# Study of the scattering of the light in aqueous samples collagen in the presence of nanoparticles and curcuma pigment

**Article** · June 2015

DOI: 10.1117/12.2181121



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# Study of the scattering of the light in aqueous samples collagen in the presence of nanoparticles and curcuma pigment

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## ABSTRACT

In this work we investigate the scattering of light in means turbid in the presence or not of pigment and nanoparticles. For this we initially using a sample of collagen from means turbid with and without the presence of curcuma pigments and nanoparticles. Our results show that the light scattering is more intense in the samples with nanoparticles and curcuma pigment.

**Keywords:** Collagen, curcuma, scattering, nanoparticles, laser

## 1. INTRODUCTION

Recently, the cosmetic industry has invested heavily in the use of nanoparticles to potentiate the effect of the conventional products the nanoparticles have great power of get in skin. The first product using this technology was a face cream done of vitamin E nanocapsules used in the aging combat of the skin is due L'Oréal in 1995. The products using this new technology are applied in the skin with action anti aging and photoprotection.[1] The sunscreens based in this technology generally use nanoparticles zinc oxide and dioxide titanium with sizes of 70 and 200 nm.[2]

This work has the purpose of investigating the scattering of light in means turbid when we added nanoparticles and pigments. The turbid means studied was the hydrolysed collagen obted of the extraction from the collagen present in skin, cartilage and bone of animals that is very utilized in human diets. This is a rich font of fibres and animal protein that promote resistance and elasticity in present tissue.[3,4] The pigment used in this work was extracted from curcum plant that belongs to Zingiberaceae family,also know as turmeric, compost of three curcuminoids pigments: curcumin, demethoxy curcumin and bisdemethoxy curcumin. Formed by rhizomes the curcum is a typical plant of tropical and subtropical regions of the world. This has great applicability in the oriental medicine and in the cosmetics and aliments industry.[5,6] This work seeks to contribute to better understanding of how the presence of nanoparticles can alter the diffusion and scatting of light in turbid means. Here, we used calcium and barium tungstate nanoparticles.

## 2. MATERIALS AND METHODS

### 2.1 Materials

In this work we used Hydrolyzed Collagen Gelita, provided by the Brazilian industry Vital Naturallis of Natural Products LTD to simulate a turbid medium. The pigment used in this work was the curcuma oleoresin extracted from curcuma. The curcuma used was provided by a vegetable garden located in the in Altos city, Piauí-BR. We also use nanoparticles calcium and barium tungstate here obtained by Pechinni technique size 200nm.[7]

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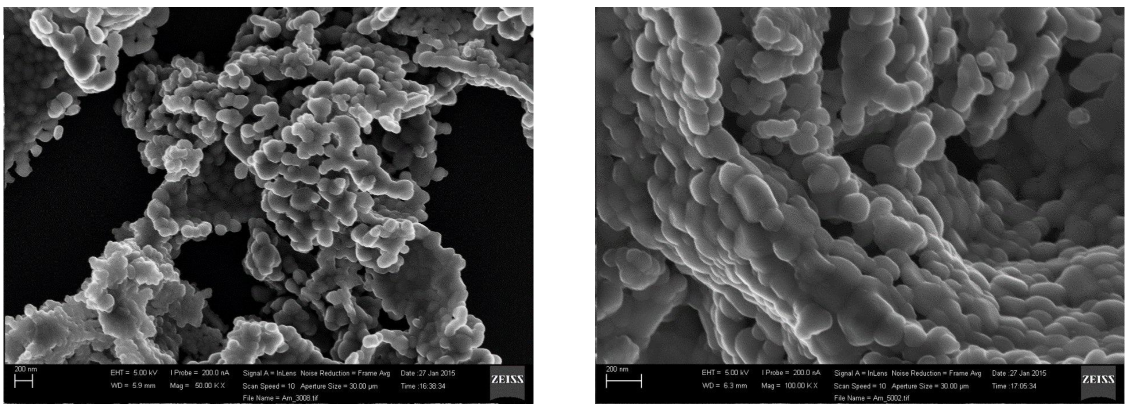
Biophotonics South America, edited by Cristina Kurachi, Katarina Svanberg, Bruce J. Tromberg, Vanderlei Salvador Bagnato, Proc. of SPIE Vol. 9531, 95311R · © 2015 SPIE
CCC code: 1605-7422/15/$18 · doi: 10.1117/12.2181121

## 2.2 Method

The method used here was divided into four parts: extration of pigment, experimental set, sample preparation and analysis of the images.

