Determination of Cloud Points of Poly (propylene glycol) Aqueous Mixtures Using Particle Counting Method

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Abstract
Cloud points of aqueous poly (propylene glycol) (PPG) mixtures at various concentration of PPG are determined using particle counting method. The number average molecular weight of the PPG is 2025 and its concentrations are changed from 1 up to 15 weight percents. In this method, initially an aqueous solution of PPG with a specified concentration at a specified temperature is made. At this condition, the number of particles in the solution is measured by a particle counter apparatus. Then by slowly increasing of the solution temperature, the number of particles is measured. The temperature at which a sudden increase in the number of particles is observed is noted as the cloud point. The increase of the particles is due to the formation of new liquid phase in the mixture. This procedure is repeated for various PPG concentration mixtures. We could determine the cloud point curve of the aqueous PPG mixture with an easy and rapid and precision method.

Key Words: Cloud Point, Particle Counter, Aqueous Polymer Solutions, Partial Miscibility

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Introduction:

Cloud point of a solution is temperature at which the solution becomes to formation of two phases. This phenomenon can be observed for some components which they have partial miscibility respect to each other. Determination of cloud point is very important from different point of view, such as designing of extraction apparatus and holding of a homogenous system at a stable condition respect to the composition of the system species. There are several methods for cloud point measuring. For example: visual observation [1], turbidimetry [2], light scattering [3], viscometry [4], thermooptical methods [5] and so on. Particle counting method is a new method for cloud point measuring which has been introduced by Eliassi et al [6, 7]. The basis of this method for cloud point measuring is determining the number of particles in a mixture. Namely, when a new phase appears in a solution, this phase arise as a large number of small particles. At this time, the solution becomes cloudy due to the scattering of the light beam passing through the solution. So, if the number of particles in a solution is measured at various temperatures, it is expected that at the temperature where a new phase appear, a sudden change in number of particles would be observed and this temperature indicates the cloud point for the solution.

Apparatus and procedures

Figure 1 shows the diagram for the experimental system. A laser particle counter (Spectrex Corporation, Model PC-2000, United States), was used for particle counting.

The samples compartment consist of a flow cell where PPG aqueous solution was pumped by a pump to it from storage vessel kept at constant temperature water bath system. The temperature of the solution was recorded at the entrance of the cell by a thermocouple. The precision of the thermocouple was $\pm 0.1^{o}C$. The required time for determining the number of particles was 15 seconds. Therefore, the temperature of the water bath was changed and controlled by a thermostat with an appropriate rate to maintain the required temperature at the flow cell. At each temperature, the out put of the apparatus has been sent to a PC and finally the number of particles per cubic centimeter will be recorded by a printer.

PPG2025 was prepared from Merk (Germany) and distilled water was used for preparing the solutions. All of solutions were prepared by mass, using an analytical balance with an accuracy of ± 0.1 mg.

