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The Effect of Temperature on the Ternary System of Telon Oil, Apple Cider Vinegar, and Mineral Water

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ABSTRACT

The main purpose of this experiment is to observe the effect of temperature on the resulting ternary diagram. Observations were made by observing the temperature of the samples, namely at 25°C, 30°C, 45°C, 60°C and 75°C, as well as observing the ternary phase diagram of natural ingredients such as telon oil, apple cider vinegar, and mineral water. The method used was titration by comparing telon oil and apple cider vinegar 1:5, 2:4, 3:3, 4:2, and 5:1 (mL). Based on the results of the experiment, it can be concluded that temperature affects the volume of titration used, the higher the temperature used, the smaller the titration volume will be.

Keywords: Temperature, titration, ternary diagram, solubility and molarity

1. INTRODUCTION

Phase is a part of a system that is homogeneous and separated from each other either physically or by its components. While the component is the minimum number of parameters or variables needed to describe the composition of each phase of a system. The degree of freedom of the system is the smallest number of intensive variables that must be specified to fit the values of all remaining intensive variables. One phase requires two degrees of freedom to describe the system perfectly, and for two phases in equilibrium, one degree of freedom. So, the phase diagram can be drawn in one plane.[1]

The transition from one phase to another is called a phase change or phase transition. The change from one phase to another generally takes place at a state of phase equilibrium between the two phases, and for a given pressure, occurs only at a given temperature.[2]

The equilibrium condition for any system is that the chemical potential of each constituent throughout the system must be the same. If there are several phases of each constituent, then the chemical potential of each constituent in each phase must have the same value. A phase is defined as a part of a system that is uniform or homogeneous among its submacroscopic states, but is completely separated from the rest of the system by a well-defined boundary. A mixture of solids or two immiscible liquids can form separate phases, while a mixture of gases is a single phase because of its homogeneous system. According to the phase rule, the degrees of freedom are given by:

$$F = C-P+2$$
$$= 5-P$$

and if the pressure and temperature are fixed, the above equation becomes:

$F = 3-P$.[3]

The three-component system has a degree of freedom $F = 3-P$, because it is impossible to make a diagram with 4 variables, then the system is made at constant pressure and temperature. So that the diagram is only a function of composition. The maximum degree of freedom value is 2, because the value of P only has 2 choices of 1 phase, namely the three components are mixed homogeneously or a phase that includes 2 pairs of mibels. Generally, a 3-component system is a liquid-liquid-liquid system. The total mole fraction of the three components is 1. The coordinate system of this diagram is depicted as an equilateral triangle which can be % mole or mole fraction or % weight.[4]

In this experiment, a ternary system will be carried out with natural ingredients that are often found in everyday life. The ingredients used are telon oil, apple cider vinegar and mineral water. Observations were made by making several comparisons of the volume of telon oil with apple cider vinegar, then titrating it with mineral water. Apple cider vinegar has a high acetic acid content and is made from natural extracts and fermentation of apples,[5] and apple cider vinegar is the result of fermented apples and contains enzymes and amino acids. Telon oil is a product that is familiar to the Indonesian people. Almost all levels of society in the region use telon oil for newborns.[6] The meaning of the word Telon or in Javanese means three. The composition of telon oil is eucalyptus oil (*Oleum Cajuputi*), Fennel (*Oleum Foeniculi*), and coconut oil (*Oleum Cocos*).[7]

The experiment was conducted by making various comparisons of the volume of telon oil and apple cider vinegar and then it will be saturated by titration using mineral water. Then all observations were made at several different temperatures to observe how the temperature affects the volume of added mineral water to be titrated.

2. EXPERIMENTAL

2.1. Chemicals, Equipment and Instrumentation

The equipment we used in this experiment was a beaker glass, a medium beaker, a measuring cup, an Erlenmeyer flask, a biuret, a thermometer, a stand, a glass pipette, a tube brush, alcohol, and a dropper. The ingredients used are telon oil ($CHCl_3$), apple cider vinegar (CH_3COOH), and mineral water (H_2O).