For extracting the curcum pigment first washed and cut into slices the curcum rhizomes. Once clean the material was placed to dry by a period of 24 hours in a vacuum drying oven Marconi Q819V2 mark model preheated to an average temperature of 75±1°C. Once dry in oven rhizomes has been ground in a grain mill and then weighed, in which one obtains 40g of curcum, curcum was diluted in 240 ml of acetone so that concentration of the solution is approximately 0,17g/mL and the solution obtained was put in a reflux system. This system was assembled using a heating mantle, a round bottom flask in which the solution is deposited to the flask and coupled an air condenser. This the solution remained in the system for 40 minute period a mean temperature of 80°C, removed from the system after the solution was filtered through filter paper. The solution obtained after filtration has been isolated and leave a period of six days for the whole acetone evaporate so that in the end only from obtaining oleoresin curcuma, consisting of a folder.[6] The pigment was diluted in ethanol at a ratio of 0,001g/ml.

The nanoparticles used this work were obtained by Pechini technique.[7] The Fig.1a and Fig.1b show the micrography of calcium tungstate ($CaWO_4$) and barium tungstate($BaWO_4$) nanoparticles, respectively.




(a) (b)

Figure 1. Micrography of nanoparticles (a) $CaWO_4$ and (b) $BaWO_4$.

The experimental apparatus used in our study was based on the arrangement of Melo et al.[8] and by Souza M.V.[9] For this purpose we use a He-Ne laser, wavelength 632.8 nm and a power of 0.5 mW, a CCD connected to a computer, supports and a box lined to isolated the system. The laser was positioned so that its focusing beam perpendicularly on one of the sides of the sample and the camera positioned on top of the perpendicular to the beam direction.

Samples were prepared in aqueous solution using deionized water, where the proportion of collagen, curcuma and nanoparticles, is respectively 0.67 g/ml 0.000067 g/ml and 0,0067 g/ml. Were prepared six samples different numbered of according with Tab. 2.

Table 1. Specifications of the samples

| **Samples** | **components** |
|---|---|
| 1 | Collagen |
| 2 | Collagen e curcuma |
| 3 | Collagen e $BaWO_4$ |
| 4 | Collagen e $CaWO_4$ |
| 5 | Collagen, curcuma e $BaWO_4$ |
| 6 | Collagen, curcuma e $CaWO_4$ |

The images obtained in the experiment was analysed using the ImageJ software, multidimensional image processing software and open source, which provides gray shades, on a scale from 0 to 255 in each pixel of the sample.[10] The Fig. 1 show analyse of the light transmission and light scattering 90°.

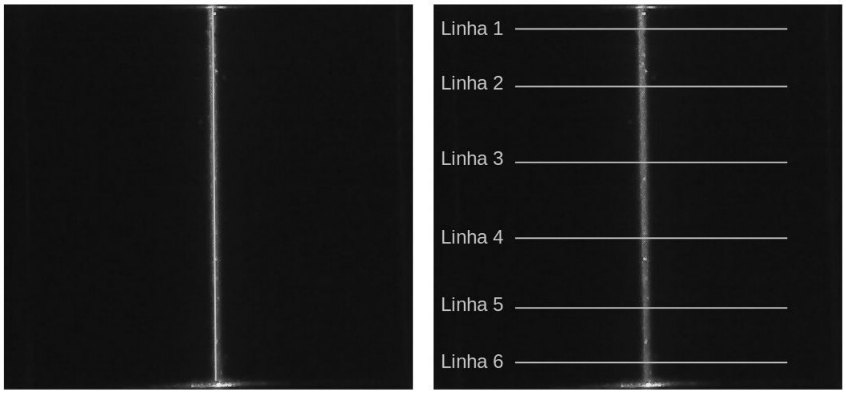
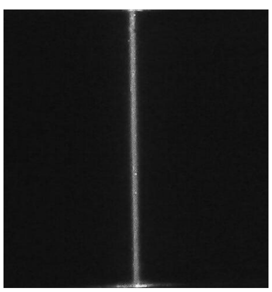


