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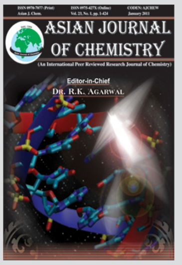

Phase Transition in Nanofluid of Platinum Above Room Temperature†

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Nanofluids are attracting a great deal of interest with their enormous potential to provide enhanced performance properties, particularly with respect to heat transfer. Metal nanoparticles can be used in various application fields, such as optical filters or nanolithography. Platinum nanoparticles with narrow size distribution dispersed onto smooth, non-catalytic surfaces are of interest as model systems for the investigation of particle shape and size dependence of the catalytic activity of platinum towards reactions of interest in fuel cell systems. Measurement of ultrasonic velocity gives the valuable information about the physico-chemical behaviour of the liquid and liquid mixtures. Ultrasonic velocity is the velocity with which the ultrasound propagates through the material. It depends on material density and elasticity. It is related in a simple way to the various coefficients of compressibility, isentropic, isenthalpic and isothermal, hence the importance of its measurement and modeling in temperature and pressure ranges are widely used. Here we have measured the ultrasonic velocity at different temperature and frequencies of nanofluid of platinum using Interferometer technique and phase transition in the experimental temperature range has been discussed.

Key Words: Phase transition, Nanofluids, Ultrasonic velocity, Nanotechnology, Interferometric techniques.

INTRODUCTION

Nanofluids are stable suspensions of nanoparticles in a liquid. In order to avoid coagulation of the particles, the particles must be coated with a second distance holder phase which in most cases, consist of surfactants that are stable in the liquid. An important application of nanofluid containing nanoparticles is as a coolant, since the addition of only a few volume per cent of nanoparticles to a liquid coolant and significantly improves its thermal conductivity. The term nanotechnology has also been used more broadly to refer to techniques that produce or measure features less than 100 nanometers in size; this meaning embraces advanced micro fabrication and metrology. Nanotechnology based on molecular manufacturing requires a combination of familiar chemical and mechanical principles in unfamiliar applications. Platinum is used in jewelry, laboratory, equipment, electrical contacts and electrodes as well as platinum resistance. Platinum occurs naturally in the alluvial sands of various rivers, though there is little evidence of its use by ancient people. The most important application of platinum is in automobiles as a catalytic converter, which allows the complete combustion of low concentrations of unburnt hydrocarbon from the exhaust into carbon dioxide and water vapour. Platinum is also used in the petroleum industry as a catalyst. In the laboratory, platinum wire is used for electrodes and platinum pans are used in thermogravimetric analysis. Nanotechnology is a most important and growing area in science. Nano-science, the science under pinning nanotechnology, is a multidisciplinary subject covering atomic, molecular and solid state physics, as well as much of chemistry. Nanostructures are known to exhibit novel and improved material properties. Nanotechnology is design, fabrication and application of nanostructures or nanomaterials and fundamental understanding of the relationships between physical properties and material dimensions.

Application of nanostructures and nano-materials are based on the peculiar physical properties of nanosized materials, the huge surface are the small size that offers extra possibilities for manipulation and room for accommodating multiple functionalities. In future, amazing nanotech-based products are expected, including extraordinarily tiny computers that are very powerful, building materials that withstand earthquakes, advanced systems for drug delivery and custom-tailored pharmaceuticals as well as the elimination of invasive surgery, because

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repairs can be made from within the body. Future developments and implemention of nanotechnology could certainly change the nature of almost every human made object and activity. Its ultimate societal impact is expected to be as dramatic as first industrial revolution and greater than the combined influences that aerospace, nuclear energy, transistors, computers and polymers have in this century. Nanotechnology development is the need to understand the techniques for atomic and molecular based study of matter in nanoscale[1-3].

Nanofluids are dilute liquid suspensions of nanoparticles with at least one of their principal dimensions smaller than 100 nm. There is a growth in the use of colloids which are nanofluids in the biomedical industry for sensing and imaging purposes. This is directly related to the ability to design novel materials at the nanoscale level alongside recent innovations in analytical and imaging technologies for measuring and manipulating nanomaterials. This has led to the fast development of commercial applications which use a wide variety of manufactured nanoparticles. Nanofluids have higher thermal conductivity and single-phase heat transfer coefficients than their base fluids[4]. Nanofluids could be applied to almost any disease treatment technique by reengineering the nanoparticles properties. Several significant gaps in knowledge are evident at this time, including, demonstration of the nanofluid thermal-hydraulic performance at prototypical reactor conditions and the compatibility of the nanofluid chemistry with the reactor materials[5].

Ultrasonic velocity has become a valuable tool for the study of various physical and chemical properties of the matter. Ultrasonic velocity measurement offers a rapid and destructive tool for the characteristics of materials. Various elastic parameters and estimation of grain size has been going on far the past several years. Elastic constants of isotropic solid can be determined ultrasonically when both longitudinal and transverse wave velocities are known[6,7]. The aim of present work is to study the characterization of platinum nanofluid using ultrasonic techniques.