2.2. Research Procedure

The method used is titration, with the titrant being mineral water. The first step is to prepare apple cider vinegar and telon oil in separate containers. The volume of telon oil is measured to 1 mL then put into Erlenmeyer 1 (E.1) then 5 mL of apple cider vinegar is added to E.1 and left for 5 minutes in water at a temperature of 25 ℃ then titrated until turbidity occurs. The experiment is continued by replacing the volume of the solution, namely (E.2), 2 mL of telon oil: 4 mL of apple cider vinegar, then titrated again until turbidity occurs. In (E.3) the volume is replaced to 3 mL of telon oil: 3 mL of apple cider vinegar and titrated with

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mineral water. In (E.4) the volume of the solution is replaced to 4 mL of telon oil: 2 mL of apple cider vinegar. In (E.5) the volume is replaced to 5 mL of telon oil: 1 mL of apple cider vinegar. Before titrating with mineral water, the sample in the Erlenmeyer must be left in a container filled with water at a temperature of 25 ℃. After the five Erlenmeyers were finished, the same treatment was repeated, but the water temperature used to soak the Erlenmeyers was 30℃, 45℃, 60℃ and 75℃. All titration volumes used were observed and recorded.

3. RESULTS AND DISCUSSION

3.1. Analysis of Characterization Results

Table 1 shows the titration ability used to dissolve each sample with different ratios at a temperature of 25°C. It is known that for samples of telon oil and apple cider vinegar with a ratio of 1:5, 2:4, 3:3, 4:2, and 5:1, the resulting titration volume (water) is 2,1 mL, 1,5 mL, 1,1 mL, 2 mL, and 2,2 mL.

Table 1. Titration ability to dissolve samples at 25°C

Oil Volume (mL)	1	2	3	4	5
Apple Cider Vinegar Volume (mL)	5	4	3	2	1
Water Titration Volume (mL)	2,1	1,5	1,1	2	2,2

Table 2 shows the titration ability used to dissolve each sample with different ratios at a temperature of 30°C. It is known that for samples of telon oil and apple cider vinegar with a ratio of 1:5, 2:4, 3:3, 4:2, and 5:1, the resulting titration volume (water) is 2,1 mL, 1,4 mL, 1,1 mL, 1,9 mL, and 2,2 mL.

Table 2. Titration ability to dissolve samples at 30°C

Telon Oil Volume (mL)	1	2	3	4	5
Apple Cider Vinegar Volume (mL)	5	4	3	2	1
Water Titration Volume (mL)	2,1	1,4	1,1	1,9	2,2

Table 3 describes the titration ability used to dissolve each sample with different ratios at a temperature of 45°C. It is known that for samples of telon oil and apple cider vinegar with a ratio of 1:5, 2:4, 3:3, 4:2, and 5:1, the resulting titration volume (water) is 1,8 mL, 1,4 mL, 1 mL, 1,7 mL, and 2,1 mL.

Table 3. Titration ability to dissolve samples at 45°C

Telon Oil Volume (mL)	1	2	3	4	5
Apple Cider Vinegar Volume (mL)	5	4	3	2	1
Water Titration Volume (mL)	1,8	1,4	1,1	1,7	2,1

Table 4 shows the titration ability used to dissolve each sample with different ratios at a temperature of 60°C. It is known that for samples of telon oil and apple cider vinegar with a ratio of 1:5, 2:4, 3:3, 4:2, and 5:1, the resulting titration volume (water) is 1,5 mL, 1 mL, 0,7 mL, 1,4 mL and 1,7 mL.

Table 4. Titration ability to dissolve samples at 60°C

Telon Oil Volume (mL)	1	2	3	4	5
Apple Cider Vinegar Volume (mL)	5	4	3	2	1
Water Titration Volume (mL)	1,5	1	0.7	1,4	1,7

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Table 5 ilustrates the titration ability used to dissolve each sample with different ratios at a temperature of 45°C. It is known that for samples of telon oil and apple cider vinegar with a ratio of 1:5, 2:4, 3:3, 4:2, and 5:1, the resulting titration volume (water) is 1 mL, 0,8 mL, 0,5 mL, 1 mL and 1,3 mL.

