GRAPHENE NANOPARTICLES ON REFRACTIVE INDEX OF CANCEROUS BREAST TISSUES: SPECTRAL APPROACH

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Abstract

This work presents a study on the influence of graphene nanoparticles on the refractive index (RI) for application in breast tissues as an aid in the diagnosis of cancerous cells, using a spectral approach to evaluate the behaviour of glycerine and water-based nanofluids in various proportions. Glycerine-water solutions with different volumetric fractions of graphene were prepared, and the RI was measured using an Abbe refractometer. UV-Vis absorption spectra were analysed, indicating that higher volumetric fractions of graphene significantly affect light absorption and scattering patterns. This preliminary study identifies the optimal graphene volumetric fractions for future analyses of light-tissue interaction, aiming to improve diagnostic methods and characterisation of cancerous tissues through light scattering.

Introduction

The study of the refractive index (RI) in biological tissues is of great importance due to its numerous applications in medical optics. This physical quantity provides information about the interactions between light and tissues, and its quantification is essential for the identification and diagnosis of various pathologies and their respective therapies. Biological tissues have structural complexity in response to light beams, with structures (cells, membranes, and macromolecules) embedded in a heterogeneous network of fibres. The scattering of the optical field occurring in these structures is a complex phenomenon, closely related to both the spatial variations in RI and the morphological parameters of scattering canters, such as the size, numerical density, and shape of the particles. Therefore, any alteration in these parameters will be reflected in the light dispersion patterns [1].

This analysis is a highly useful auxiliary tool in the detection and characterization of tumours, as cancerous tissues show significant variations in their cellular structures, leading to changes in light scattering. In addition to these variations, light absorption by endogenous chromophores in tissues, such as melanin (RI = 1.70), also represents a characteristic that enables the classification of a tissue as pathological. These biomolecules, with high light absorption efficiency, especially in the ultraviolet region (high RI values), are vital for the organism's photoprotection against ionizing radiation [1].

It is also possible to relate the RI value with different parameters, such as dehydration, protein concentration, infections, elasticity, conductivity, cell division, oxygen saturation, metabolic rate, among others. Another example is the optical mapping of RI in breast tissues, which allows identifying differences in cancerous tissues, as they present higher RI compared to healthy breast tissues. Recent studies have shown important and significant differences in RI between healthy adipose tissue (which constitutes most of the breast) and epithelial and tumour tissues [2].

With the advancement of nanotechnology, graphene nanoparticles have been incorporated into RI studies. Graphene, composed of a single layer of carbon atoms arranged in a hexagonal structure, has unique and extremely important physical and chemical properties, such as being an excellent electrical and thermal conductor, highly resistant, impermeable to gases but permeable to water, possessing good elasticity, and exhibiting excellent optical transparency [3].

Methods

This poster presents the preliminary study conducted to select the ideal concentration to achieve the proposed objective. For this purpose, we used glycerine and water as the base fluid in different concentrations, $x C_3H_8O_3$+(1- x)H_2O. The refractive indices of the following base solutions were measured: 100:0, 80:20, 60:40, 50:50, 40:60, and 20:80.

Five nanofluids were prepared with different volumetric fractions of graphene nanoparticles, namely 0.01%, 0.025%, 0.05%, 0.075%, and 0.1%, for glycerine-water base fluids with volumetric ratios of 50:50 and 20:80. The nanofluids were prepared using the two-step method [4], employing graphene nanoparticles with CAS 7782-42-5, size 11-15 nm, sourced from the commercial supplier *MK-nano*; glycerine solution provided by *labKem*, with CAS number 56-81-5; along with distilled water obtained in the laboratory on the same day. To homogenize the solution, we used an HD 2200 ultrasonic homogenizer from *Bandelin Sonopuls* with a titanium tip (M72). A *Kern* analytical balance with a resolution of 0.0001 g was used for mass measurements.

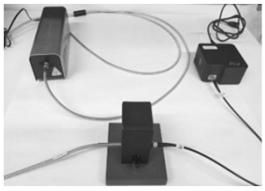

Figure 1. Spectral aquisition configuration

The RI measurement was performed using an Abbe refractometer from *Kern*, model ORT-1, with a resolution of 0.0005. For spectral acquisition, the FLEX STD UV-VIS T24402 spectrometer from *Sarspec* was used, along with the *Avantes* CUV-ALL-UV/VIS SF210125 sample holder and 10x10 mm quartz cuvettes from *PG Instruments*. The light source was a deuterium-tungsten lamp T17805 from *Sarspec*, and the fiber optic cables used were UV/VIS with diameters of 200 nm (T15717) and 600 nm (T05512), both with a length of 50 cm. This setup, as shown in figure 1, was configured based on spectral acquisition, where the nanofluid dilution used was 0.1 cc in 3 cc of base fluid.