EXPERIMENTAL

Interferometry is the technique of diagnosing the properties of two or more waves by studying the pattern of interference created by their superposition. It is an important investigative technique in the fields of astronomy, fiber optics, engineering metrology, optical metrology, oceanography, seismology, quantum mechanics, plasma physics and remote sensing. An ultrasonic interferometric sensor has been introduced for the measurement of suitable changes in the physical properties of fluids such as density, viscosity and bulk modulus[8].

The ultrasonic interferometer is simple in construction and operation and gives accurate and reproducible results. From these results, one can readily determine the velocity of sound in a liquid with high accuracy. Formerly, the absorption of sound in the liquid and the coefficient of reflection at the reflector surface have been obtained through a complicated analysis of the electrical and equivalent electrical circuits of the quartz crystal and the associated fluid column. In our experimental work we use multifrequency interferometer. This multifrequency generator can generate ultrasonic waves of several frequencies form 1 MHz to 12 MHz in the medium. The multifrequency ultrasonic interferometer consists of the two parts- the high frequency generator and the measuring cell. The high frequency generator is designed to excite the quartz plate fixed at the bottom of the measuring cell at its resonant frequency to generate ultrasonic waves in the experimental liquid in the measuring cell. A micro ammeter to observe the changes in current and two controls for the purpose of sensitivity regulation and initial adjustment of micro ammeter is provided on the high frequency generator. A fine micrometer screw has been provided at the top, which can lower or raise the reflector plate in the cell through a known distance. It has a quartz plate fixed at its bottom the ultrasonic interferometer may be used for determination of ultrasonic velocity. The measuring cell is connected to the output terminal of the high frequency generator through a shielded cable the cell is filled with the experimental liquid before switching on the generator the ultrasonic waves moves normal from the crystal till they are reflected back from the movable plate and the standing waves are formed in the liquid in between the reflector plate and the quartz crystal. The micrometer is slowly moved till the anode current meter on high frequency generator shows a maximum. A number of maximum readings of anode current are passed on and their n is counted the total distance x thus moved by the micrometer gives the value of wavelength λ with the help of the following relation;

$$x = n \times \lambda /2 \qquad (1)$$

Once the wavelength is known the ultrasonic velocity (V) of copper nanofluid can be calculated with the help of following relation;

$$V = \lambda \times f \qquad (2)$$

Evaluation: Ultrasonic velocity measurements have been successfully employed to detect and assess weak and strong molecular interactions present in nanofluids. These studies can also be used to determine the extent of complexation and calculate the stability constants of such complexes[9]. Nanofluids are suspensions of nanoparticles in fluids that show significant enhancement of their properties at modest nanoparticle concentrations. Nanofluids are considered to offer important advantages over conventional heat transfer fluids. Nanofluids contain suspended metallic nanoparticles, which increases the thermal conductivity of the base fluid by a substantial amount[10,11]. Measurement of ultrasonic velocity gives the valuable information about the physico-chemical behaviour of the liquid and liquid mixtures. Several relations, semi-empirical formula and theories are available for the theoretical computation of ultrasonic velocity in liquid and liquid mixtures. Temperature variation of ultrasonic velocity for nanofluid of platinum is given in Table-1 and frequency variation of ultrasonic velocity for this fluid is shown in Table-2.

RESULTS AND DISCUSSION

Ultrasonic velocity measurements are helpful to study the ion-solvent interactions in aqueous and non-aqueous solutions in recent years. Ultrasound has been extensively used to determine the ion solvent interactions in aqueous containing electrolytes.

TABLE-1
TEMPERATURE VARIATION OF ULTRASONIC VELOCITY IN NANOFLUID OF PLATINUM

Frequency (MHz)	Temperature (K)											
	311	312	314	315	317	318	320	321	323	324	326	327
1	1343	**1330**	1363	**1380**	1398	**1400**	1390	**1390**	1394	**1400**	1364	**1300**
2	**1530**	1534	**1540**	1541	**1530**	1531	**1530**	1533	**1550**	1567	**1590**	1589
3	**1520**	1534	**1510**	1548	**1590**	1586	**1530**	1507	**1520**	1552	**1600**	1542
4	**1510**	1531	**1520**	1512	**1500**	1506	**1540**	1556	**1580**	1571	**1460**	**1330**

TABLE-2
FREQUENCY VARIATION OF ULTRASONIC VELOCITY IN NANOFLUID OF PLATINUM

Frequency (MHz)	1	2	3	4	5
Velocity (m/sec)	1329	1513	1570	1430	1414

The measured data of ultrasonic velocity for nanofluid of platinum at different temperature and frequencies are given in Tables 1 and 2. Graphical representation of data is given in Figs. 1 and 2. From Fig. 1(i), at 1 frquency(F) in MHz. It is observed that at increasing temperature from 311 to 317 K, the ultrasonic wave velocity increases and when temperature again increased up to 320 K, it slightly decreases, when temperature is reached slightly at 323 K, velocity increases but at 326 K velocity again decreases. Temperature variation of ultrasonic velocity at 2 MHz frequency is shown in Fig. 1(ii), one can say from this figure velocity increases from temperature 312 to 315 K but when we increase temperature at 318 K, velocity decreases. Again increasing temperature till 327 K, ultrasonic velocity increases. This shows proportionality relation between temperature and velocity. It is clear from Fig. 1(iii), on increasing temperature from 312 K up to 318 K, the velocity of ultrasonic wave increases and up to 321 K the velocity is slightly decreases and at 324 K the velocity of ultrasonic wave slightly increases and again at 327 K the ultrasonic wave velocity slightly decreases. This shows linear and inverse relation separately between temperature and velocity.

