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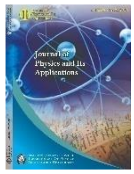

Characteristics of Colloid Silver Solution Based on Changes in Concentration and Electric Field Using Electrooptic Equipment

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ABSTRACT

Research on the characteristics of colloidal silver solutions based on changes in concentration and electric field using electrooptic devices has been carried out. The purpose of this study is to determine the characteristic of colloidal silver solution based on variations in concentration and electrooptic effects. Electro-optics works based on changes in the polarization angle of the sample. The sample used is a colloidal silver solution with various concentrations. The colloidal silver solution was obtained by laser ablation method and then dissolved in pure water. The light source used is a laser pointer with = 532 nm. The electric field applied to the sample is 0-9 kV. The results showed that colloidal silver solution at an angle of 0º showed active plasmon resonance at the peak of polarization with concentrations of 1.9 ppm, 2.28 ppm, and 3.8 ppm. An angle of 90º also shows active plasmon resonance at the peak of polarization with a concentration of 3.8 ppm. From the results, it can be concluded that the characteristics of colloidal silver solution on change in the polarization angle due to an electric field show non-linier properties with increasing concentration.

1. Introduction

Therefore, further studies on the characteristics of silver nanoparticles are needed to understand and control the synthesis and application of silver nanoparticles in various fields [1].

The characteristics of silver nanoparticles can be carried out using various techniques such as Transmission Electron Microscope (TEM), Scanning Electron Microscope (SEM), Atomic Force Microscope (AFM), Dynamic Light Scattering (DLS), X-ray Photoelectron Spectroscopy (XPS), X-ray Diffraction (XRD), Fourier Transform Infrared Spectroscopy (FTIR). The technique is used to determine different parameters such as particle size, shape, crystallinity, fractal dimensions, pore size, and surface area [2]. However, the technique is relatively complex to study the characteristics of silver nanoparticles, the costs involved in the test are quite expensive and special skills are needed by an expert. Other techniques such as UV-Vis spectroscopy are methods that use UV-Vis light sources and have many advantages such as being able to distinguish between organic materials, silica, water, and colloidal silver and being able to record scattering on digital cameras or video and the cost required is quite cheap [3]. However, this technique has not been able to display the characteristics of the optical properties contained in colloidal silver.

The polarization method has been widely applied to distinguish the quality of various types of cooking oil. Although the resulting polarization angle change is relatively small, the value of the change can still be measured manually with a pair of polarizers [4-11]. In previous studies, the application of natural and electro-optical transmission polarization methods to determine the characteristics of colloidal silver nanoparticles has been carried out by several researchers, such as Rahmawati et al [12], Sugito et. al. [13], Firdausi et. al. [14]. Where the transmission polarization method is a method by observing changes in polarization angle due to the absence or presence of external electric field interference and this method can be used to test the optical properties of a material. Based on the results of previous studies, it was found that the change in polarization of colloidal silver nanoparticles is not linear either as a function of field or concentration [12]. This phenomenon is very interesting and has not been revealed because the application of the transmission polarization method by measuring the polarization of silver nanoparticles is relatively new. The purpose of this study is to determine the characteristic of colloidal silver solution based on variations in concentration and electrooptic effects. This research was conducted by varying the concentration and applying an electric field to the sample.

2. Method

The electro-optic equipment used in the study (shown in Fig. 1.) consisted of 1) light source using a green laser with a wavelength of 532 + 10 nm, 2) polarizer that functions to select the direction of the electric field from the light source passed on the sample with a scale of 00 to 3600, 3) analyzer that serves to measure the change in angle polarization of light after passing the sample on a scale of 00 to 3600, 4) A cuvette that functions as a container for the sample to be tested. The overall cuvette used has a transparent side with an optical path length of 3 cm, 5) The source of a high DC power supply that functions as a static electric field generator with a voltage of 0-9 kV, 6) The camera functions to observe changes in polarization angle after passing through the analyzer, 7) Two metal plates parallel with the size is 3x5 and 2 cm apart which function to induce samples, 8) PC which connected to the camera to observe changes in polarization angle [15].

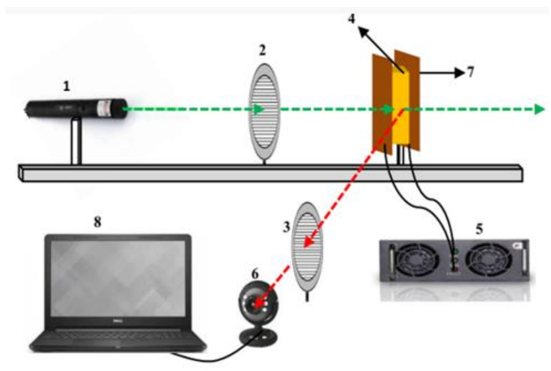

Fig .1: The electro-optic equipment.

The sample used in the study was a colloidal silver solution with a concentration of 1.4, 1.9, 2.28, 2.3, 3, 3.8, and 4 in ppm. In the data collection process, the first thing to do is to measure the absorption spectra of colloidal silver solution with various concentrations to ensure that the solution contains colloidal silver. Then tested using an electro-optic device that works based on the electro-optical polarization method by applying an electric field of 0-9 kV with a voltage increase of 1 kV.

In the early stages of the study, UV-vis testing was carried out which aims to determine the initial characteristics of colloidal silver solution and ensure that the sample used contains a colloidal silver solution.