Discussion and Conclusion

The refractive index results for the different glycerin-water base fluids are presented in table 1, where it can be observed that the index decreases with the increase in the percentage of water.

Table 1 – Base fluid refractive index

x $C_3H_8O_3$ + (1 - x) H_2O	RI
20:80	1,3675 ± 0.00003
40:60	1,3944 ± 0.00003
50:50	1,4085 ± 0.00003
60:40	1,4235 ± 0.00003
80:20	1,4475 ± 0.00003
100:0	1,4745 ± 0.00003

Table 2 – Refractive index of nanofluids with different concentrations of graphene

x % (V/V) *graphene*	RI (50:50)	RI (20:80)
0.011%	1.4056 ± 0.00003	1.3605 ± 0.00003
0.024%	1.4055 ± 0.00003	1.3605 ± 0.00003
0.048%	1.4056 ± 0.00053	1.3605 ± 0.00003
0.064%	1.4056 ± 0.00003	1.3605 ± 0.00003
0.082%	1.4056 ± 0.00005	1.3605 ± 0.00003

It was observed that at low concentrations of graphene nanoparticles, the RI did not show significant changes between the prepared samples. However, the RI decreased compared to the base fluid used in these samples (50:50). In figure 2, graph (a), an increase in RI can be observed with the rise in the volume concentration of glycerine in the base fluid solution, showing a linear relationship between the change in concentration and the refractive index. However, for low volume fractions of graphene nanoparticles, the RI does not show significant changes between the prepared samples, with the RI value decreasing compared to the base fluid without nanoparticles. In graph (b) of figure 2, it can be observed that with a slight increase in the volume fraction of graphene, the variation in RI is almost negligible.

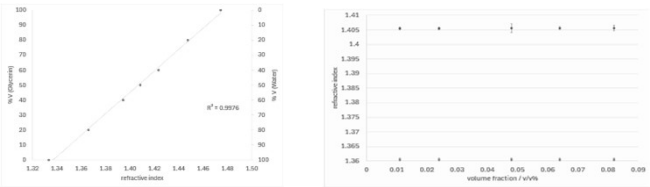

Figure 2. Study of the refractive index, (a) of the different base fluids, (b) with different volume fractions of graphene in two base fluids with concentrations of 50:50 and 20:80.

Figure 3 shows the UV-Vis absorption spectra. Due to the presence of graphene in the base fluid, it was observed that, for concentrations of 0.075 and 0.1% by volume, absorption reached the maximum limit of the equipment in the 190 to 200 nm range, while at lower concentrations, the peak at around 200 nm was visible in a 50:50 glycerine-water base fluid.

For the 20:80 base fluid, at concentrations of 0.05, 0.075, and 0.1% by volume, the absorption spectrum could not be analysed due to signal saturation in the 190 to 208 nm range, even with diluted samples, as shown in figure 4.

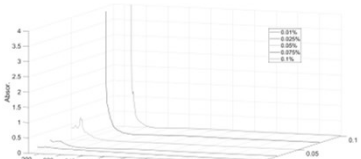

Figure 3. UV-Vis absorption spectra of nanofluids diluted in the base fluid with 0.01%, 0.025%, 0.05%, 0.075% and 0.1% graphene in 50:50 volume fraction.

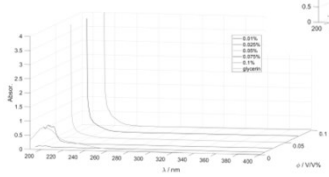

Figure 4. UV-Vis absorption spectra of nanofluids diluted in the base fluid with 0.01%, 0.025%, 0.05%, 0.075% and 0.1% graphene in 20:80 volume fraction.

However, additional absorption bands appeared between 850 and 950 nm, which were not visible in the 50:50 nanofluid, as shown in figure 5.

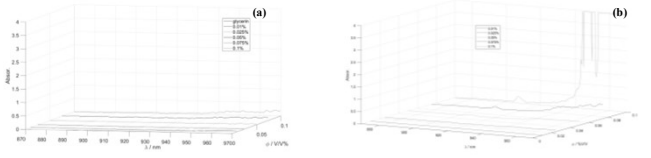

Figure 5. Absorption spectra in the infrared zone of nanofluids with glycerin-based fluid plus water in the proportion of (a) 50:50 and (b) 20:80

The study aims to further investigate the nanofluids with graphene nanoparticles in both UV-Vis absorption and transmittance, as well as to apply an alternative method for measuring the refractive index to quantify the RI of tissues embedded in the nanofluid. Therefore, the next step is to apply these nanofluids to tissue samples with the objective of analyzing the influence of graphene on the interaction of light with the tissues, assessing possible differences in light scattering.

Acknowledgements

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