Size Based Comparison of Colloidal Silver Nano Particles as Coolants

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Abstract- ***Colloidal silver shows different colours with changing shape and size of nano silver particles. This is due to light absorption and scattering based on Plasmon resonance wavelength, which depends upon particle shape and size. This was studied using the visible spectrums of silver colloidal solutions, which showed strong absorbance at wavelengths 450nm to 520 nm, indicating the increasing sizes of silver nano particles. We have measured the rate of cooling of aqueous colloids, containing different sized silver nano particles, having the same concentration. The results strongly suggest increase in the rate of cooling with increasing size of nano particles, i.e. the aqueous nano fluid, having larger sized nano particles, are more efficient coolants.***

Keywords- ***Silver nanoparticles, colloid, thermal conductivity, size dependence, cooling, absorbance, visible spectrometry.***

I. INTRODUCTION

Low thermal conductivities of traditional coolants like water, ethyl alcohol or propylene glycol hinders the efficiency and compactness of heat transfer devices. In recent years, metal nano particle dispersed heat transfer fluids or nanofluids have found favour as coolants because of their increased heat transfer capabilities. [1] [2] Nano particles have high surface to volume ratio and since their size is very small, a large number of nano particles are present on the surface.This enhances the conduction of heat in nano fluids, as heat transfer is a surface phenomenon. Thus, the size of nano particles plays an important role in the heat transfer mechanism.

Silver nanoparticle of various sizes and shapes like nano sphere, nano rods, nano wires etc. are desirable for their optical, electronic, biological and chemical properties [3-7]. Various factors like temperature, the rate and time of reaction etc decides the shape and size of silver nano particles formed by colloidal synthesis[8,9]. The size can be studied using UV-visible spectroscopy along with Mie theory [10-11]. The metals have free electrons in the conduction band and hence the metal surface behaves like a plasma. Surface plasmon resonance (SPR) is the resonant oscillation of conduction electrons stimulated by incident light. The particle size and shape decides the vibration frequencies of the electron. This is the reason the aqueous silver nanoparticles show vibrant colours and have characteristic absorption spectrum. Therefore, the sizes of so formed silver nanoparticles can be detected using UV-vis spectroscopy [12, 13].

II. PRESENT WORK

In the present work silver nano particles were prepared using the colloidal route. We prefer colloidal silver to dispersing silver nano particles in water. This is because the colloidal solution so formed is very stable. Also, since nano particles are to be used as coolants, the colloidal silver solution will not cause clogging and erosion. Further, the problem of agglomeration and nonuniform solution does not arise in this method.

The change in particle sizes of silver nano particles was confirmed, by multi colours of aqueous colloid and by visible spectroscopy.

Rate of cooling of aqueous silver nano particles as a function of their sizes was studied to see their effectiveness as coolants.

III.RESEARCH METHODOLOGY

A. Preparation of Silver Nano Particles

$AgNO_3$ and sodium citrate were procured from local vendor. For preparing silver nano particles in the colloidal form, 0.002 M aqueous $AGNO_3$ at 80^0C was mixed with 0.02M aqueous sodium citrate also at 80^0C. The mixture was continuously stirred on a magnetic heater cum stirrer, 1MLH REMI make, while maintaining the temperature at 80^0C. The total volume of colloid was maintained at 50ml, hence keeping the concentration of prepared colloid constant.

Density of Silver was calculated from the total amount of silver used for the synthesis, and the volume of the solution in which they were synthesized.

B. Visible Spectroscopy

The silver colloids were characterized using a colorimeter, Elico make, in the wavelength range from 450nm to 670nm.

C. Rate of Cooling

50 ml colloidal silver solution of various colours i.e. various sized nano particles was prepared. The solution colours were pale yellow, bright yellow, dark yellow, brownish yellow, brown and green.

Fig.1 The colloidal solution containing different sized nano particles

The colloidal solution was allowed to cool naturally in a closed 50 ml beaker. The readings for temperature were taken with the help of digital multimeter, of the make MECO, at an interval of 1 min, which was later increased to 3 min for the lower temperatures, once the temperature had fallen from 70^0C to 50^0C.

IV. RESULTS AND DISCUSSIONS

Spherical Ag nanoparticles with diameter smaller than about 100 nm show a plasmonic resonance in the UV-Vis spectra, centered at around 410 nm, depending on the size of nano particle. Larger particles will show a red-shift. The shape of nano particles is also important. For non-spherical shaped silver nano particles expected peaked contribution could be at wavelengths even larger than 500 nm. As a rule, increasing the nanoparticle size, or occurring aggregation of nanoparticles, will cause a sensible broadening of the plasmonic band towards larger wavelengths.

Figure 2 shows the extinction spectra of the silver nanoparticle colloids of different colours. The major SPR bands in the spectra peak are changing from approximately 450 nm to 520 nm. The curve also becomes flatter and broader as the colloidal silver changes colour from dark yellow to brown to green. This indicates the increase in size of nano particles.

