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Characteristics of changes polarization angle of brake fluid

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Abstract
This research was conducted to determine changes in the polarization angle in variations of brake fluid using the polarization method. This research was carried out using brake fluid samples with codes DOT-3, DOT-4, and DOT-5.1. The light source used is laser pointer with wavelengths of λ = 532 nm and λ = 650 nm. In this study, changes in the polarization angle were measured in brake fluid samples. The results showed that all samples had two asymmetric axes at polarizer angles of 30° and 60°. Assuming all brake fluid samples are equivalent to synthetic oil, a uniform molecular size is obtained which is indicated by the almost the same active optical properties of the two samples. This method can be further developed as an evaluation of the quality of brake fluid and similar samples.

Keywords: Polarization, brake fluid, active optical properties

Introduction

One important component in motorized vehicles that needs attention is brake fluid. The role of brake fluid is to lubricate the brake pads and discs in the braking system of motor vehicles. When the brake lining rubs against the disc, the brake fluid absorbs the heat caused by the friction. This requires drivers to better understand the importance of brake fluid to ensure safety when driving. A truly safe brake system can be said to be the key to safe transportation. Safe driving is based on an active and effective brake system [1].

Brake fluid is a hydrocarbon compound consisting of the elements carbon and hydrogen. The brake system produces heat due to friction between the brake fluid and the channel surface. This requires brake fluid to have special specifications regarding temperature changes, namely its boiling point and properties do not change drastically at high temperatures [2]. Every brake fluid has a DOT code number printed on the packaging. What differentiates the number behind the DOT code is the boiling point. The higher the DOT code number, the higher the boiling point. Based on research on vehicle lubricating oil (oil) samples conducted by Prabawa [3] and Rahmadawati [4] using the polarization method, shows that lubricating oil has a distinctive characteristic, namely having two peak points of change in polarization value. Corner found in polarizer angles 30° and 60°. The change in polarization angle proves that the vehicle lubricating oil (oil) samples were indicated to have a non-molecular form symmetrical. Based on research that has been carried out regarding changes in angles of polarization of vehicle lubricating oil (oil), then research is carried out on changing the polarization angle of the brake fluid in the same way, namely polarization to find out in more detail the location of the asymmetric axis when Brake fluid molecules interact with electric fields. This research was conducted using samples of various types of brake fluid. Angle change analysis Polarization is carried out by identifying changes in angle based on type variations Brake fluid uses a polarization method and determines the asymmetric axis in the molecules that make up the brake fluid. Brake fluid experiences a change in polarization angle because there are indications of asymmetric molecules, an axis model can be created Asymmetry uses hydrocarbon chains.

Materials and Methods

The arrangement of research tools is shown in Figure 1. The research was carried out by shooting a laser at a sample to determine changes in the polarization angle using a variety of different types of brake fluid samples.

The light source that hits the polarizer causes the electric field vector component that then hits the sample to change the polarization angle. Changes in the polarization angle that occur in the sample are captured by the analyzer according to the desired angle and transmitted to the screen. The data obtained is in the form of a table of changes in polarization angle by observing the minimum intensity of polarized light that has been captured by the screen.

The research material used is brake fluid vehicle. In this study, 3 samples of brake fluid were used 3 different types. The sample from this research is DOT-3, DOT-4, and DOT-5.1. Each sample was tested at room temperature conditions. The light source used is a laser pointer with λ = 532 nm and λ = 650 nm. For each sample, data collection was repeated 5 times, then the average value was found.

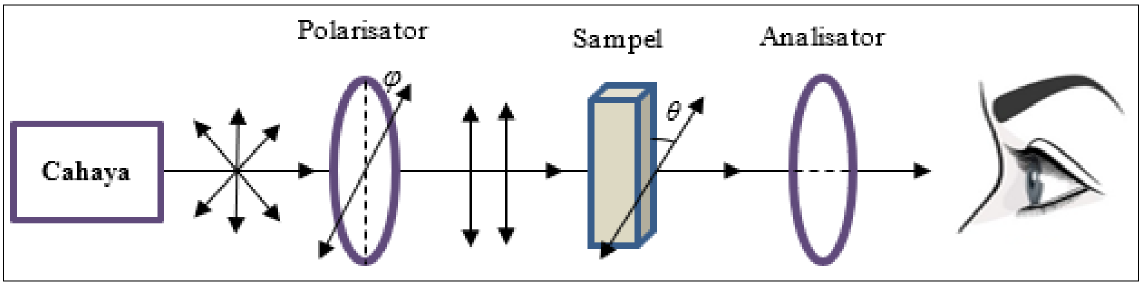

Fig 1: Research Tool Scheme. Where φ is the polarizer angle and θ is the change in polarization angle after hitting the sample.

