

Construction of Binary Phase Diagram of Palm Kernel Oil Based Glucosides

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ABSTRACT: The glucosides with an average alkyl chain length of 14 carbon atoms derived from fatty acid of palm kernel oil have been synthesized and their phase behavior has been studied. The objectives of this study is to prepare a series of glucosides sample in water with different concentrations and to construct the binary phase diagram from palm kernel oil based glucosides. The scope of study is to study the formation of lyotropic phases at different concentration and temperature. The phase diagram is a best way to show formation of different phases with a given temperature and construct a phase diagram and know how to use it to predict behavior of materials which is glucosides. These phase diagrams provides boundaries of different phases. The binary phase diagrams of glucosides are constructed using cross polarizer films and optical polarizing microscopy (OPM).

Keywords – binary phase diagram, lyotropic phase, glucosides, hexagonal phase, structure, surfactant

INTRODUCTION

Palm kernel oil is derived from palm kernel or seeds of the palm fruit. Palm kernel contains more saturated fats than palm oil. Some research even suggests that the fatty acids in palm oil do not raise cholesterol the way saturated fats traditionally do. (Kostik.V, 2003) It is mainly used in cosmetics, oleo chemicals and a raw material for surfactants. Palm kernel oil have different pattern of saturated fatty acid composition. In this case, we use carbon 14 (C^{14}) which is lauric. The oleic, linoleic and linoleic is unsaturated fatty acid. The oleic acid is predominant unsaturated on palm kernel oil, while for saturated fatty acid, lauric acid is the predominant because of high content of short chain fatty acid. (Kostik.V, 2003)

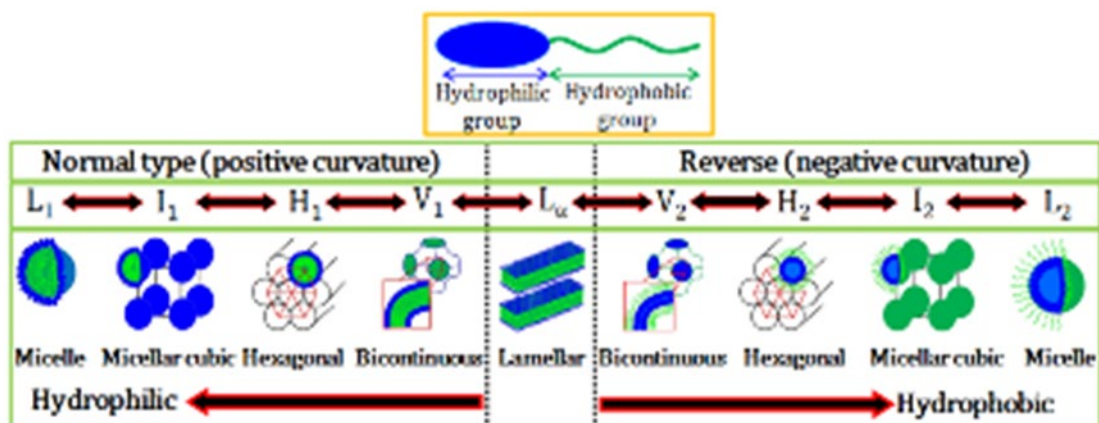


Figure 1: Schematic representation of phase behavior of amphiphilic compound (P.Hill, 23 June 2014)

The glucoside is important because it is used as a surfactant. Glucoside is a non-ionic surfactant and ideal for all foaming and cleansing product. It can produce a very adequate level of foam compare to anionic surfactants. (Hessler, Jan 12, 2011). Sugar surfactants have several rather flexible properties. Furthermore, sugar esters and sugar glycosides are generally nontoxic and non-cumulative. They are temperature insensitive as to their properties. (Hessler, Jan 12, 2011) The purposes of study the binary phase diagram are to identify the types of dispersion systems formed by the mixtures of glucosides and water in different concentrations and to determine the equilibrium phase's boundaries of the glucosides

Based on figure 1 above, it represent about the phase behavior of amphiphilic compound. The meaning of amphiphilic is a compound (such as a surfactant) consisting of molecules having a polar water-soluble group attached to a water-insoluble hydrocarbon chain, also being a molecule of such a compound.