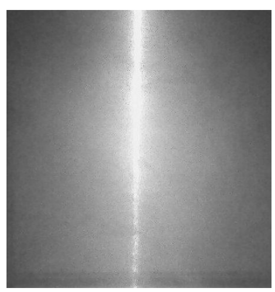

Figure 2. Analysis of samples

## 3. RESULTS AND DISCUSSION

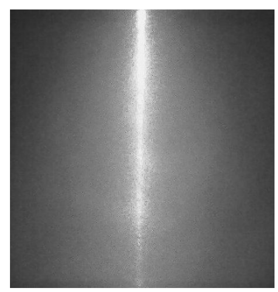
The Fig. 3 shows images of the six samples illuminated with He-Ne laser. We note that the samples presents considerable alterations of light scattering that are evidenced in Fig. 3b , Fig. 3c, Fig. 3e and Fig. 3f that are the images of the samples containing nanoparticles.



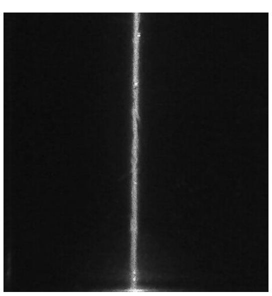
(a) Sample 1



(b) Sample 3

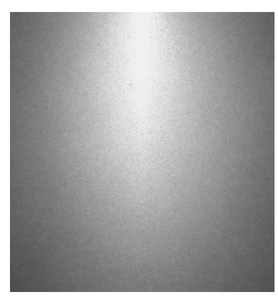


(c) Sample 4



(d) Sample 2

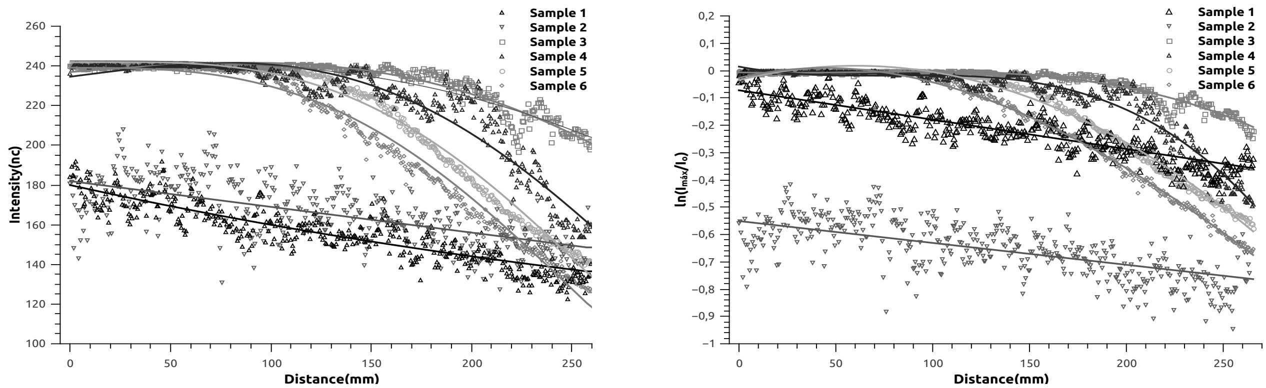
(e) Sample 5



(f) Sample 6

Figure 3. Photos of the sample illuminated with laser.

The samples 5 and 6 of Fig. 3e and Fig. 3f are composed of collagen, curcuma and nanoparticles, we observed an increase in the scattering of incident light, indicating an interaction between the pigment and the nanoparticles.




(a) (b)

Figure 4. (a) Decay of light intensity in the sample versus distance. (b) Logarithmic plot of the Fig. 4a.

In Fig. 4a curve of light intensity decay characteristics are shown when penetrating the samples, these graphs we can see that samples 1 and 2 have similar behaviours to an exponential decay that given by the Beer-Lambert Law[8]

$$I = I_0 e^{-\mu_a r}, \tag{1}$$

when $\mu_a$ coefficient of absorption. However, the samples containing nanoparticles have a different exponential decay.

