

Effect of Nanoparticles on the Various Physical Parameters of Human Blood

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ABSTRACT: Different nanoparticles commonly available and used for research purposes were added to human blood samples in very low concentrations. Various physical parameters of blood; Viscosity, Surface tension, Conductivity, Refractive index and Size of RBC have been studied with very simple techniques and low cost materials available in the laboratory, before and after addition of nanoparticles. The results show a notable variation in the respective values. A change in these physical parameters in normal human blood indicates abnormalities at the cellular level. Thus the results presented suggest a caution in the unprotected handling of nanoparticles.

KEYWORDS: Nanoparticles, RBC, Viscosity, Surface Tension, Conductivity, Refractive index.

I. INTRODUCTION

Nanoparticles have potential commercial applications which make them the latest research subject. But one neglects their toxicological effects with respect to humans and the environment [1]. While working with nanoparticles in the laboratory, if proper precautions are not taken, then there is a possibility that the nanoparticles may enter the blood vessels through adsorption from skin pores, inhalation of vapours and powders, directly through wounds and cuts. Many nanomaterials have the ability to successfully penetrate cell membranes. Among synthetic nanomaterials, only cationic nanoparticles (metallic, quantum dots and dendrimers) [2] are capable of penetrating cell membranes. There are several ways nanoparticles damage cells [3-4]. There is a proof that they create pores in the cell membranes that can lead to cellular toxicity and abnormality in the functioning.

In light of this, different synthetic nanoparticles in very small quantities were added to normal blood samples and the various physical parameters have been studied. Literature review reveals that extensive work has been done on the various physical parameters of blood for normal and diseased persons [5-10]. But there is no much literature available comparing all the parameters at once and that too with added nanoparticles. Therefore the present study has been taken up to observe the influence of synthetic nanoparticles on the physical parameters of blood.

II. MATERIALS AND METHODS

Blood (3 ml) from 3 volunteers (free from chronic diseases), was collected in the laboratory into plastic tubes in anticoagulant medium heparin and same quantity of 0.9% NaCl was mixed to it and was used for different measurements at room temperature. 1mg of nanoparticles (CoFe_2O_4 , $\text{MnZnFe}_2\text{O}_3$ and TiO_2) with average particle size range of 30-40 microns synthesized by sol-gel method were mixed to the same blood samples and measurements were repeated at room temperature.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

The following are the experimental techniques adopted to calculate the different physical parameters of blood:

1. Size of RBC (LASER diffraction method):

A glass slide was prepared using normal blood sample. LASER of wavelength 6328 \AA was allowed to pass through the slide to see a circular diffraction pattern on a screen. Taking the radii of the 1st order fringe at different distances of the sample from the screen, the average size of the RBC was calculated using the formula:

$$d = 1.22 \lambda D/r \quad \dots \dots \dots (1)$$

where, d is the diameter of the blood cell, λ is the wavelength of the LASER light used, D is the distance between sample and screen, and r is the radius of the 1st circular fringe formed due to diffraction at RBC

The procedure and derivation of the equation has been mentioned elsewhere [11].

2. Viscosity (Open capillary tube method):

The open capillary tube method developed in the Biophysics research unit, Nizam college [12], was used to find the viscosity of the blood before and after addition of Nanoparticles. Viscosity was measured with the following expression,

$$\eta = R^2 \rho g / 8 v_0 \quad \dots \dots \dots (2)$$

Where R is the radius of the capillary tube, ρ is the density of the blood, g is acceleration due to gravity and v_0 is the maximum velocity of blood in the tube.

3. Surface Tension:

Surface tension of blood was calculated using the same open capillary tube method mentioned in section 2. The formula used was

$$T = 4 \eta \tan \alpha / R \cos \theta \quad \dots \dots \dots (3)$$

θ is the angle of contact of plasma and blood (30°), $\tan \alpha$ is the slope of the line drawn for $1/L$ (L is the length of column in capillary tube) and v is the velocity of blood.

4. Refractive index :

Plasma was separated from normal blood sample and nanoparticle mixed sample by centrifugation of blood. Refractive indices of the plasma were measured used Abbe's refractometer.

5. Specific conductivity:

The digital conductivity meter (Digisun electronics, Model No. DI 9009) was used to measure the specific conductivity of blood samples at 10 milli mho, in steps of 15 minutes each for the three normal blood samples and also the three blood samples mixed with nanoparticles.

III. RESULTS AND DISCUSSION

Table 1 presents data on Physical parameters such as size (diameter) of erythrocytes; coefficient of viscosity and surface tension of blood; and refractive index of plasma of human blood before and after adding three types of nanoparticles namely, CoFe_2O_4 , $\text{MnZnFe}_2\text{O}_3$ and TiO_2 . Here, the investigation on the influence of nanoparticles on human blood is at three levels of complexity - molecular (plasma), Cellular (erythrocytes) and tissue (whole blood) levels.