(Meriam-Webster, 1985) In this case, the glucoside is one of the amphiphilic compounds. Amphiphilic molecules consist of at least two moieties of differing characteristics, for instance, hydrophilic and hydrophobic. Thus, surfactants are typical amphiphiles. Surfactants are classified on the basis of the charge of the hydrophilic group and they can be either ionic (anionic and cationic) or nonionic. The hydrophilic domains become exposed to water and the hydrophobic parts are shielded. In this research, the glucoside is exposed to water so it means that it is hydrophilic. (P.Hill, 23 June 2014)

A rich phase behavior with lamellar, normal hexagonal, and bicontinuous cubic regions, as well as water-rich (L_1) solutions, was observed. (Alexan, Jan 1996) The phase boundaries were inspection under cross polarizer.

The purposes of the research study are to prepare a series of glucosides sample in water with different concentrations and to construct the binary phase diagram from palm kernel oil based glucosides. In this research study, 29 samples

need to be prepared with different concentration of water from 5% until 90%.

METHODOLOGY

A. Materials

Glucoside palm kernel oil (GPKO) was used as main compound in this research study. Palm kernel oil and glucosides mixture were serially titrated with water at ambient temperature. (Reimer, 1 July 2005) Acetone was used to clean up the tube before used. Distilled and deionized water was used throughout the experiments.

B. Sample Preparation

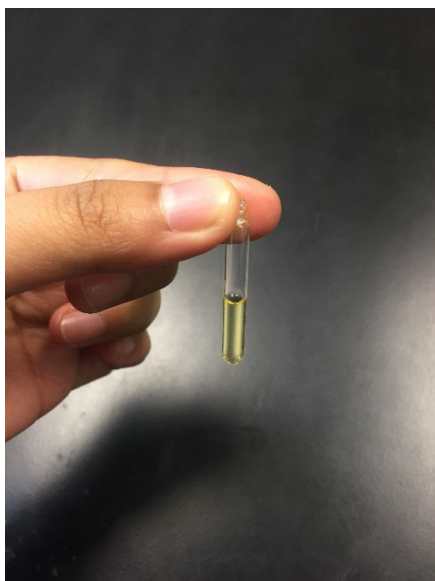


Figure 2: Sample with 40mg glucoside + 70% concentrations of water

Based on figure 2 above, prepare sample containing 40 mg of glucosides in 2.11 μ L water which is 5% of water concentration by using micropipette. We need to prepare 29 sample due

to the different concentration from 5% until 90%. After that, we need to seal the tube to prevent from the leakage. If leakage occurs it can change the concentrations of water. Then, we need to centrifuge all the samples within 60 second with 3.0 rpm. Next, put all the samples into the oven for 30 minutes with temperature 60 °C to homogenize. After that, re-centrifuge the samples within 5 min with 8.0 rpm. If the sample still do not homogenize well, centrifuge the sample repeatedly. Next, place the samples in water bath for 1 hour in various temperature such as 30°C, 40°C, 50°C, and 60°C. Last but not least, observe the samples by using cross polarizer. We also use optical polarizing microscopy (OPM) to observe.