Results and Discussion

Observations were made of changes in the polarization angle in four brake fluid samples using green and red laser pointer light sources with wavelengths of λ = 532 nm and λ = 650 nm, respectively. The research was carried out at polarizer angles of 0°, 10°, 20°, 30°, 40°, 50°, 60°, 70°, 80° and 90°.

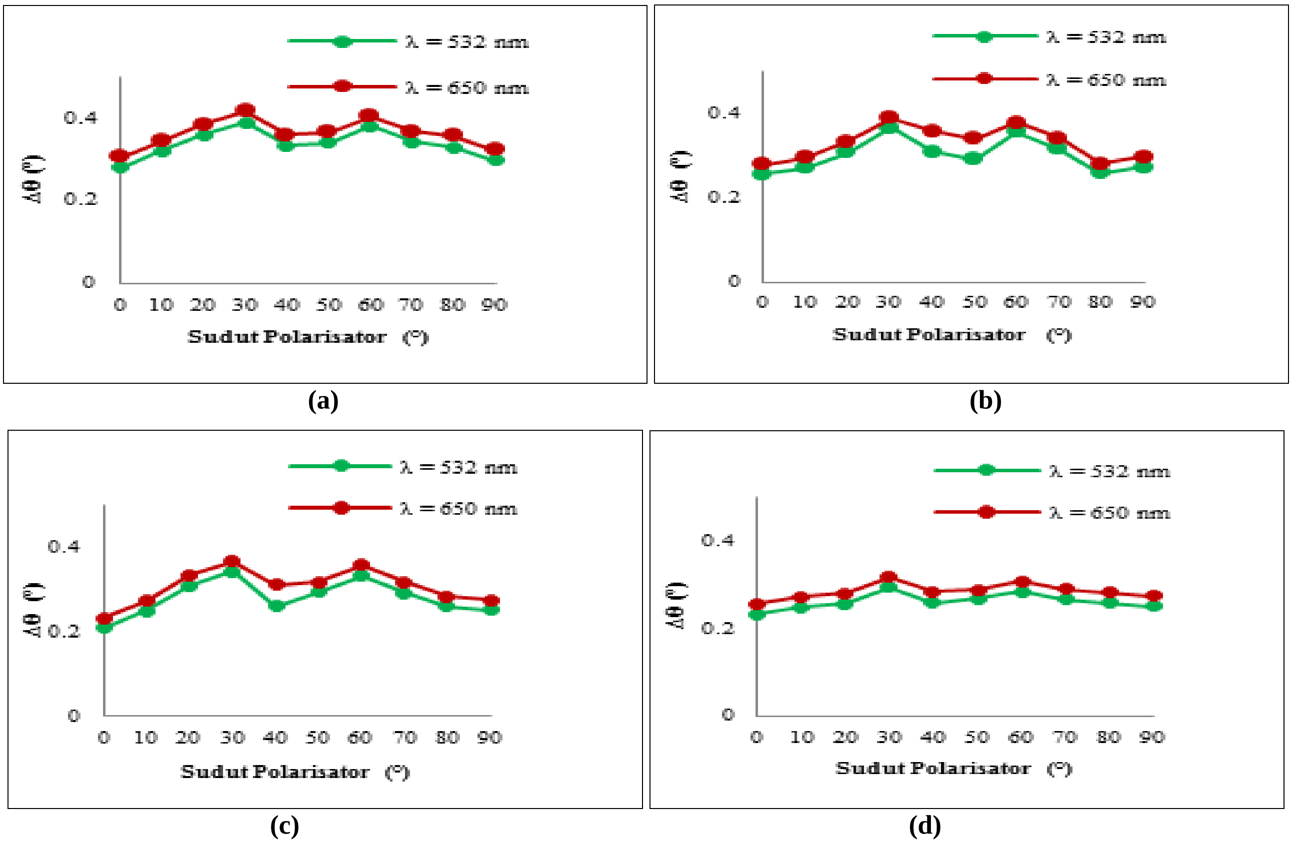

Fig 2: (a) Change in Polarization Angle of DOT-3 Brake Fluid; (b) Change in Polarization Angle of Brand A DOT-4 Brake Fluid; (c) Change in Polarization Angle of DOT-4 Brand B Brake Fluid; (d) Change in Brake Fluid Polarization Angle DOT-5.1. The asymmetric axis occurs at polarizer angles of 30° and 60°.

