

Study the Flow Behavior of Gnanops Filled Water Using Cone-On Plate Viscometer

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Abstract

This work investigates the rheological behavior of gold nano particles filled water (GNPS- water) prepared by Nd - YAG laser ablation. Noble metal goldNPs were synthesized by pulsed (Q-switched, 1064-Nd: YAG, 10 ns pulse duration and energy $E=550\text{mJ}$ and 650mJ laser ablation of gold metal plates immersed in double distilled and deionised water DDDW. Absorbance spectra of the produced nanoparticles solution was measured by UV-VIS spectrophotometer which show sharp and single peaks 530 nm indicating the produced Au nanoparticles with a narrow size ranging from 10nm to 20 nm with almost spherical shape. The morphology and size was estimated by TEM. The rheological behavior of GNPs filled water with particle sizes (10 nm) and (20 nm) called nano1 and nano2 respectively were tested using cone –on - plate viscometer. The viscosity, torque, shear stress where measured at different shear rate. The results show that the shear stress increases with the shear rate increasing for nano1 and nano2. The viscosity decreased with the shear rate increasing for nano1 and nano2. The viscosity for 10 nm concentration is lower than that for 20 nm concentration due to the difference in particles size and energy value .

Keywords: GNPS- water, Viscosity, Flow behavior, Shear Thinning, Cone –on - plate viscometer.

Introduction

Many applications in the medical filed .The gold nanoparticles (GNPs) aqueous solution exhibit particles significance in rheological behavior as non - Newtonian flow. Nanoparticle size has been shown to be an extremely important parameter affecting the nanoparticle uptake and cellular internalization. Mostly gold and silver, has attracted much interest due to their surface Plasmon resonance related properties that are potentially useful for their biological applications[1].Gold nanoparticles (AuNPs) are promising metal nanoparticles, utilized in drug delivery , biosensing and biolabeling applications due to their unique optical and electronic properties[2,3]. These properties are size and shape dependent, hence gold nanoparticles with different shapes and sizes are required for each application. In addition, the AuNPs are also having biological activities such as antioxidant, anti-inflammatory, anti-angiogenesis and anticancer properties [3]. Laser ablation in liquid environment is capable to produce metal NPs without using any surface active substances, called also as “green synthesis” (Besner et al., 2008)[4,5]. With this method, can be prepared NPs without chemical surfactants, therefore, having a more direct and reliable response to their surrounding material, increasing the possibility to be used in a wider range of applications [4]. Nanoparticle distribution within the body is based on various parameters such as their relatively small size resulting in longer circulation times and their ability to take advantage of tumor characteristics. For example, nanoparticles less than 20 nm in size are able to pass through blood vessel walls and such small particle size allows for intravenous injection as well as intramuscular and subcutaneous applications [6]. The rheological measurements are performed with a cone and plate geometry with a cone diameter 25 mm and a cone angle of 1° . All experiments are conducted at a constant gap of 0.5 mm and an initial stabilization period of 2 minutes is given for achieving the temperature equilibration. The liquid is placed on horizontal plate and the cone is placed into it. An electrically commutated synchronous motor drive rotates the cone at a set speed and this determines the shear rate inside the annulus of the sample. The sample tends to drag the plate, and the force it exerts on that plate (torque) is measured, which can be converted to a shear stress. Viscosity is calculated from the shear stress shear rate relation [7]Solution viscosity, as controlled by changing the polymer concentration, has been found to be one of the biggest determinants of fiber diameter and morphology when spinning polymeric nanofibers. At low polymer concentrations, defects in the form of beads and droplets have been observed. Increasing the solution viscosity by increasing the polymer concentration yielded uniform fibers along with the formation of a few beads [6].They found that increasing the temperature yielded fibers with decreased fiber diameter and this reduction in diameter was attributed to the decrease in the viscosity of the polymer solutions at higher temperatures ,Casper *et al.* [8].The release of drug from semi-solid carriers is influenced by the rheological behavior as well. The effect of certain parameters such as storage time on the quality of GNPs can be also investigated via rheological measurements[9].The objective of the present experimental work is to explore the effects of the GNP size on the rheological properties of GNPs water solutionat a fixed temperature of 37°C [10].