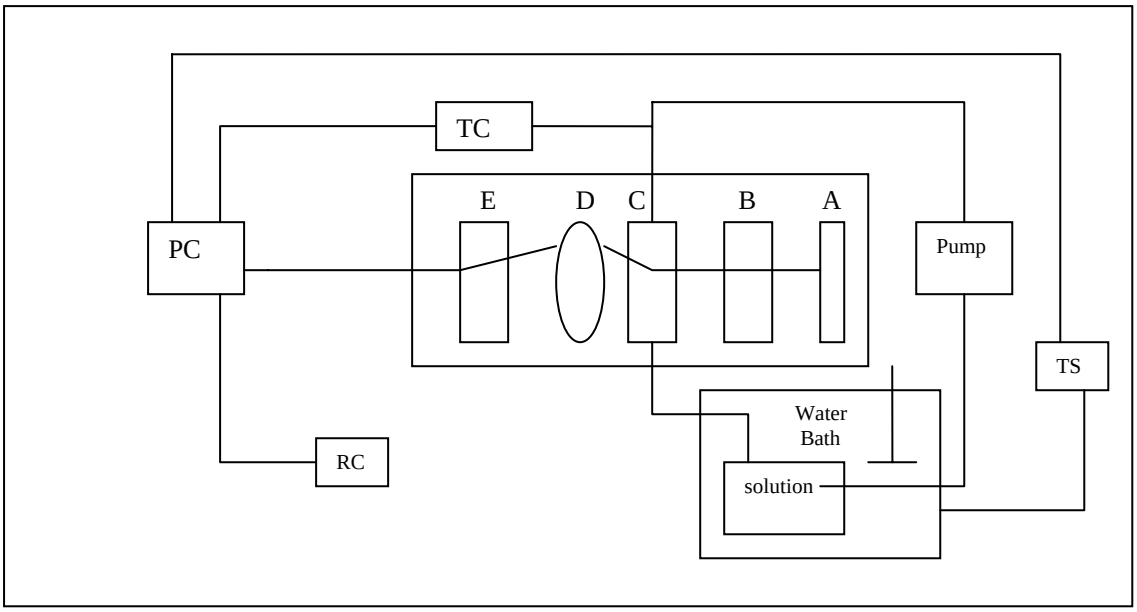

Figure 1. Shematic diagram of the apparatus used in this work for determining of cloud point of PPG aqueous solution. PC: personal computer TC: thermocouple TS: thermostate RC: recorder A: laser diode B: scanner C: flow cell D: detector lens E: photo detector

Results and Discussion

Figure 2 shows the results of number of particles versus temperature for PPG2025+H_2O mixture. Weight percent of PPG in this mixture is 15. According to this figure, on increasing the temperature of the solution from 5 to 6.5^oC, the number of particles is nearly constant, but at 6.1^oC, a sharp increase is observed which is due to appearance of first particles for formation of a new phase. Therefore, 6.1^oC is recorded as the cloud point of this mixture.

Figure 3 shows the results of number of particles versus temperature for PPG2025+H_2O mixture. Weight percent of PPG in this mixture is 10. According to this figure, on increasing the temperature of the solution from 7.1 to 8^oC, the number of particles is nearly constant, but at 8.1^oC, a sharp increase is observed which is due to appearance of first particles for formation of a new phase. Therefore, 8.1^oC is recorded as the cloud point of this mixture.

Figures 4-6 show the changes of number of particles for three other different PPG aqueous solutions which are considered in this work. Figure 4 shows a sudden increase in number of particles at 9.8^oC. This temperature shows the beginning of formation of new phases.

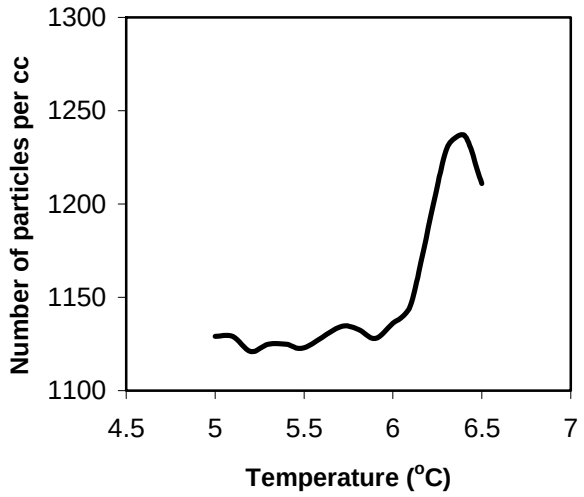

Figure 2 . Number of particles versus temperature for a mixture of PPG2025+H_2O (PPG% =15, H_2O%=90)

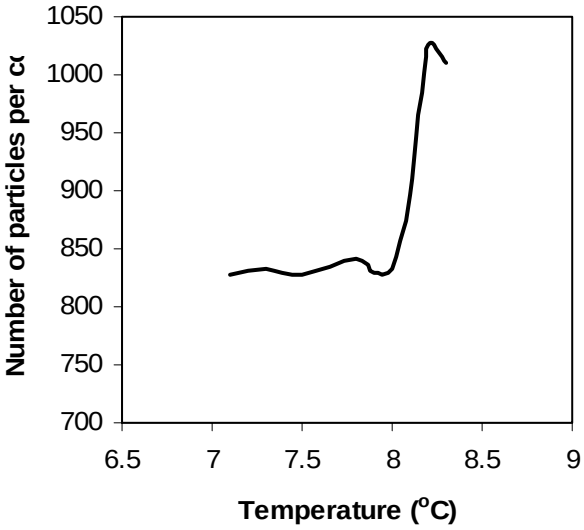

Figure 3 . Number of particles versus temperature for a mixture of PPG2025+H_2O (PPG% =10, H_2O%=90)

Figure 5 shows the behavior of another PPG aqueous solution with temperature variations. According to this figure, the number of particles are nearly constant at temperatures lower than 12.8°C, but at 12.8°C the number of particles begins to a sudden increasing and finally. This temperature is cloud point of PPG aqueous solution which the PPG concentration is 2 weight percent.