The Fig. 4b show the logarithm of the intensity decay curves of light through the medium versus distance. In this graph we see that samples 1 and 2 show a linear fit confirming an exponential decay, as suggested by Equation (1). The graphs of samples 3, 4, 5 and 6 can be adjusted by a third degree polynomial this form the light intensity decay of the samples containing nanoparticles given by the following expression

$$y = y_0 exp(-x^3/t_1 - x^2/t_2 - x/t_3) \tag{2}$$

We construct the a plot log-log of the Fig. 4a to understand decay of light intensity versus distance of the samples containing nanoparticles. In this graph we observed that the light intensity decay curve of the nanoparticles it has three different regimes that can be observed in Fig. 5. The values of the curve inclination of each regimes are specified in Tab. 2.

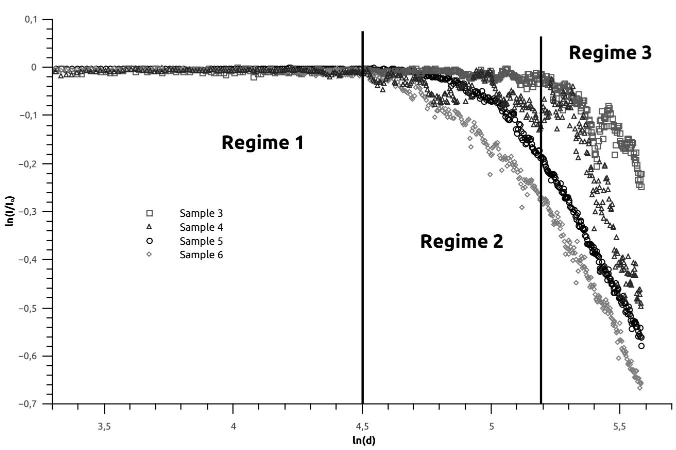



Figure 5. Logarithmic plot conforming the exponential decay versus logarithmic of the distance.

We note in Fig. 5 that the samples with barium tungstate nanoparticles present major penetration of light of that the samples with calcium tungstate nanoparticles.

Table 2. The $\theta_1$, $\theta_2$ and $\theta_3$, are the value of the curve inclination for the regime 1, regime 2 and regime 3, respectively.

| **Angle** | $\theta_1$ | $\theta_2$ | $\theta_3$ |
|---|---|---|---|
| **Sample 3** | $3,81 \cdot 10^{-4}(6)$ | $2,84 \cdot 10^{-2}(4)$ | $0,46(3)$ |
| **Sample 4** | $1,37 \cdot 10^{-3}(5)$ | $1,00 \cdot 10^{-1}(4)$ | $1,27(3)$ |
| **Sample 5** | $5,22 \cdot 10^{-4}(6)$ | $2,59 \cdot 10^{-1}(4)$ | $0,97(4)$ |
| **Sample 6** | $2,53 \cdot 10^{-3}(7)$ | $3,88 \cdot 10^{-1}(4)$ | $1,01(3)$ |

The $\theta_1$, $\theta_2$ and $\theta_3$ are the values of the curve inclination for the regime 1, regime 2 and regime 3, respectively. The value of $\theta_1$ correspond the a distance of 0 to 90,4 mm, $\theta_2$ of 90,4 to 181,4 mm and $\theta_3$ of 181,4 to 265 mm. In regime 1 the decay of light intensity is the same for all samples has a steady behaviour. The Regime 2 present a comportment of transition. In Regime 3 the light intensity in the samples falls obey a power law with we note that to samples 5 and 6 the exponents are equal due presence of the curcuma pigment and absence of the pigments i.e.,in the samples 3 and 4 we note that light decay intensity is more intensity in the sample calcium tungstate than of the sample barium tungstate. This show that th pigment interacts with the nanoparticles of forms different but the light decay intensity in this samples are equal however the nanoparticles present light decay intensity different.