The shear stress , viscosity and torque are tested with different speed and shear rate at fixed

temperature 25°C .using cone-on- plate viscometer type Brookfield (DV-III) Ultra.Also the shear thinning effect in nano1 and nano2 is analyzed.

Materials and methods:

GNPs were synthesized by pulsed laser ablation of gold target in double distilled and deionized water DDDW at room temperature. The gold target (purity of 99.99%) was fixed at bottom of glass vessel containing of 1 ml of double distilled deionized water DDDW. Ablation is carried out with laser operating at 1064 nm wavelengths. The pulse energy was (550 mJ , 650mJ).The number of laser shots applied for the metal target at 100 pulses. The absorbance spectra of the nanoparticles solution measured by UV-VIS double beam spectrophotometer.Fig.1 shows the experimental setup for laser ablation of solid metal target immersed in water or aqueous solution .The viscosity, torque, shear stress at different shear rate. Were measured using Brookfield DV-III Ultra Programmable viscometer supplied with temperature bath and controlled by a computer.Cone-on-plate viscometer setting at 25 °C and different shear rate.

The principle of operation of the Cone-on-plate viscometer is to drive a spindle (which is immersed in the test fluid) through a calibrated spring. The viscous drag of the fluid against the spindle is measured by the spring deflection. Spring deflection is measured with rotary transducer. The viscosity measured range of the DV-III Ultra (in centipoises or cp) is determined by the rotational speed of the spindle , the size and shape of the spindle , the container the spindle is rotating in , and the full scale torque of the calibrated spring .

The DV-III Ultra can also measure yield stress 0.5 ml of each GNP filled aqueous solution was poured in the sample chamber of the rheometer.Fig.2 shows the cone-on – plate viscometer.Torquerange must be scattered in the examine (10 – 100) %correct reading.

Results and discussion

Fig.3 shows the absorbance spectra of gold colloids prepared by laser ablation of a gold plate immersed in DDDW at various concentrationsfor laserenergy of (550 and 650) mJ, $\lambda=1064$ nm.The figure show broadband in the visible region with maximum peaks around 530nm. The concentrations of GNPs for 650 mJ is higher than of 550 mJ

Fig.4 shows TEM pictures and size distributions of nano1 and nano2, produced by laser ablation of metal plates immersed in DDDW; the laser wavelength is 1064 nm. The nano1 and nano2 shows spherical morphology and with good particle size distribution dispersed in the solution .The nanoparticles thus produced were calculated to have the average diameters of 10nm and 20 nm at the laser energies of 550mJ and 650 mJ, respectively. The average particles sizes increase and the size distribution broadens with an increase of applied laser energy. The origin of the surface morphology of the irregularly shaped particles in case of low energy can be explained by absorption by defects and thermally induced pressure pulses which cause cracking [11].

Fig.5Shows that the shear stress increased with the shear rate increasing and nano1 exhibits higher shear stress than nano2due to the high viscosity of nano2.The shear stressincreased rapidly at 255 shear rate while change gradually after that. The 650mJ power produces higher particle size than that of 550 mJ power. The surface area and the contactdistance is high for higher particle size than that for lower particle size. The viscosity increases with concentration, size and surface area increasing .The shear stress depend on the viscosity, shear rate and power index.

The rheological properties for the different GNPs sizes in aqueous solution (water) can be described by the power law model:

$$\tau = \eta \gamma^n \dots (1)$$

Where τ is the shear stress, η is the viscosity (CP), γ is the shear rate, and n is the flow behavior index. η can be used to describe the variation in viscosity for the different GNPs sizes [12].

Fig.6.Indicate that the viscosity of nano1and nano2 are decrease with speed increasing and the viscosity of nano2 is greater compared with that of nano1 due to the lower nanoparticle size in nano1 and large size of thenanoparticlesin thenano2.The large nanoparticle size and diameterincrease the contact between particles and the drag to flow.

Fig.(7and 8) Shows that the viscositydecreased with the shear rate increasing for nano1 and nano2that called the shear thinning behavior associated with the non – Newtonian flow of nano - fluid .The maximum viscosity magnitude occurs at low shear rate due to the accumulation and slowly nanoparticles movement .Also the viscosity drop rapidly at the first step and then decreases gradually to the final step , where the behavior become approximately stable . The viscosity magnitude of nano2 is higher than that of nano1 due to the high nanoparticle size.