Table 5. Titration ability to dissolve samples at 75°C

Telon Oil Volume (mL)	1	2	3	4	5
Apple Cider Vinegar Volume (mL)	5	4	3	2	1
Water Titration Volume (mL)	1	0,8	0.5	1	1,3

Here is a graph of the Effect of temperature on sample solubility titration

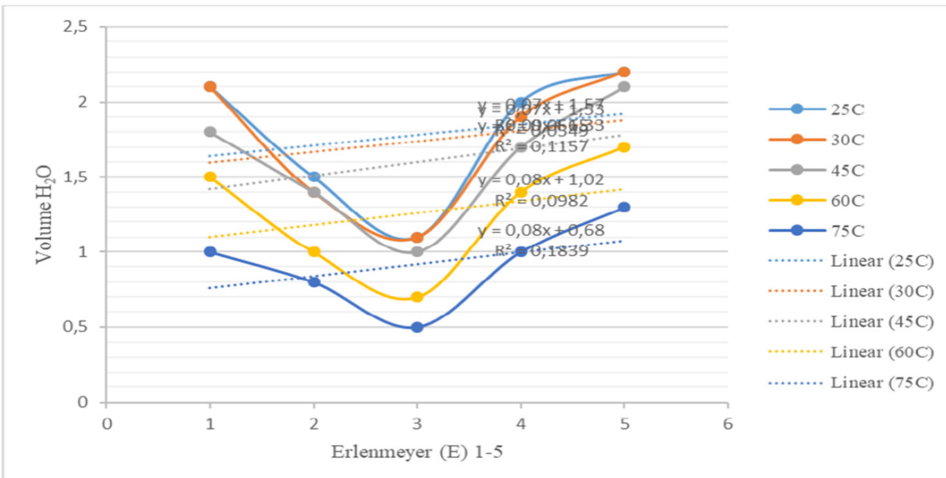

Figure 1. the effect of temperature on sample solubility titration

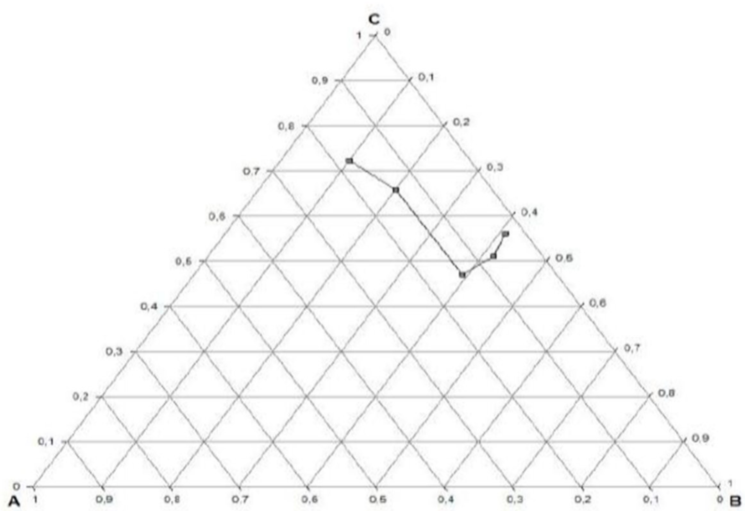

Figure 2. Ternary diagram of telon oil, apple vinegar, and water at 25°C

Figure 2 above shows the equilibrium graph formed from a single phase mixture of telon oil, apple cider vinegar, and water. It can be seen that the graph is tilted upwards, this shows that the mole fraction at this temperature of 25°C is large.

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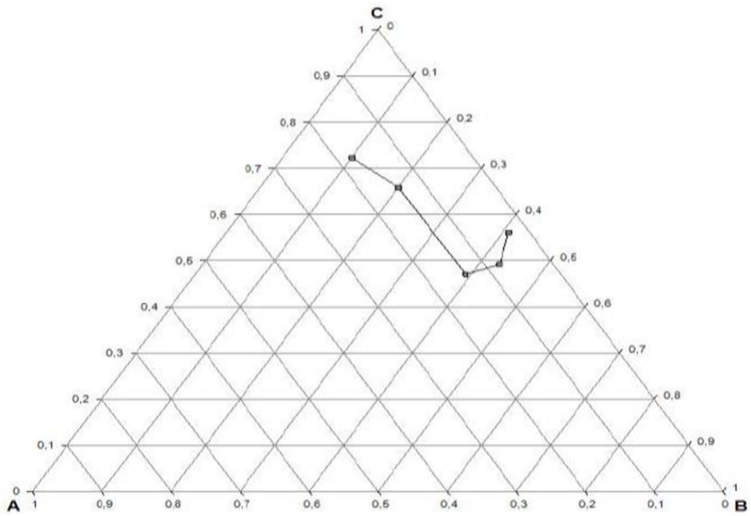

