International Journal of Progressive Sciences and Technologies (IJPSAT)
ISSN: 2509-0119.

Vol. 44 No. 2 May 2024, pp. 206-211

Characterizing the Impact of Gold Nanocolloids on the Polarization Properties of Olive Oil

Winarno, Qidir Maulana Binu Soesanto, Ketut Sofjan Firdausi, and Ali Khumaeni*

Department of Physics, Faculty of Science and Mathematics,
Diponegoro University, Jl. Prof. Soedharto, S.H., Tembalang, Semarang 50275, Indonesia
*Corresponding email: khumaeni@fisika.fsm.undip.ac.id

Abstract— We conducted the research to investigate the impact of adding gold nanoparticle colloids on the changes in the polarization angle of olive oil. This study employs the natural polarization method. A laser pointer with a wavelength of 532 nm serves as the light source in this study. We obtain the gold colloid solution using the laser ablation method and then dissolve it in the aquabidest. The samples used were olive oil and gold colloids at concentrations of 10 ppm, 20 ppm, 30 ppm, and 40 ppm. This research revealed that gold nanoparticles exhibit active optical properties characterized by nonlinear graphic patterns due to the influence of asymmetric molecules. The results also showed a straight-line connection between higher levels of gold colloid and changes in polarization angles because of the buildup of molecules that are not symmetrical. The addition of gold colloids to olive oil results in an increase in the polarization angle, which is dependent on the size of the gold colloid concentration. Although there is an improvement in optical properties, adding gold colloids does not alter the original characteristics of olive oil. This finding allows the use of gold colloids in trace detection applications and opens up opportunities for nanotechnology applications in the manufacture of new materials with adapted optical properties.

Keywords— Colloidal gold, optical properties, natural polarization, change in polarization angle.

I. INTRODUCTION

The phenomenon of light polarization has been the subject of extensive study across multiple scientific disciplines due to its fundamental significance in areas such as physical optics, photochemistry, and spectroscopy. The polarization angle, a critical parameter that denotes the vector orientation of the electric field in a light wave, is known to undergo changes when the light interacts with a variety of media. Such interactions can cause a wide array of effects that have significant implications for various applications, ranging from optical filtering to the analysis of molecular structures. In the recent literature, Yan et al. have elaborated on the pervasive influence of polarization within the context of optical physics[1], while Tamaki et al. have offered insights into the interaction of polarized light with different substances.[2]

Olive oil is a very useful ingredient in the fields of food and health. Olive oil's refractive index and its sensitivity to light make it an interesting subject for optical experiments[3]. Olive oil's unique optical properties, like its refractive index and absorption spectrum, provide valuable insights into its purity and composition. Variations in these optical properties can indicate differences in the type of fatty acids present or the presence of other organic compounds, which may indicate a deviation or degradation of the product. By examining how the polarization of light changes as it passes through various oil samples, we can apply light polarization techniques to the study of olive oil. It refers to the vector orientation of the electric field of light that is sensitive to the composition and structure of the medium and therefore can provide information about the quality of olive oil[4]. The ability to quickly and accurately assess the quality of olive oil using optical methods is valuable for quality control, ensuring compliance with standards, and proving product label claims[5].

The impact of the gold colloid addition on the change in polarization angles has been an interesting research topic in recent decades. Several previous studies have extensively studied the unique optical properties of the gold colloid, including its ability to reduce light wavelengths and improve polarization efficiency. Hue et al. chose gold nanoparticles because they have special surface plasmon resonance properties and can change the optical properties of the material they are in[6]. Surface plasmon resonance occurs when conductive electrons in nanoparticles resonate with light at a certain frequency, which results in a significant increase in light absorption and dissipation. These properties make gold nanoparticles a very interesting material for the study of various optical applications, such as enhanced spectroscopic signals and biosensor surface modeling[7]. Furthermore, olive oil possesses attractive optical properties, as previously mentioned, and the addition of gold colloids can significantly influence olives' polarization properties.

Experiments by emitting laser light on olive oil combined with gold colloids enabled us to observe changes in polarization angles and identify the roles of various variables, such as wavelengths of light, size, and concentration of nanoparticles, as well as complex interactions between nanoparticles with laser light and oil medium[8]. By looking at how light interacts with gold nanoparticles and oil, the study goes into more detail about how adding a golden colloid changes the optical properties of oil. This can reveal how light and matter interact on a nanometer scale and suggest new uses for optical sensor technology and photochemical and optoelectronic devices. Through this research, we hope to make a significant contribution to the development of new technologies in the fields of spectroscopy, optical cryptography, and sensory science[9].