Fig.9 IndicatesThe torque increases with the shear rate increasing, due to shear stress increasing.

Conclusions

1. The high energy laser ablation produces higher average nano-gold particle size.

2. The higher a verge GNPS diameter exhibit higher viscosity than that of lower average GNPS diameter.
3. The GNPS – water solution exhibits shear thinning behavior and compatible with power law non – Newtonian viscosity.
4. The shear thinning drop faster for nano2 than that for nano1 due to the particle distribution style.

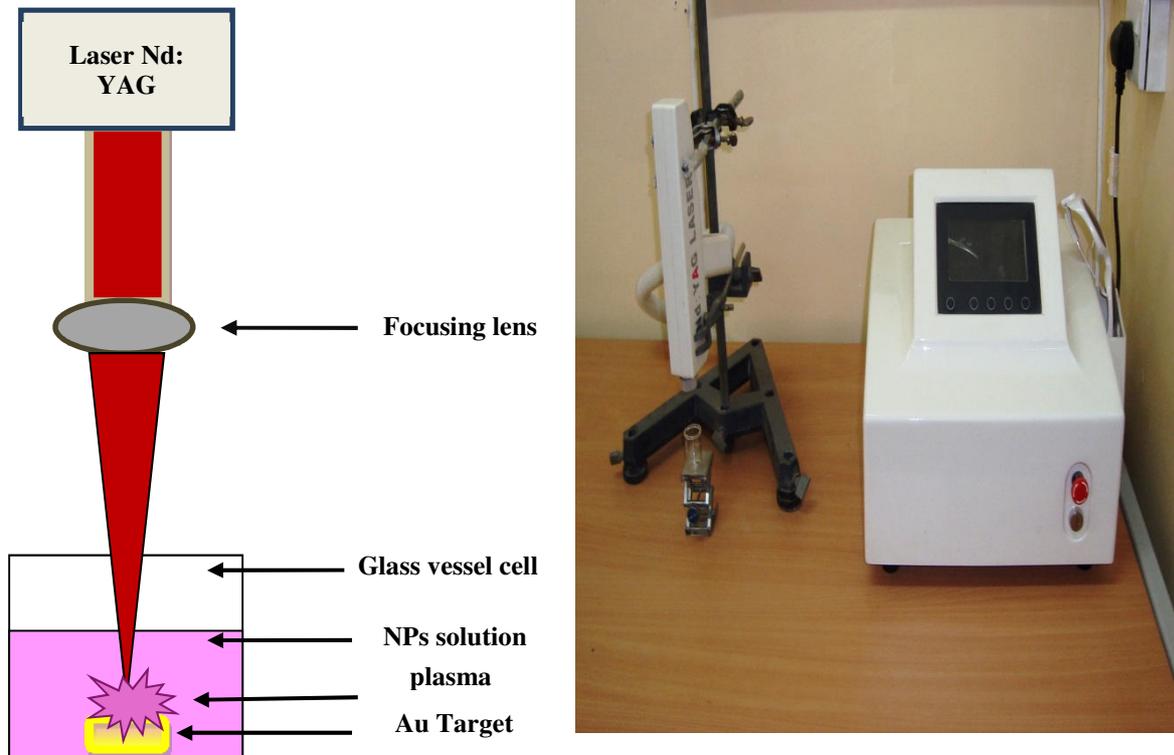


Fig. 1: Experimental setup for nanoparticles synthesis by PLAL process.