The scattering of light perpendicular to the optical path of light, was carried out by analysing six different points of the samples, as shown in Fig.6, Fig.7 and Fig.8. In these graphs we observe the extension of curves so we can see how the light and spread the samples. We observed that samples 1 and 2, Fig.6a and Fig.6b does not have an expansion curve in accordance with the penetration of light into the sample, so that the decrease of light intensity is related to the absorption .

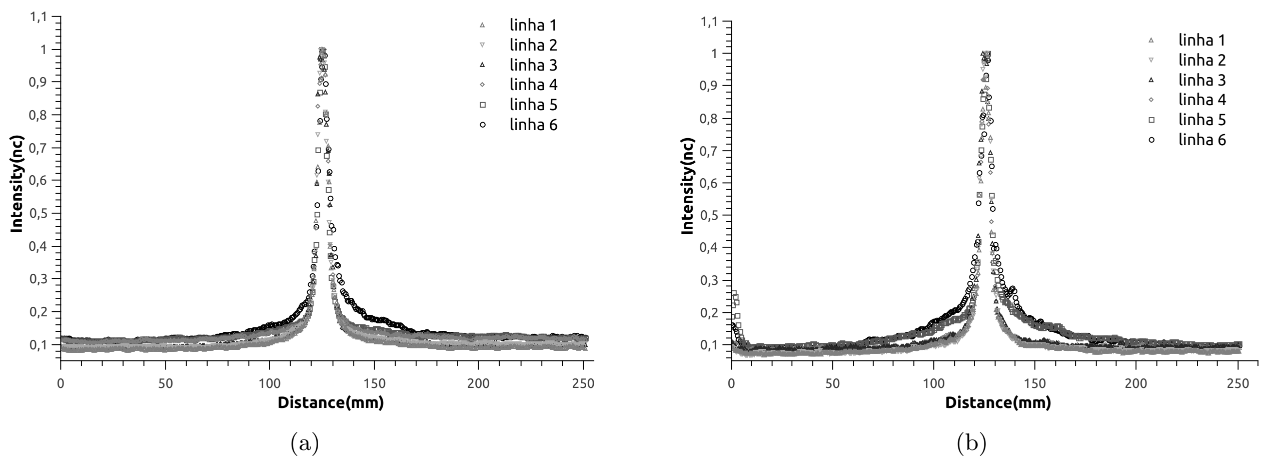
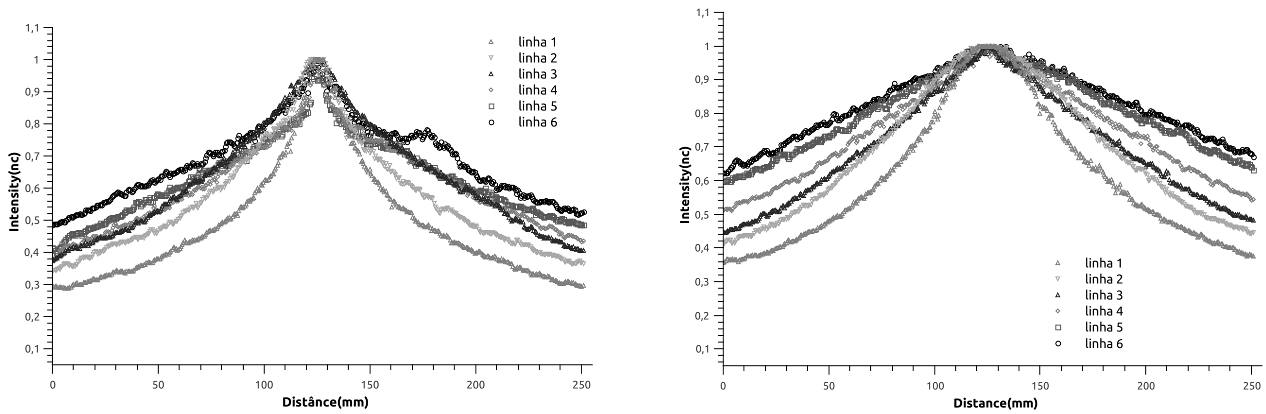



Figure 6. Scattering of light 90° of the laser beam in six different points. (a) Collagen. (b) Collagen and curcuma.