TABLE I
ABSORBANCE SHOWN BY DIFFERENT COLOURED COLLOIDAL SOLUTIONS AT VARIOUS WAVELENGTHS

Wavelength (nm)	Colour of colloidal solution			
	Dark yellow	Brownish yellow	Brown	Green
450	0.54	1.37	0.1	0.15
470	0.5	1.46	0.12	0.2
510	0.42	1.04	0.23	0.37
520	0.37	0.69	0.14	0.39
540	0.14	0.5	0.06	0.32
570	0.08	0.45	0.04	0.31
600	0.01	0.19	0	0.29
670	0.54	0	0	0.17

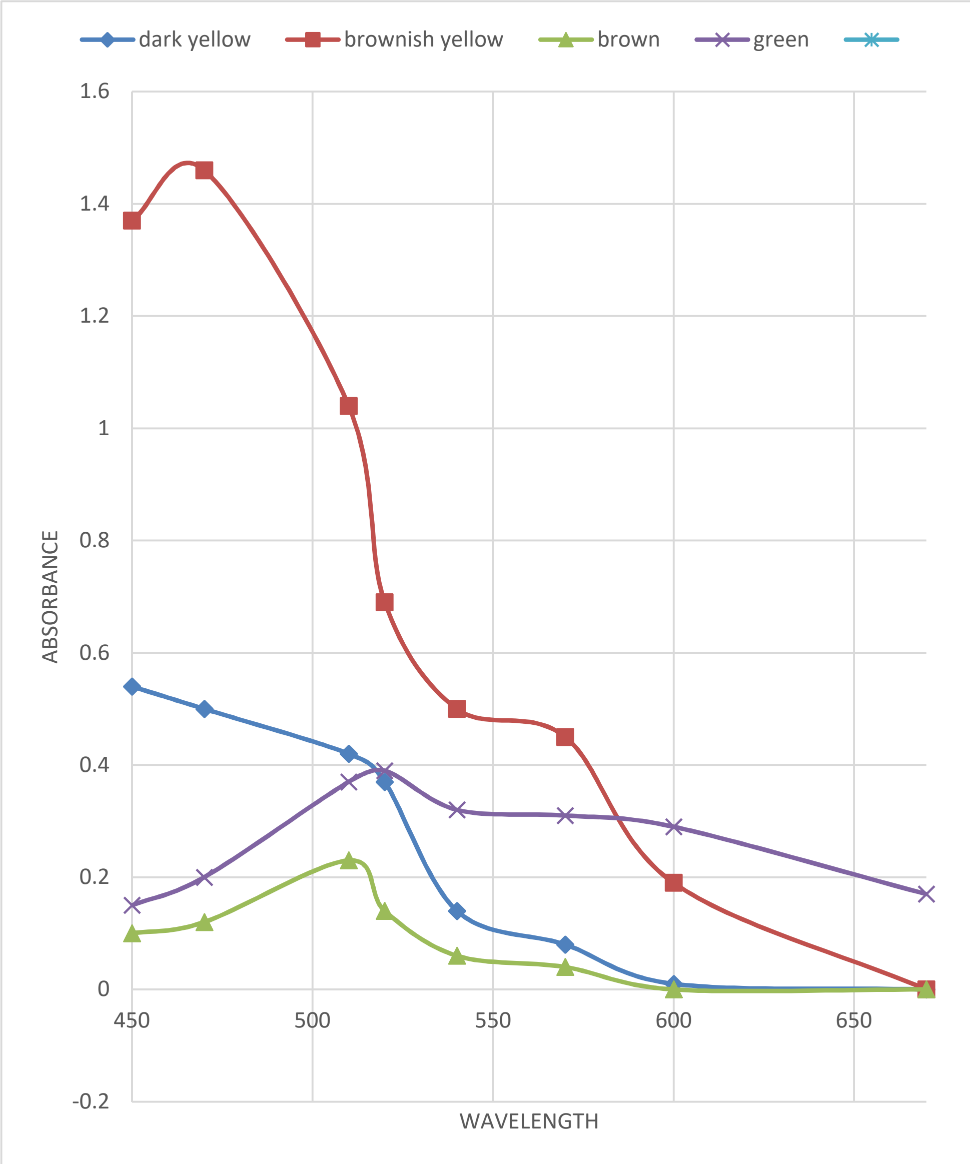

Fig.2 Absorbance versus wavelength of various coloured nano colloidal solution indicating a change in size of the nano particles

We could not get proper readings of visible spectroscopy for pale yellow and bright yellow solutions. This could be because their absorbance lay beyond the range of visible spectroscopy/our instrument.

Though the concentration of silver in the colloidal solutions is the kept constant (0.016% of solution), the solution starts becoming opaque towards brown colour and then once again starts becoming transparent as it goes towards green. This is also observed in the absorbance spectra, where the absorbance of yellow brown colour is the highest.