C. Measurement

The volume of water was confirmed through the following calculation based on the concentration of water:

$$\frac{m_{H_2O}}{m_{H_2O} + m_{Glucoside}} \times 100\% = \text{concentration of water}$$

Where; m = mass

Take 5% of concentration as an example;

$$\frac{m_{H_2O}}{m_{H_2O} + m_{Glucoside}} \times 100\% = 5\%$$

$$\frac{m_{H_2O}}{m_{H_2O} + 40 \text{ mg}} \times 100\% = 5\%$$

$$\frac{m_{H_2O}}{m_{H_2O} + 40 \text{ mg}} = 0.05$$

$$m_{H_2O} = 2.1 \text{ mg} \approx 2.1 \mu\text{L}$$

RESULTS AND DISCUSSION

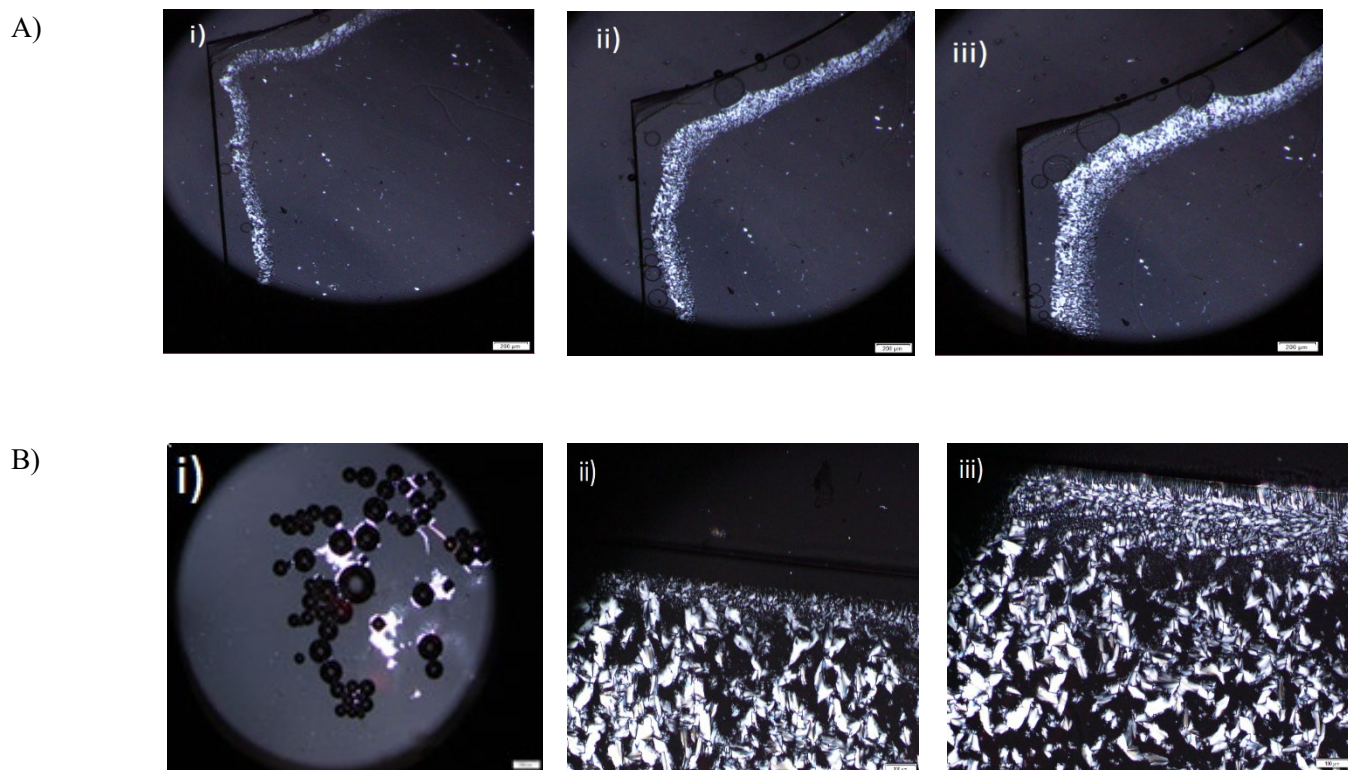


Figure 3: Data from optical polarizing microscopy (OPM). Figure (A) indicates at 50°C while figure (B) indicates at 60°C