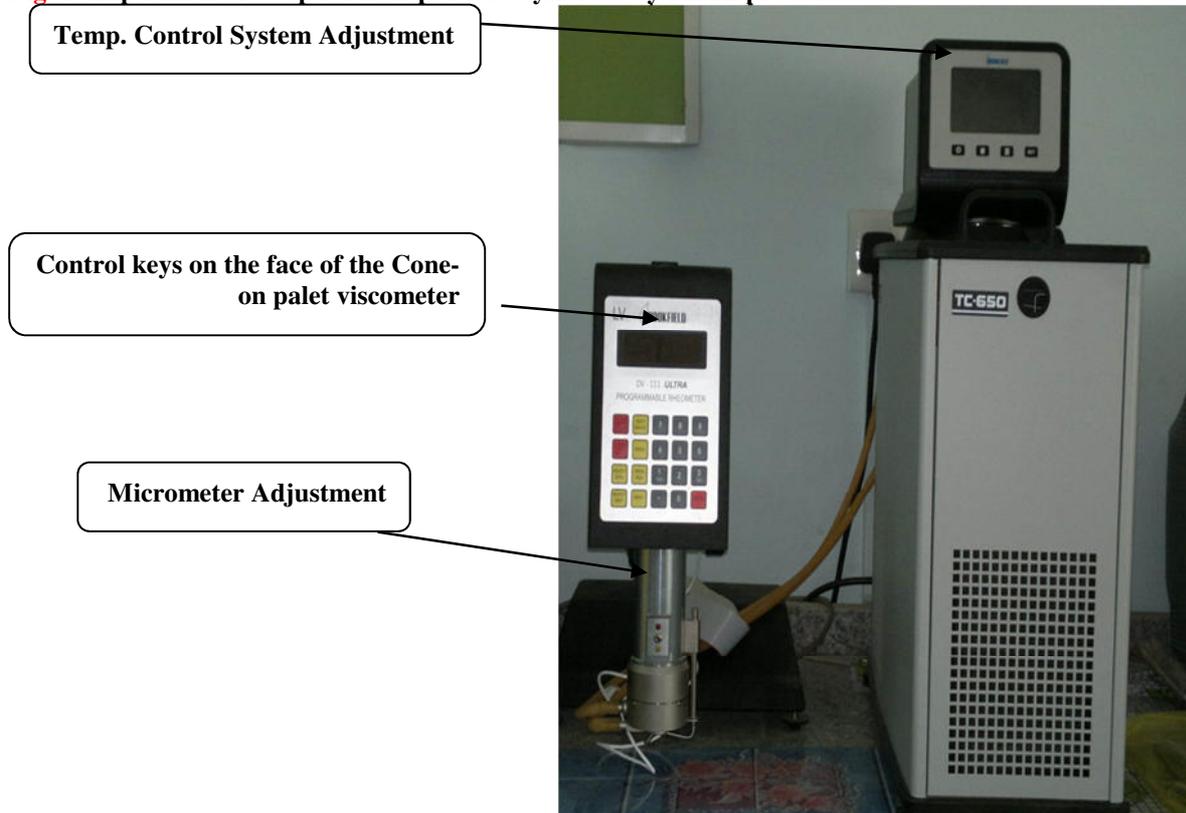


Fig.2 Cone-on – plate viscometer.