Figure 2 shows a change in the polarization angle when a brake fluid sample is exposed to a laser light source. This indicates that the brake fluid sample has an asymmetrical molecular shape which can prove that the brake fluid sample is optically active.

Figure 2 shows that the four brake fluid samples produced the same typical pattern, namely the presence of two peaks at polarizer angles of 30° and 60°. The change in polarization angle that occurs indicates the presence of asymmetric molecules in the molecules that make up brake fluid. At the two peaks at polarizer angles of 30° and 60°, the electric field from the light source hits the most asymmetric molecules of the brake fluid constituent material, resulting in maximum polarization. Meanwhile, at angles other than 30° and 60°, the electric field from the light source only partially hits the asymmetric molecules of the brake fluid, resulting in minimum polarization which causes relatively smaller changes in the polarization angle [3].

Figure 2 also shows that changing the polarization angle using a red laser with a wavelength of 650 nm produces a change in polarization angle that is greater than using a green laser with a wavelength of 532 nm. This is because the refractive index of the brake fluid sample when subjected to a red laser is smaller than when a green laser is applied. A small refractive index causes the optical density of the medium to be small so that the rays bend further away from the normal line, as a result, the optical path becomes longer and results in a large polarization angle. This follows the research conducted by Mukhlis [5], that a smaller refractive index value causes the optical path that light passes through to be longer. If the optical path traversed is longer, the result will be a larger change in angle.

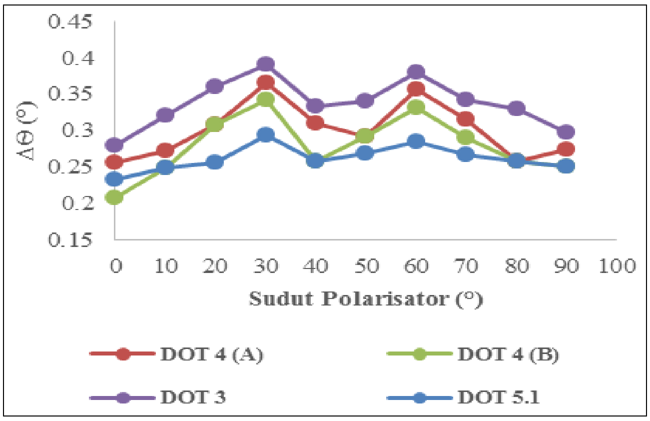

Fig 3: Changes in Brake Fluid Polarization Angles DOT 3, DOT 4, and DOT 5.1.

Even though the four brake fluid samples produced the same typical pattern, namely there were two peaks at polarizer angles of 30° and 60°, Figure 3 shows that each type of brake fluid has different polarization angle change values. In research conducted by Rahmadawati [4], using samples of lubricating oil, it was explained that the alleged difference in the value of the change in polarization angle occurred due to differences in the character of the molecules that make up the oil samples used. This might also happen to brake fluid samples. Because the types and brands are different, the percentage composition of the ingredients and the characteristics of the molecules that make up them are also different. So changes in the polarization angle of the four brake fluid samples produce different values.

Figure 3 also shows that the DOT 3 brake fluid sample has the largest change in polarization angle, while the DOT 5.1 brake fluid sample has the smallest change in polarization angle. DOT 3 brake fluid likely has more asymmetric molecules, in this case, ethylene glycol which is the main composition of brake fluid. When the constituent molecules are large or long, their tendency to polarize is also greater, resulting in large changes in the polarization angle. The assumption that explains this is that the quality of DOT 5.1 brake fluid is better than other types, so the change in polarization angle is smaller.

Apart from that, in Figure 3, two samples of different brands of DOT 4 brake fluid produce different polarization angle change values. Because they are different brands, the percentage composition of the ingredients and the characteristics of the molecules that make up them are also different, resulting in different angle change values. Even though two samples of brake fluid of the same type produce different polarization angle change values, their peak values are not smaller than the peak value produced by DOT 5.1 brake fluid and not greater than the peak value produced by DOT 3 brake fluid. So the order of brake fluid from the smallest to the largest change in polarization angle are DOT 5.1, DOT 4, and DOT 3 brake fluids.

Conclusion

Based on the results and discussion in the previous chapter, the following conclusions are obtained brake fluid has two peaks, namely at polarizer angles of 30° and 60°, which is the location of the asymmetry axis. At these two peaks, maximum polarization occurs where the electric field from the light source mostly hits the asymmetric molecules of the brake fluid composition. Given the two peak angles, an asymmetric axis model can be proposed based on the overall average molecule.

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