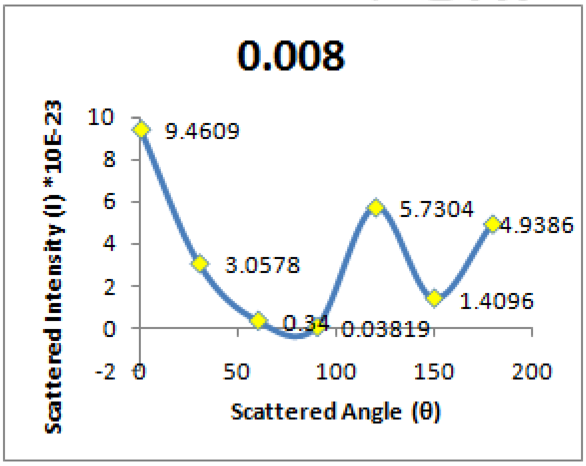

Figure 11: Variation of scattered intensity versus scattered angle

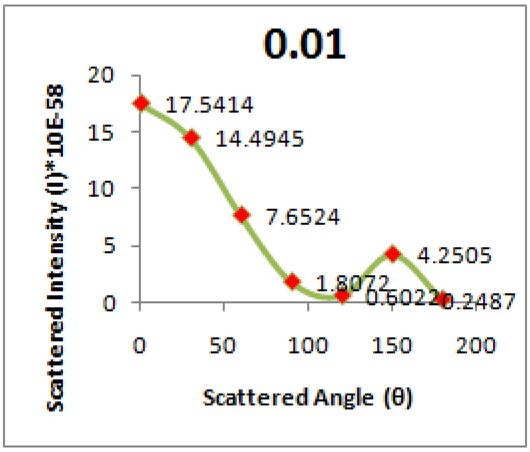

Figure 12: Variation of scattered intensity versus scattered angle

4. Conclusions

1. The ultrasonic velocity increases with an increase of the concentration of nanoparticles. It is due to association of gold nanoparticles in methanol based nano suspension indicating strong interaction between the constituents.
2. Ultrasonic velocity decreases with increase in temperature, this is due to Brownian motion of nanoparticles in methanol based nano suspension and thermal agitation.
3. It is confirmed that aggregation of nano particles in nanocolloids play a key role for association and hence enhancement of ultrasonic velocity.
4. Aggregation of nanoparticles play very important role in drug delivery system because colloidal form of drug are easily adsorbed by the body tissues and hence are more effective.
5. There is maximum intensity initially for all molar concentrations as the compressibility is not sufficient with respect to the surrounding medium methanol.
6. There is forward and backward scattering of acoustic waves from the cluster nanoparticles for all molar concentration. This is may be attributed to more compressibility of nanofield as compared to surrounding medium methanol.
7. Mismatch of density and compressibility play very important role in the variation of scattered intensity with scattered angle.

5. Applications

1. Back scattering of ultrasonic waves from the cluster of nanoparticles are used to solve nanocluster scattering problems.
2. Back scattering phenomena used for the treatment of earlier stages of lung cancer and for hyperthermia treatment.
3. When the tumor is located in the superior sulcus or is close to the critical normal organ, such as the esophagus and spinal cord, back scattered radiation destroyed it by heating effect.

6. Future Scope

1. When the patient is in an in-operable situation according to their lung function, cardiac function, and bleeding tendency or other reasons including the patient's refusal for surgery, then radiation therapy by back scattering will be a beneficial option.
2. The known values of density and compressibility of single nano-particle and surrounding liquid might be used to examine particle size determination by accosting back scattering.

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