We expect this research to provide new insights into how gold nanoparticles can modify the optical properties of olive oil, and its potential applications in various optical applications. We will study the gold nanoparticles in olive oil using polarimetric methods to measure changes in the polarization angle of light as it passes through the medium. We anticipate that the gold colloid's addition will significantly alter the polarization angle, offering fresh perspectives on the optical characteristics of the altered olive oil. In addition, an in-depth understanding of the interaction between gold nanoparticles and olive oil can also make a significant contribution to the development of optical biosensors and new optical materials. Researchers anticipate that the results will aid in the advancement of optical sensor technology and surface modeling through the use of colloidal optical properties[10]. A better understanding of this phenomenon can also pave the way for new applications in the fields of medicine, the environment, and information technology. This study could also serve as the foundation for future research on the optical properties of materials that incorporate nanoparticles for various purposes. Understanding how gold nanoparticles interact with the medium allows us to optimize the use of optical properties in the development of more sophisticated and effective technologies.

II. Material and methods

2.1. Experimental Procedure

Here are the equipment used in this study: Light source: The 532 nm wavelength green laser indicator serves as a light source. We chose a green laser because it can enhance the interaction of light with the sample because it reacts with the surface plasmon of the gold nanoparticles. Unpolarized light can be converted into linearly polarized light using polarizers. To test a variety of polarization orientations, the researchers could adjust the polarizers from 0 to 360. Cuvette: To see how light interacts with the sample, the researchers placed the samples inside a transparent glass cuvette with an optical canal length of 1 cm. The analyzers have the same scale to assess how the polarization angle of light changes after interacting with the sample. To this, rotate the analyzer to the minimum light intensity of the screen. Screens: function to read changes in light intensity by capturing polarization laser beams when interacting with samples.

The study used a gold colloid solution made using laser methods of 40 ppm ablation and then weakened by aquabidest to 10 ppm, 20 ppm and 30 ppm. People often choose laser ablation because of its ability to produce nano-sized particles with high purity and size control, without the need for chemical contaminants added during the manufacturing process. We conducted research using natural polarization methods to identify the characteristics of olive oil and gold colloid solutions at different concentrations. We then combined the olive oil with the gold colloid to observe the increased polarization angle as a result of samples merging. This study can provide valuable insights into how the addition of gold nanoparticles in different concentrations affects the nonlinear optical properties of olive oil.

III. Result and discussion

This study used the method of transmission polarization to observe characteristic changes in the polarization angle of light in the gold colloid. Due to the non-symmetrical properties of its constituent molecules, we use transmission polarization to study the active optical properties of a material. Observations of the changes in polarization angles produced by asymmetric and symmetric molecules are important and interesting. Figure 1 shows the change in the polarization angle of the gold colloid as a function of the polarizing angle for various concentrations using a wavelength of 532 nm.

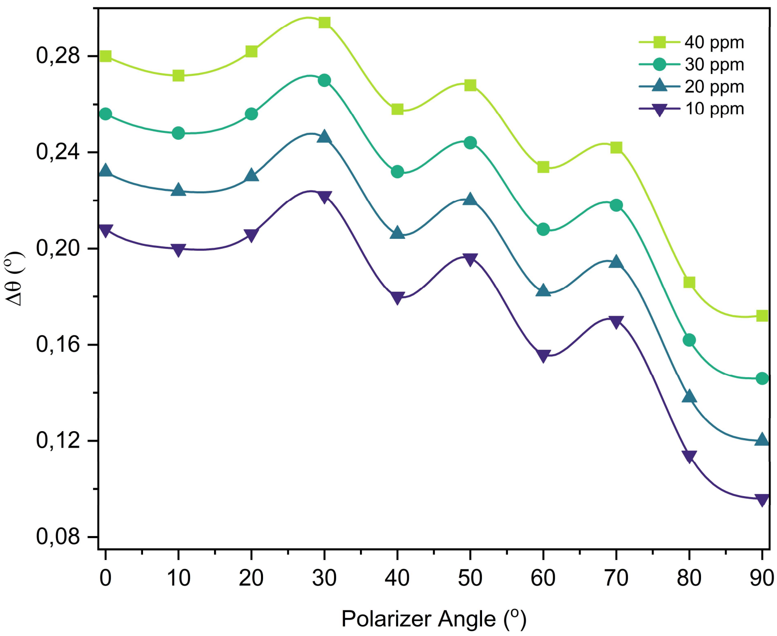

Figure 1. Changes in the gold colloid's polarization angle as a function of the polarizer angle

Figure 1 test results show that the gold colloid has active optical properties due to the presence of non-symmetrical molecules that generate non-linear graphic patterns. An asymmetrical molecule produces the greatest polarization angle change shown at a polarizer angle of 30˚, whereas a symmetric molecule results in the smallest polarization angle change indicated at a 90° polarizer angle. This suggests that there is a dependence between the shape of the molecules and the orientation of the electrical field of light on the rate of polarization produced[11]. When the electric field of light interacts with these molecules, the orientation of the vector polarization of light can change more significantly.