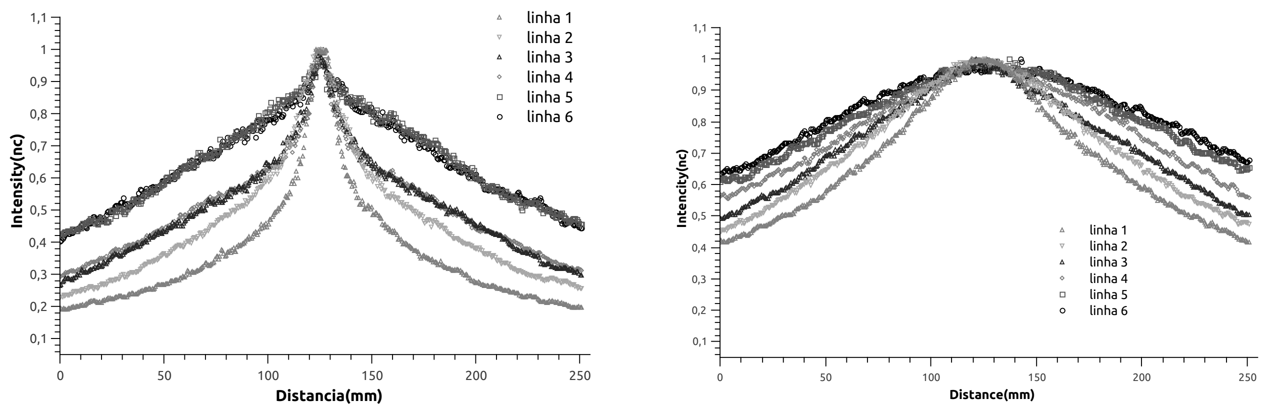
The Fig.7a and Fig.8a show the behaviour of Samples 3 and 4 in relation to the 90 scattering, we found that the effect was higher in sample 3 compared to sample 4, indicating a relationship with form of nanoparticles, since both materials have 200 nm in size. In Fig.7b and Fig.8b are graphs of the scattering at 90 degrees of show samples 5 and 6, we can observe the specimen 6 has a higher scattering compared to sample 5.

When analysing the Fig.7a, Fig.7b, Fig.8a and Fig.8b, we can say that the scattering effect to 90° is greatly modified when we add turmeric solving nanoparticles and collagen, this effect was more evident in the samples of $CaWO_4$, indicating an interaction of these molecules with the possible formation of agglomerates or links. For studies of the light scattering effect in turbid media this solution proved to be promising, requiring further investigation.




(a) (b)

Figure 7. Scattering of light 90° of the laser beam in six different points. (a) Collagen and $BaWO_4$. (b) Collagen, curcuma and $BaWO_4$.




(a) (b)

Figure 8. Scattering of light 90° of the laser beam in six different points. (a) Collagen and $CaWO_4$. (b) Collagen, curcuma and $CaWO_4$.

## 4. CONCLUSIONS

In conclusion this work we can observed that the decay of light intensity through the collagen solution is similar to that found in biological tissues, have both an exponential decay which obeys Lambert Beer's law. As we study the light scattering to 90 degrees in collagen solutions and nanoparticles, we find that the solutions with calcium tungstate nanoparticles were more efficient than barium tungstate nanoparticles, although they have the same size 200 nm, such behaviour may be due morphology of nanoparticles however in the presence of the curcuma pigment the light decay intensity present identical as show in the Tab. 2 to samples 5 and 6. Nanoparticles of calcium tungstate are more efficient for retaining the light in the outer layers compared to the barium tungstate. The measurements of solutions with the addition of curcuma pigment showed changes in the scattering of light through the samples with calcium tungstate, where there was an increased effect, indicating a strong interaction between the nanoparticles and the pigment for these studies that solution showed promise, requiring further investigation. This work shows that the presence of nanoparticles changes the behaviour of light in a turbid mean. With the data obtained in this work we can see that the use of nanoparticles can intensify the scattering of light in a biological medium so that its use should be further investigated.

## 5. ACKNOWLEDGMENTS

Universidade Federal do Piauí-UFPI
Fundação de Amparo à Pesquisa do Estado do Piauí-Fapepi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