Figure 3. Ternary diagram of telon oil, apple vinegar and water at 30°C

Figure 3 above shows the equilibrium graph formed from a single phase mixture of telon oil, apple cider vinegar and water. It can be seen that the graph is further down compared to Figure 2. This shows that the mole fraction at this temperature of 30°C is reduced.

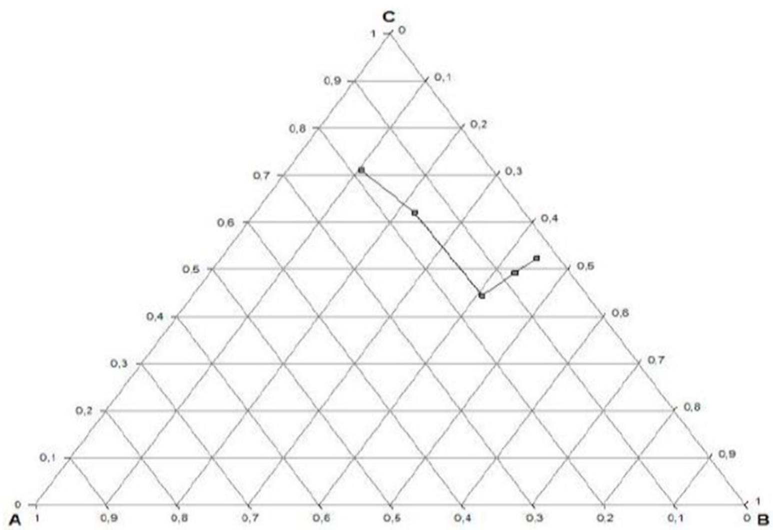

Figure 4. Ternary diagram of telon oil, apple vinegar and water at 45°C

Figure 4 above shows the equilibrium graph formed from a single phase mixture of telon oil, apple cider vinegar and water. It can be seen that the graph is further down compared to Figures 3 and 2, this shows that the mole fraction at this temperature of 45°C is reduced.

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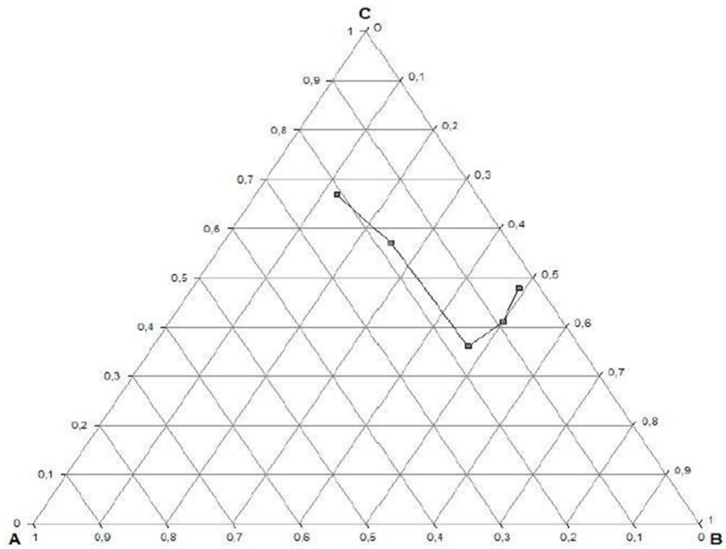

Figure 5. Ternary diagram of telon oil, apple vinegar, and water at 60°C.

Figure 5 above shows the equilibrium graph formed from a single phase mixture of telon oil, apple cider vinegar and water. It can be seen that the graph is further down compared to figures 3 and 4, this shows that the mole fraction at this temperature of 60°C is decreasing.