A polarizer angle of 30° is likely to make this interaction work better for molecules that are not symmetrical. This is because the electric fields of light may be able to line up with the uneven charge on the molecule. In contrast, a symmetric molecular has a more even charge distribution and a lower dipolar moment, or zero. This means that their interaction with the light's electrical field doesn't change the direction of the vector of polarization as much. When the polarizer angle is set to 90°, the polarization angle may not change much when it interacts with symmetric molecules. This is because the light electric field and the charged molecules may not line up as well[12]. This phenomenon's implications are very useful in the design of optical sensors that require high sensitivity to changes in a sample's chemical composition and molecular structure. The analysis and development of techniques that exploit this sensitivity could allow for more specific identification of molecules based on their symmetrical or asymmetric forms.

We can observe the value of the change in the polarization angle against the concentration of the gold colloid using a transmission polarization tool. Figure 2 shows the effect of concentration on the change in polarization angle on the gold colloid with a laser wavelength of 532 nm.

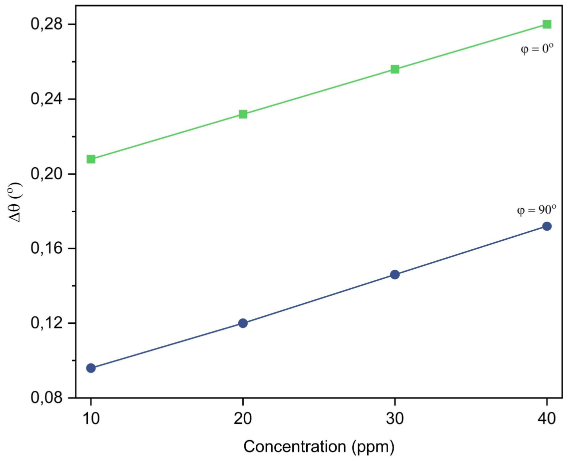

Figure 2. Changes in the polarization angle compared to the concentration value at the 90° angle

Figure 2 shows a natural polarization curve as a concentration function with a laser wavelength of 532 nm. Interestingly, in this study, we observed that using a laser with a wavelength of 532 nm, there was a linear increase in the polarization angle as the gold colloid concentration increased. The accumulation of asymmetric molecules specifically triggers this phenomenon as the number of nanoparticles increases. Due to the shape and distribution of their charge, these asymmetric molecules have the ability to interact with the electric field of light, thus changing the orientation of the original polarization vector. This polarization sensitivity to colloidal concentrations opens up opportunities for the development of new methods for quantitative detection and characterization of material properties. In this context, gold colloids play a dual role, not only as optical signal enhancers due to their resonance but also as agents modifying the structure of the medium that can dramatically affect optical properties such as polarization. By understanding how these changes in properties relate to the presence of nanoparticles, our research contributes to a deeper understanding of light polarization as well as paving the way for nanotechnology applications.

In this study, we tested a combination of gold colloids and olive oil by sticking two cuvettes containing both samples. Figure 3 shows a graph of the combined gold colloid and olive oil polarization angle change with a laser wavelength of 532 nm.

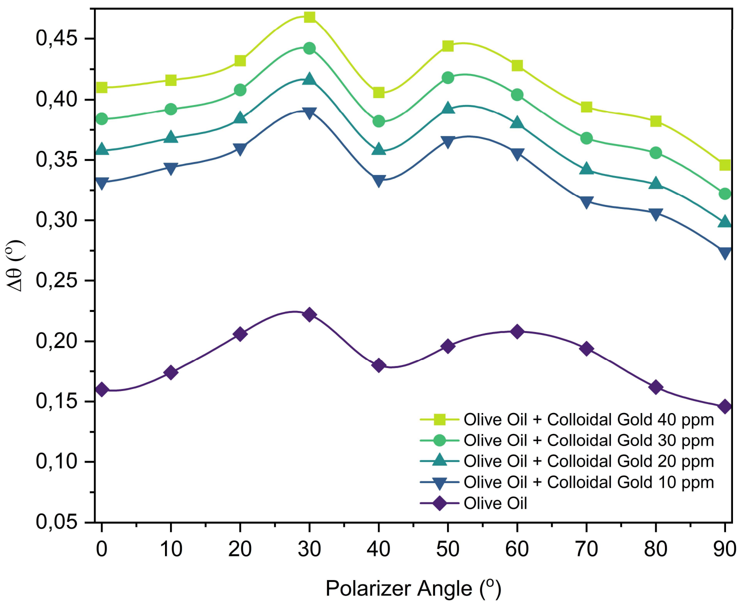

Figure 3. Changes in the polarization angle of the combined colloid gold and olive oil