Size of erythrocytes is an important clinical parameter, which is very much concerned with tonicity of blood. It is evident from the table that size of erythrocytes increases, when compared to that of erythrocytes of normal blood, irrespective of type of nanoparticles. This may perhaps be due to the variation in tonicity of blood, when nanoparticles are added.

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 4, Issue 7, July 2015

Table1: Physical parameters of blood before and after addition of different nanoparticles

S. NO	Parameters	CoFe ₂ O ₄		MnZnFe ₂ O ₃		TiO ₂	
		Sample1 (only blood)	Blood+ CoFe ₂ O ₄	Sample2 (only blood)	Blood+ MnZnFe ₂ O ₃	Sample3 (only blood)	Blood + TiO ₂
1	Diameter(d) (μm)	6.8	7.2	6.2	6.72	6.3	6.8
2	Viscosity(η)(Poise)	0.0278	0.0253	0.0343	0.0321	0.0401	0.0462
3	Surface Tension(T)(dyn/cm)	31.022	28.353	58.599	33.267	34.223	24.837
4	Refractive index(μ)	1.341	1.342	1.341	1.342	1.342	1.347

Coefficient of viscosity is a potential rheological parameter in cardiovascular system. In the present study, this parameter of human blood decreases in the case of nanoparticles of CoFe₂O₄, MnZnFe₂O₃, while increases with the addition of nanoparticles of TiO₂. In the first two cases, there may be more separation of cells thereby decreasing cellular concentration (ie number of erythrocytes per unit volume). In the case of TiO₂ nanoparticles, there is possibility of aggregation of erythrocytes, hence increase in the viscosity.

Further, there is no significant change in refractive index of plasma, whatever may be nanoparticles added to the blood, revealing the fact that plasma is not affected by nanoparticles. It is interesting to note from Table 1 that surface tension of blood changed significantly with the addition of different type of nanoparticles under study.

Table 2 gives data on electrical conductivity of human blood before and after adding nanoparticles of CoFe₂O₄, MnZnFe₂O₃ and TiO₂ as a function of storage period varying from 0 to 60 min with an interval of 15 min. An increase in electrical conductivity of whole blood with the increase of storage period is evident from the table, whether nanoparticles added or not. Further it can be noted that electrical conductivity of whole blood increased, when nanoparticles were added.

Table2 : Data on Specific Conductivity (σ) (μσ) at 10mmho

S. No	Time in Min	CoFe ₂ O ₄		MnZnFe ₂ O ₃		TiO ₂	
		Sample1 (only blood)	Normal blood+ CoFe ₂ O ₄	Sample2 (only blood)	Normal blood+ MnZnFe ₂ O ₃	Sample3 (only blood)	Normal blood+ TiO ₂
1	0	12.15	12.60	6.06	9.09	8.17	8.84
2	15	15.57	13.87	7.12	10.29	9.07	9.95
3	30	15.91	15.90	8.38	10.61	9.38	10.16
4	45	16.57	18.20	9.09	10.94	9.65	10.26
5	60	18.94	19.50	10.13	11.18	9.85	10.37

Finally, the results show a notable variation in physical parameters under study with the addition of nanoparticles to the blood samples, particularly in the case of metal nanoparticles compared to TiO₂. The study reveals that a change in the physical properties is at the cellular level alone.

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IV. CONCLUSIONS

In sum, improper handling of nanoparticles during synthesis, characterization, and disposal or by accidental inhalation or adsorption results in the intervention of nanoparticles into the blood and tissues. Thus, the results presented suggest a caution in the unprotected handling and usage of synthetic nanoparticles. From the study, some important conclusions are drawn:

1. Influence of nanoparticles in blood is mostly at cellular level
2. Surface tension is a sensitive parameter to nanoparticles and hence can be used in practical purposes to evaluate the effect of nanoparticles.
3. Blood plasma may not be affected much with the interaction of nanoparticles.
4. Care must be taken in handling nanoparticles because they directly enter into the circulatory system through blood.

V. ACKNOWLEDGEMENTS

The authors are very much thankful to Prof. Adeel Ahmed (Retd), Department of Physics, Nizam college (OU), for the valuable suggestions and Mr. Raju Panthagani, Research Scholar (OU), for the nanoparticles. Thanks are also due to the volunteers: Mr. N. Chiranjeevi, Mr. Mujahid and Ms. Someyah, Department of Physics, Nizam college, Osmania University, Hyderabad, for the blood samples.

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