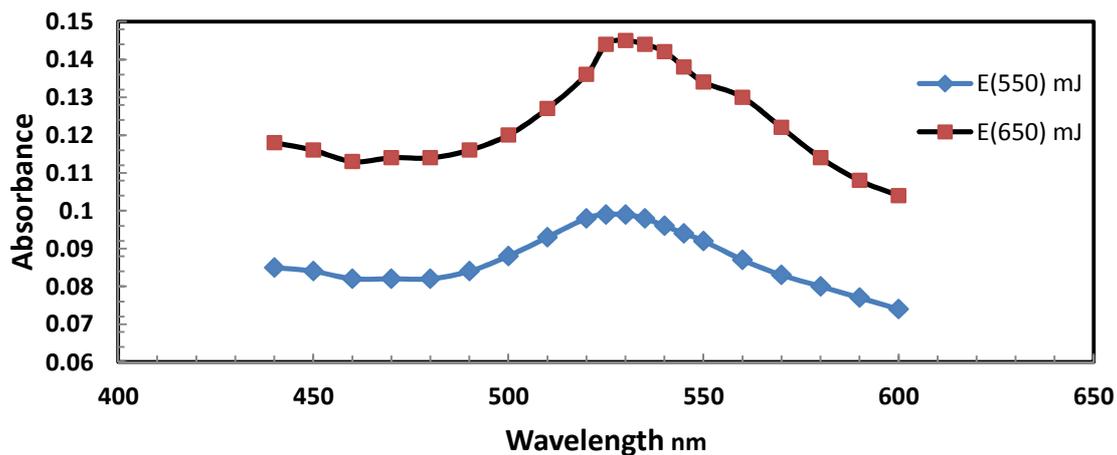
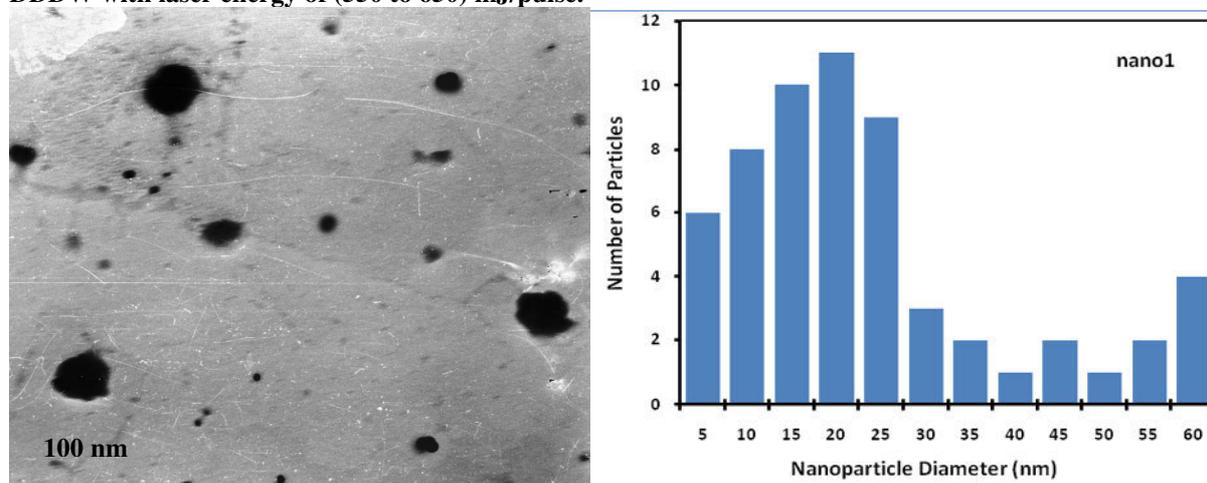
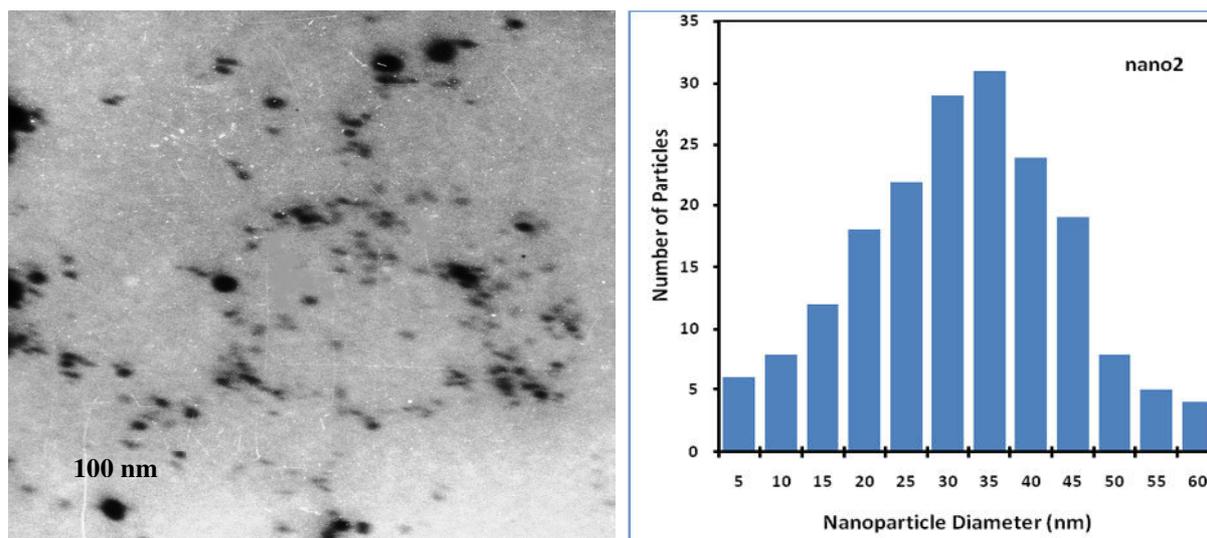


Fig.(3) .Absorbance spectra of Gold nanoparticles obtained by laser ablation of metal plate immersed in DDDW with laser energy of (550 to 650) mJ/pulse.