3. Results and Discussions

Based on the test results shown in Fig.2., shows that the overall sample of colloidal silver solution with different concentrations can absorb maximally at a wavelength of 420 nm [3], which is indicated by the presence of an absorbance peak. This also shows that the level of stability of the colloidal silver solution is quite good and the greater the concentration, the greater the absorbance value. From the test results, it can be ascertained that the sample used in this study is a solution containing colloidal silver.

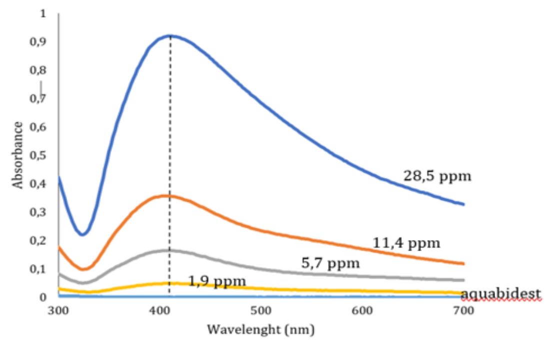

Fig. 2: The absorption spectrum of colloidal silver solutions at different concentrations

In observing changes in the polarization angle to the concentration value using an electro-optic instrument, the results are shown in Fig.3., namely the natural polarization curve as a function of concentration produces different polarizations between 0º and 90º angles. The results of these measurements provide relatively similar optical characteristics in previous studies conducted by Firdausi et. al. [14] that the change in polarization is not linear concerning the concentration of the colloidal silver solution and is homogeneous for all polarisation angles. Physically logical explanation, the cluster properties of colloidal silver solution already have internal plasmon resonance and are naturally oriented with the main axis of the cluster, so that when the light is linearly polarized. The orientation of the plasmon induction which is in the direction of the light electric field provides an optimal polarization change [14].

Fig. 3. shows that concentrations of 1.9 ppm, 2.28 ppm, and 3.8 ppm are threshold values where at an angle of 0º experiences the strongest induction of active plasmon resonance. The drastic increase in concentration from a concentration of 1.4 ppm to 2.3 ppm than at a concentration of 3 ppm to 4 ppm with a successive difference of = 0.02º. Beyond the limit of 1.4 ppm to 4 ppm, the polarization drops drastically and is said to be resonance inactive.

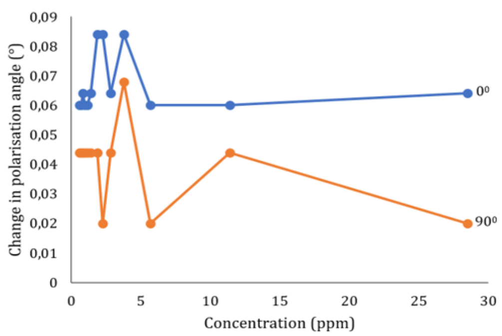

Fig. 3: Changes in polarization angle to concentration values at angles 0ºand 90º.

While at an angle of 90º, plasmon induction is also active. Whereat an angle of 90º the maximum polarization is only found at a concentration of 3.8 ppm. It can be said that the orientation of the colloidal silver solution clusters is very different from that of linearly polarized light at a 90º polarizer. However, the greater the concentration of the colloidal silver solution, some of the clusters of colloidal silver solution will be more binding so that the symmetry cluster is getting bigger, followed by the natural optical active properties decrease, indicated by the smaller polarization changes.

Figure 4 shows a change in the polarization angle due to the application of an electric field as a function of concentration at a voltage of 9 kV at an angle of 0º and 90º. Figure 4 displays a drastic increase in polarization at an angle of 0º around 1.4 ppm to 2.3 ppm then at a concentration of 3 ppm to 4 ppm, the increase is = 0.02º and = 0.022º, respectively. By comparing the previous research [7], it was found that the colloidal silver solution in pure water in addition to having natural optical properties and electrooptical effects, also active plasmon resonance at an angle of 0º in the area of 1.4 ppm to 4 ppm. At an angle of 90º, there is also a drastic increase in polarization at 2.3 ppm to 4 ppm, this area is also said to be an active plasmon resonance region.For higher concentrations above 4 ppm, at an angle of 0º and an angle of 90, the electro-optical effect contributes uniformly to an almost constant value due to the electric dipoles formed. The polarization at the 0º angle is higher than the 90º angle which indicates that the long axis of the 0º angle cluster is longer than the 90º angle.

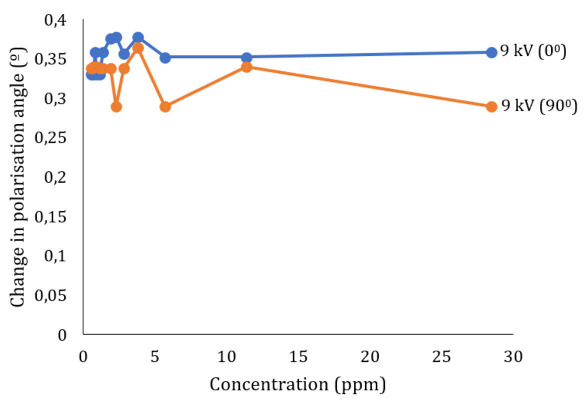

Fig. 4: Electrooptical effect of 9 kV on a colloidal silver solution withλ= 532 nm.

4. Conclusion

From the results of the study, it can be concluded that the characteristics of colloidal silver solution on changes in the polarization angle due to an electric field show non-linear properties with increasing concentration. An angle of 0º shows active plasmon resonance at the peak of polarization with concentrations of 1.9 ppm, 2.28 ppm, and 3.8 ppm. An angle of 90º also shows active plasmon resonance at the peak of polarization with a concentration of 3.8 ppm.

5. Conflict of Interest

The authors declare that they have no conflict of interest.

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