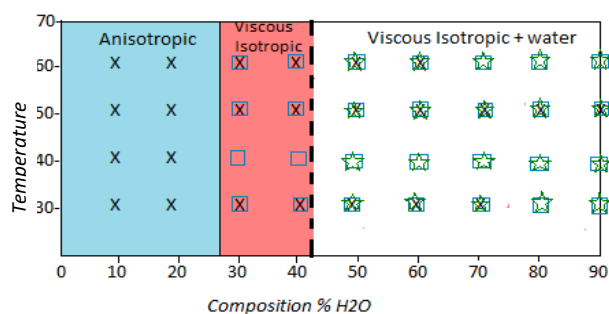


Figure 4: Binary phase diagram of glucosides palm kernel oil.

Glucoside is a non-ionic surfactant with a glucose headgroup with straight chain synthetic

glycolipid that has been used as hydrating modulating agent in the swelling of bicontinuous cubic phase. During observation by using cross polarizer we identify formation of phase of glucoside palm kernel oil through its birefringent appearance and viscosity of the sample. The results are summarized in figure 4 above.

The diagram identified from OPM are marked on the phase diagrams as (X = hexagonal phase, □ = micellar cubic phase and ☆ = micelle

solution). The coexistence of phases is also marked by combining these notations, thus (□ with X) or (□ with ☆). The excess water points are represented by dashed line.

From figure 3 above, the three distinct regions which are anisotropic (appeared as birefringent), viscous isotropic (appeared as non-birefringent) and viscous isotropic + water were denoted based on observation from cross polarizer. Based on observation, from 5% to 27.5% concentration of water were birefringent which is anisotropic, from 30% to 42.5% are viscous isotropic and from 45% to 90% are viscous isotropic + water. The results are remain constant from temperature 30°C until 60°C.

Based on figure 3(A) above shows the change of glucosides palm kernel oil at temperature 50°C. This is the example of hexagonal phase. At figure 3A(i), the hexagonal phase forms. Hexagonal phase is formed by some amphiphilic molecules when they are mixed with water. Then, it becomes more swelling due to the addition of water through contact penetration scan. When observed by OPM, thin films of the hexagonal phases exhibit birefringent, giving rise to characteristic optical textures. In the presence of low amounts of water, lipids that would normally form micelles will form larger aggregates in the form of micellar tubules in order to satisfy the requirements of the hydrophobic effect. These aggregates can be thought of as micelles that are fused together. These tubes have the polar head groups facing out, and the

hydrophobic hydrocarbon chains facing the interior.

Figure 3B(i) is isotropic. A birefringent layer was formed on addition of water at figure 3B(ii) and 3B(iii). The isotropic layer was formed at higher water content. In this case there is coexistence of phases which are micellar cubic phase and micelle solution. Micellar cubic phases are isotropic phases, but are distinguished from micellar solutions by their very high viscosity. When thin film samples of micellar cubic phases are viewed under a polarizing microscope they appear dark and featureless. Small air bubbles trapped in these preparations tend to appear highly distorted and occasionally have faceted surfaces. (Salim, 16 MAY 2016)

During experiment, some error may occur such as the weight of the sample. Besides that, when we added the sample with the concentration of water by using micropipette, the quantity of the water may be less or more due to the equipment error.

The results are based on qualitative methods, thus to get confirmation of the observed phase small angle X-ray scattering measurements are required.

CONCLUSION

The phase behavior of glucosides palm kernel oil was determined by preparing sample with a controlled water content ranging from 5% to 90% and examined in the temperature range from 30°C until 60°C. Then

optical polarizing microscopy experiments were carried out to determine the structure of the glucosides palm kernel oil. The hexagonal phase structure was formed. When the water is added through the glucosides palm kernel oil, the structure becomes swelling. The micellar cubic phase and micelle solution were formed. It can be conclude that the glucosides palm kernel oil is soluble in water. In the conclusion, the phase behavior of glucosides palm kernel oil is probably hexagonal phase. To get confirmation of the phase, small angle X-ray scattering measurements are required.

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