10 nm



20 nm

Fig.4: TEM images and size distributions of nano1 anno2

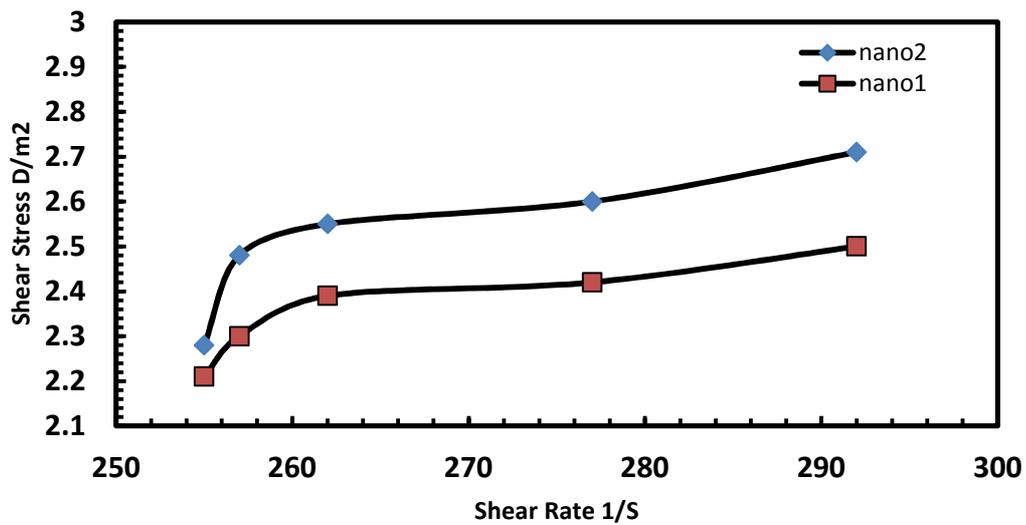


Fig. (5) . The relation between shear rate 1/s and shear stress D/m2 for nano1 and nano2 at temperature of 25°C.

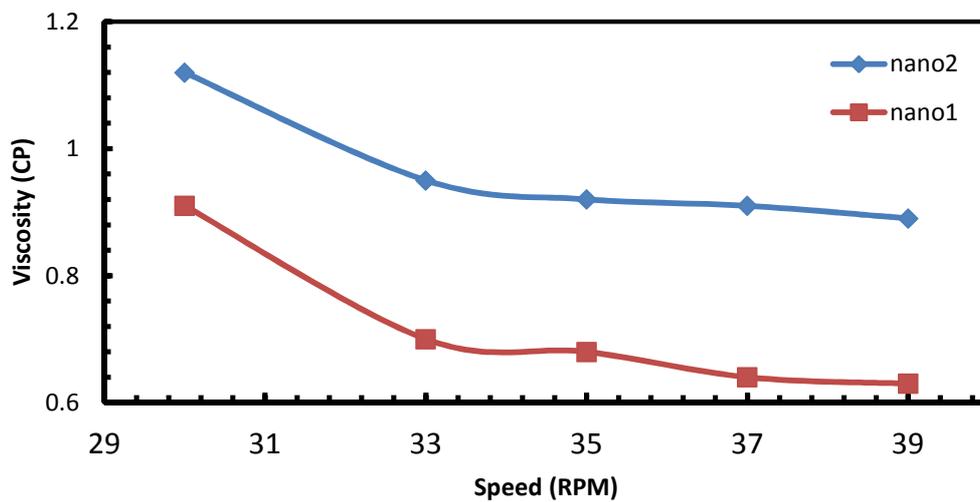


Fig.(6) .The relation between Speed and Viscosity for nano1 and nano2 at temperature of 25°C