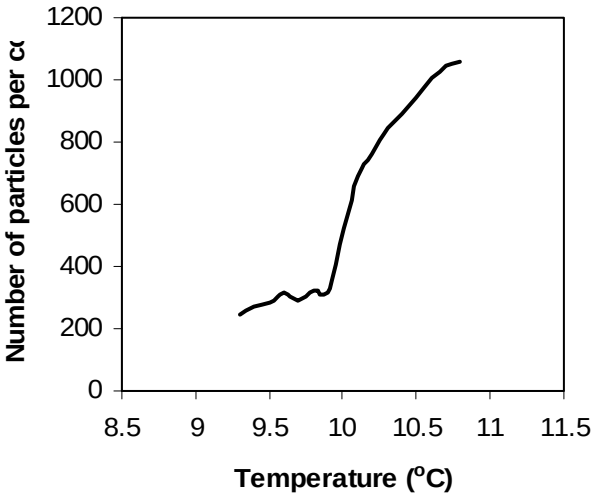

Figure 4 . Number of particles versus temperature for a mixture of PPG2025+H_2O

(PPG% =5, H_2O%=95)

Figure 6 shows variation of number of particles versus temperature for a dilute aqueous solution of PPG2025. According to this figure 13°C can be considered as the cloud point of this mixture.

By using the obtained cloud point data we are able to draw the cloud point curve for the aqueous solution of PPG2025 from 0 up to 15 weight percent of PPG. This curve is shown in figure 7.

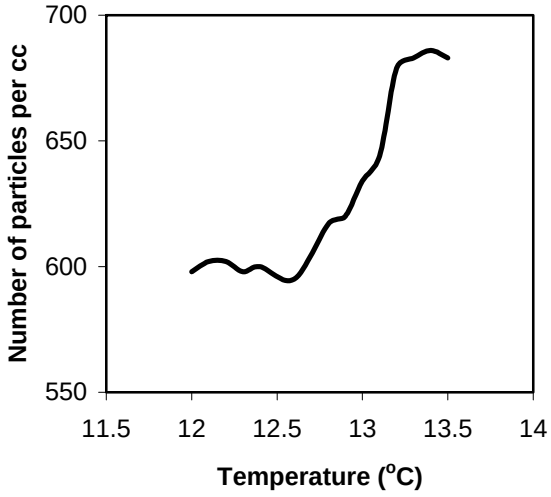

Figure 5. Number of particles versus temperature for a mixture of PPG2025+H_2O

(PPG% =2, H_2O%=98)

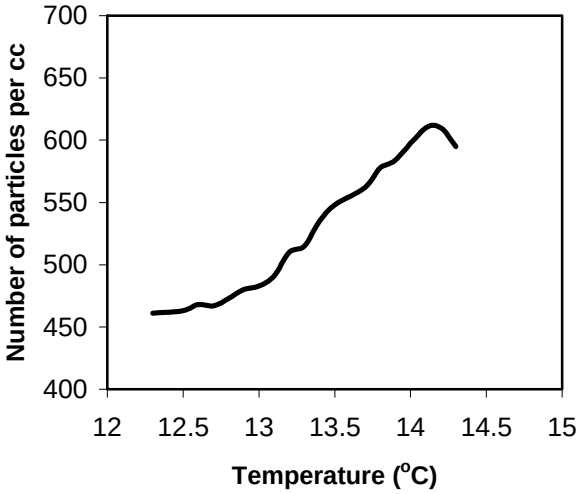

Figure 6. Number of particles versus temperature for a mixture of PPG2025+H_2O (PPG% =1, H_2O%=99)

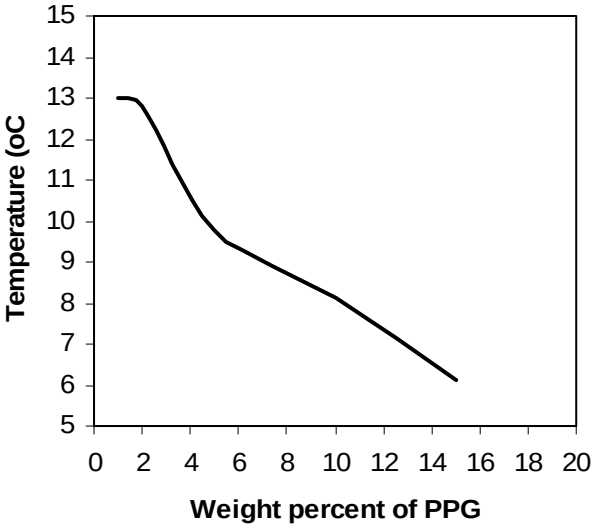

Figure 7. Cloud point curve of aqueous solution of PPG2025

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