Figure 3 shows a green laser indicator combining a colloidal gold sample with olive oil, resulting in a larger polarization angle change. The degree of strengthening depends on the concentration of the used gold colloidal solution. The higher the concentration of gold colloid used, the higher the polarization angle value. Although adding gold colloids makes olive oil stronger, it does not change its properties. It still has the same nonlinear graphic pattern and peaks at angles of 30° and 50°, like pure olive oil. The presence of gold colloids does not interfere with or alter the basic characteristics of the tested sample, so it is suitable for trace detection[13]. This could be the basis for developing new polarimetry methods that are more sensitive and efficient in detecting changes in material composition. By efficiently leveraging this phenomenon, researchers can create technological innovations that can have a positive impact on various aspects of life.

IV. CONCLUSIONS

The optical activity of gold nanoparticles is detected by nonlinear graphic patterns generated by asymmetric molecules. The test findings showed a clear relationship between the accumulation of non-symmetric molecules and a shift in the polarization angle of light, which is caused by an increase in gold colloids. The addition of gold colloids to olive oil triggers an increase in the polarization angle, the scale of which increases depending on the concentration of gold. Despite strengthening the optical properties of olive oil, the oil's polarization characteristics remain intact. This finding highlights the potential of the gold colloid in trace detection applications and opens up opportunities for nanotechnology to create new materials with adaptable optical properties.

REFERENCES

[1] Yan, L., Li, Y., Chandrasekar, V., Mortimer, H., Peltoniemi, J., and Lin, Y., 2020. General review of optical polarization remote sensing. International journal of remote sensing, 41(13), 4853-4864.

[2] Tamaki, R., Kasai, T., Asai, G., Hata, D., Kubo, H., Takigawa, Y., Takeda, J., and Katayama, I., 2022. Pulse-to-pulse detection of terahertz radiation emitted from the femtosecond laser ablation process. Optics Express, 30(13), 23622-23630.

[3] Barboza, A. B., Dinesha, P., and Rosen, M. A., 2023. Effect of green fuel and green lubricant with metallic nanoparticles on emissions of HC, CO, NOx, and smoke for a compression ignition engine. Environmental Science and Pollution Research, 30, 91344–91354.

[4] Liu, F., Li, X., Han, P., and Shao, X., 2021. Advanced Visualization Polarimetric Imaging: Removal of Water Spray Effect Utilizing Circular Polarization. Applied sciences, 11(7), 2996-2996.

[5] Avramidou, E. V., Doulis, A. G., and Petrakis, P. V., 2018. Chemometrical and molecular methods in olive oil analysis: A review. Food Processing and Preservation, 42(11), e13770.

[6] Hue, D. T., Hương, T. T. T., Ha, P. T. T., Trang, T. T., Lien, N. T. H., and Hòa, V. X., 2021. The dependence of medium refractive index on optical properties of gold nanorods and their SERS application. AIP advances, 11(5), 055319.

[7] Burdov, V. A., and Vasilevskiy, M., 2021. Exciton-Photon Interactions in Semiconductor Nanocrystals. Applied Sciences, 11(2), 497.

[8] Chen, C., and Wang, J., 2020. Optical biosensors: an exhaustive and comprehensive review. Analyst, 145(5), 1605-1628.

[9] Boudouh, D., Ikram, R., Jan, B. M., Metselaar, H. S. C., Hamana, D., and Kenanakis, G., 2021. Synthesis, Characterization, and Filtration Properties of Ecofriendly Fe3O4 Nanoparticles Derived from Olive Leaves Extract. Materials, 14(15), 4306-4306. https://doi.org/10.3390/ma14154306

[10] Saputra, F. A., Azam, M., Arianto, F., Sofjan, K. F., Sugito, H., and Alkian, I., 2021. The effect of lard concentration and ozonation on changes in polarization angle of olive oil. Journal of Physics: Conference Series, 1943(1), 012017.

[11] Winarno, W., Richardina, V., Sugito, H., Azam, M., Soesanto, Q. M. B., and Firdausi, K. S., 2021. Development of electro-optics method for evaluation of quality degradation of some vegetable oils. Journal of Physics. Conference Series, 1825(1), 012075-012075.

[12] Salsabila, A P., Azam, M., Sugito, H., Soesanto, Q. M. B., and Firdausi, K. S., 2021. Fluorescence polarization method for detection of lard mixed with olive oil, Journal of Physics: Conference Series, 1825, 012076.

[13] Kirono, N., Khumaeni, A., Soesanto, Q. M. B., Azam, M., Sugito, H., dan Firdausi, K. S., 2023, An Optical Active Amplification on Sample Combination of Gold Solution and Vegetable Oil Using Light Polarization. AIP Conference Proceedings, 2738(1), 030033.