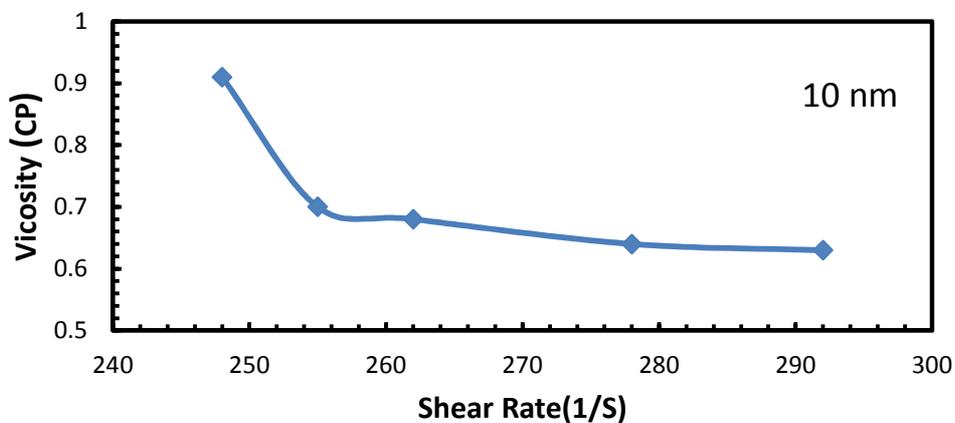


Fig. (7) .The relation between Viscosity and Shear rate for nano1 at temperature of 25°C.

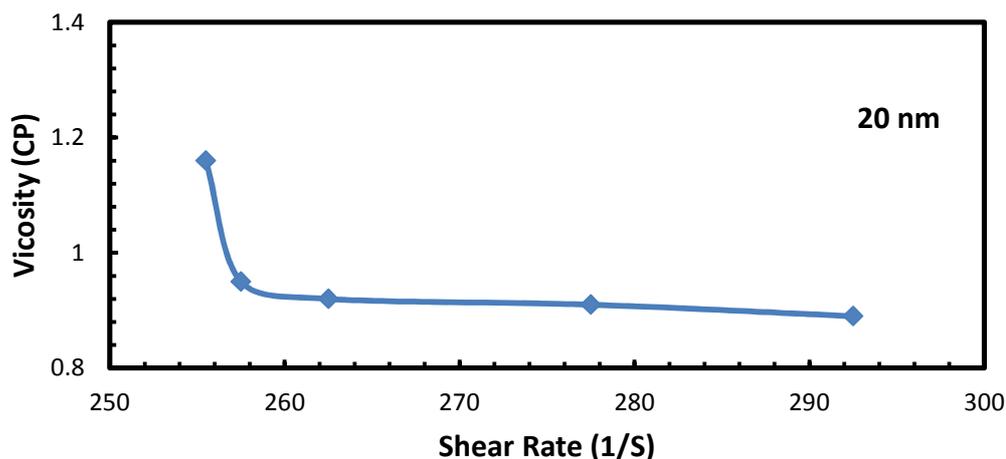


Fig. (8) .The relation between Viscosity and Shear rate for nano2at temperature of 25°C.

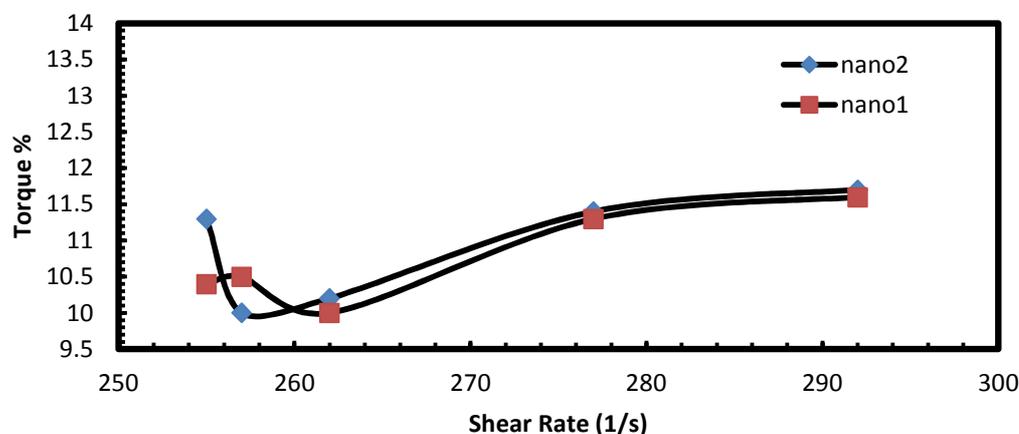


Fig.(9). The relation between Torque and shear rate for nano1 nano2 at temperature 25°C.

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