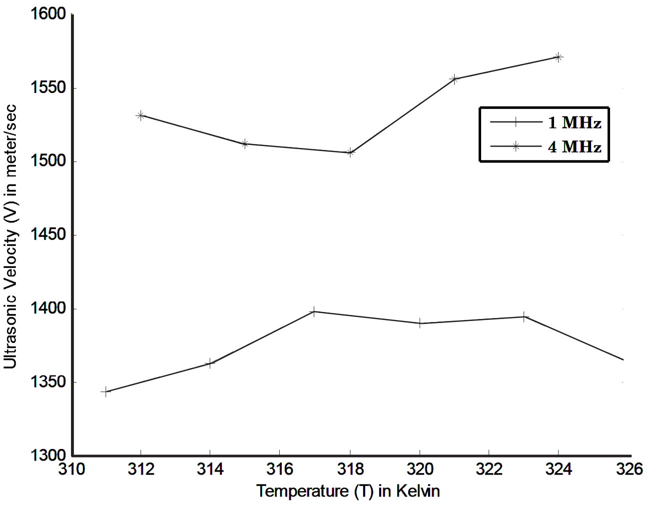

Fig. 1(i). Temperature variation of ultrasonic velocity in nanofluid of platinum

Ultrasonic wave velocity for nanofluid of platinum is measured at different frequencies ranging form 1-5 MHz at room temperature (Table-2). Frequency variation of ultrasonic velocity for this fluid is shown in Fig. 2. It is observed that

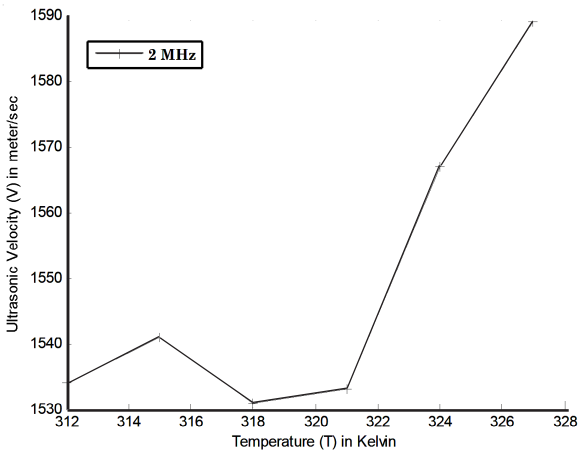

Fig. 1(ii). Temperature variation of ultrasonic velocity in nanofluid of platinum

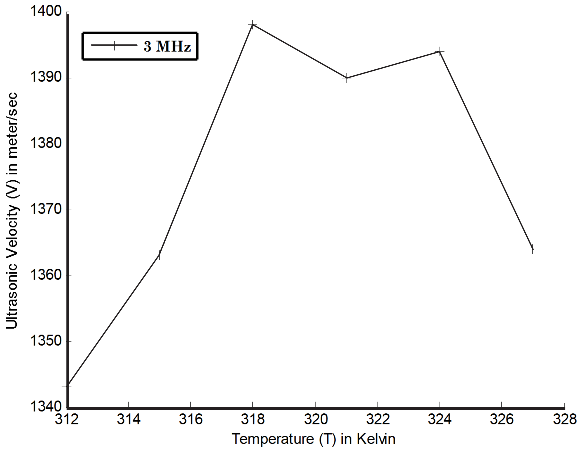

Fig. 1(iii). Temperature variation of ultrasonic velocity in nanofluid of platinum

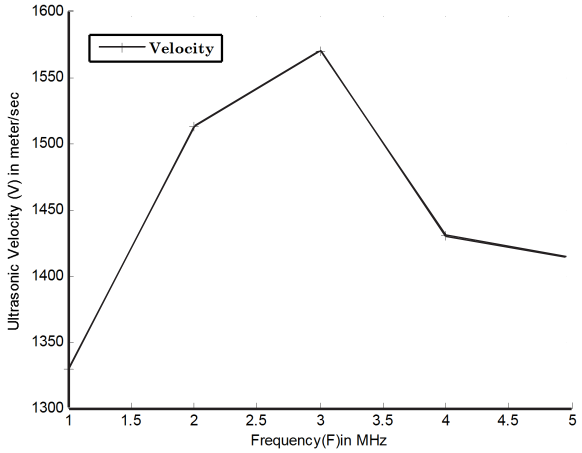

Fig. 2. Temperature variation of ultrasonic velocity in nanofluid of platinum

with increase in frequency from 1 MHz to 3 MHz, velocity increases; velocity decreases on increasing frequency up to 5 MHz.

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