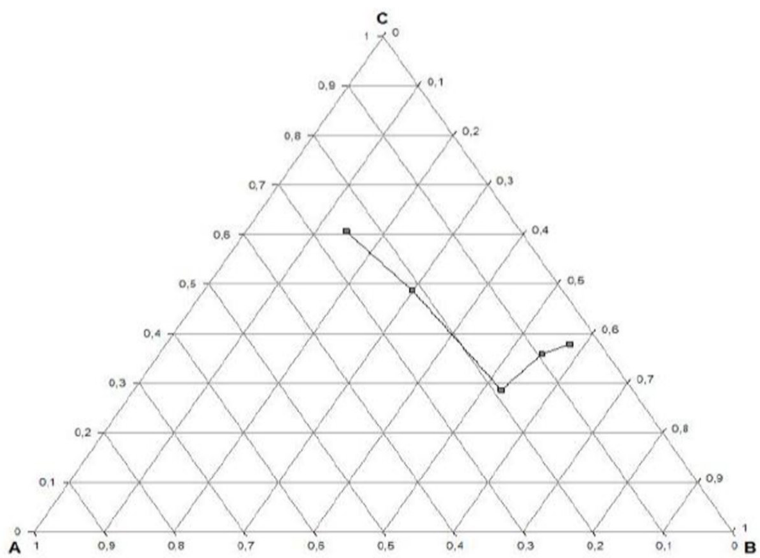

Figure 6. Ternary diagram of telon oil, apple vinegar and water at 75°C

Figure 6 above shows the equilibrium graph formed from a single phase mixture of telon oil, apple cider vinegar and water. In the graph it can be seen that the graph is leaning downwards, this shows that the mole fraction at this temperature of 75°C is getting smaller.

Based on the research conducted, it can be observed that water solvents have a good ability to dissolve telon oil and apple cider vinegar. This is due to the chemical properties of water that are able to interact with

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certain components in these two substances. Apple cider vinegar is a solution of acetic acid (CH_3COOH) in water. Acetic acid is polar and dissolves well in water which is also polar.[8] This happens because water molecules can form hydrogen bonds with acetic acid molecules, which makes them more soluble than they are.[9] Meanwhile, telon oil is a mixture of fennel oil (*Oleum Foeniculi*), eucalyptus oil (*Oleum Cajuputi*) and coconut oil (*Oleum Cocos*) in equal proportions, telon oil is mostly non-polar.[10] In general, telon oil is insoluble in water because water is polar and oil is non-polar ("soluble-like" or "soluble-like"). Therefore, the polar nature of water allows for more effective intermolecular interactions with telon oil and apple cider vinegar molecules, resulting in a better solubility process.

In addition, the influence of temperature and the increase in temperature from 25°C to 75°C can improve the solubility process by titration using water faster. In the solution there are solvents and solutes.[11] Solubility is the maximum amount of a compound or substance that can be dissolved in a given amount of solvent. Factors that can affect solubility are pressure, size and weight of volume, intermolecular forces, temperature.[12] The results of the analysis show that the higher the temperature of the water, the faster the solubility process will occur. The higher the temperature given, the smaller the titration volume. This is in line with the theory that an increase in temperature can increase the kinetic energy of the particles in the components, so that the collision between molecules becomes more effective and the reaction rate increases.[13]

Temperature and heat energy are two things that cannot be separated. Temperature is a quantity that expresses the degree of heat or cold of an object.[14] The concentration of a solution is a composition that clearly shows the ratio of the amount of solute to the solvent.[15] Solubility can be small or very large, and if the amount of solute passes the saturation point, it will come out (settle under the solution). Under certain conditions, the solution can contain more solute than in a saturated state.[16]

The solubility of the substances involved in this mixing can be increased or decreased, by looking at the ratios in the ternary chart. The mixing substances will be homogeneous (soluble with each other) if the composition is in accordance with the ratio, and if the composition of one of them exceeds then heterogeneous mixing will occur.

4. CONCLUSION

Based on the research and observations that we have done, it can be concluded that the temperature of the water used affects the titration volume used, this can be seen from the graph of the increase in the titration volume used. However, for further observations and calculations, more complex ones need to be carried out to ensure further accuracy and precision in the hypothesis.

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