The absorbance of nanoparticles was taken at 68^0C and at room temperature. The difference between the two readings was less than 1%, thereby indicating the colloidal nano particles to be stable and capable of maintaining their shape and size with temperature.

Rates of cooling are listed in table number II. Figure 3 shows the rate of cooling of colloidal silver, with increasing size of nano particles which formed the colloid.

TABLE II
SIZE (INDICATED BY THE COLOR OF THE COLLOID) BASED RATE OF COOLING

Sr. No.	Cooling time in minute	Distilled water	Color of colloidal solution					
			Pale yellow	Bright yellow	Dark yellow	Brownish yellow	Brown	Green
1	0	75	75	75	75	75	75	75
2	1	72	70	70	70	70	70	70
3	2	67	67	67	66	65	65	64
4	3	65	64	64	63	62	62	59
5	4	62	61	60	60	59	58	55
6	5	60	58	57	57	56	56	52
7	6	58	55	55	55	54	54	50
8	7	56	53	55	54	52	52	48
9	10	51	48	49	49	47	45	43
10	13	46	45	45	45	41	40	39
11	16	44	41	43	42	40	39	36

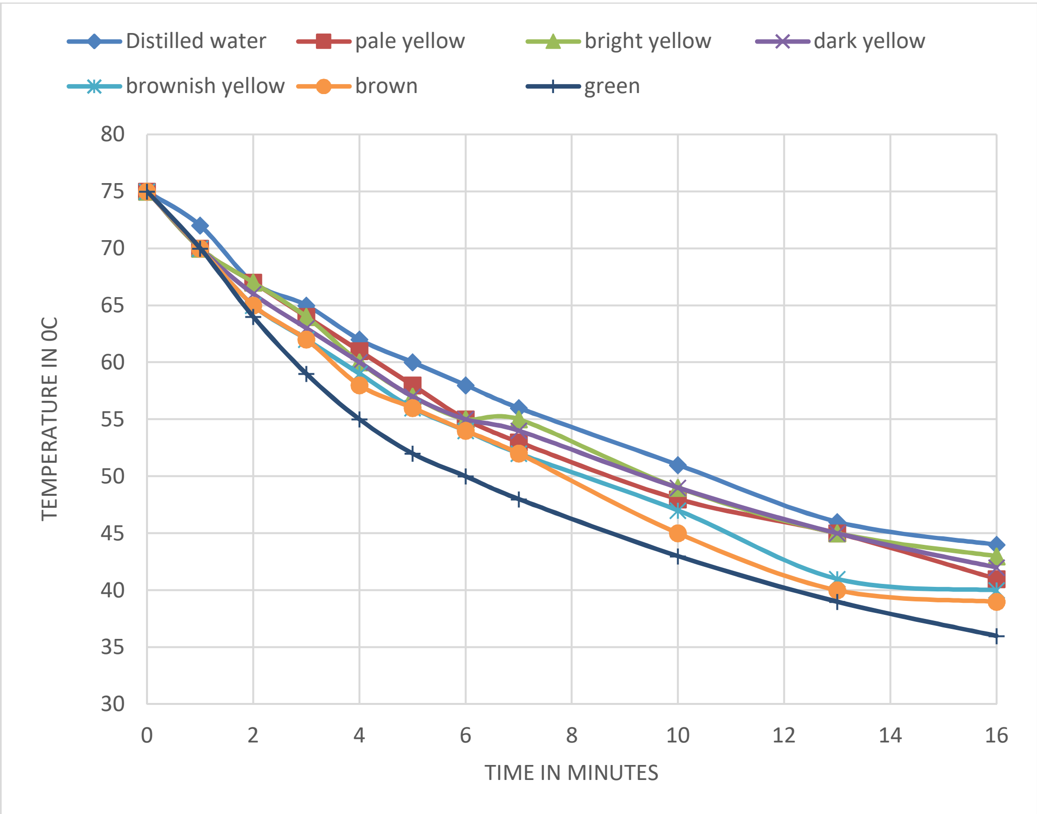

Fig. 3 Size/colour-based rate of cooling

The rate of cooling for various sized particles is visible in the figure 3. The cooling is faster by 12.5% for pale yellow in comparison to distilled water and increases up to 45% for largest silver nano particle studied i.e. green colloidal solution.

V. CONCLUSIONS AND OBSERVATIONS

Our technique produces silver nano particles above 400 nm in size and has non-spherical shapes, as concluded by the data on absorbance.

From figure 3 and table II it is observed that the rate of cooling increases with the size of nano particles. Increase in rate of cooling with the size of nano particles could be because of higher thermal conductivity and larger surface to volume ratio, of silver nano particles.

The fitted curves to data as projected in figure 3 indicates an increase in rate of cooling from 12.5% to 45% as the size of nano particle increases in comparison to distil water.

Silver nano particles produced by colloidal method are stable over long periods of time and with temperature. This prevents clogging and corrosion.

Above results indicate that silver nano particle mixed coolants will be more effective and economical.

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