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Effect of Temperature on 60nm and 100nm Nanosphere Size Standard using Dynamic Light Scattering

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Abstract: ***It is difficult to use kinetic motion as a measurement tool without temperature affecting the results. In this study, the size of a known nanosphere was used to monitor the effect of temperature towards particle size determination using dynamic light scattering principles. Temperature deviations are always picked up by size measurement using the principle of Brownian motion. The particle size of 60nm and 100nm polystyrene latex nanoparticles in 10mM NaCl solution was measured at four different temperatures set points of 20, 25, 30, 35 and 40°C using dynamic light scattering mechanism. As a result, the size of polystyrene latex nanoparticles was increased with the increases of the temperature. Therefore, for particle size analysis using dynamic light scattering mechanism the temperature of the test must be maintained at 25°C in order to obtain accurate measurement.***

Keywords* : *Particles size, temperature, dynamic light scattering.

I. INTRODUCTION

Temperature plays a vital role in optimization of product properties in a manufacturing process. It influences the growth of particle during the phase transitions of the materials, where kinetics and thermodynamic of the particle plays a role [1]. Raising the temperature improves the reactant particles kinetic energy, which increases the particles acceleration, thus enhances the frequency of collision. Therefore, the collision of particles occurs with more energy, which improves each collision's probability of success [2].

Dynamic light scattering (DLS), also known as photon correlation spectroscopy, is an effective method for characterizing the size of molecules in solutions and colloidal dispersions to illuminate random motion of particles or molecules under Brownian motion [3]. Brownian motion is the random particle movement due to the solvent molecules surrounding them being bombarded. It indicates that the particles fluctuate continuously affect the intensity of the scattering. The fluctuation of the scattering intensity is due to the time taken by a molecule at a specific wavelength to travel for a significant distance. The change of the particle position is correlated to the size of the particle. According to Brownian motion the smaller size particles travel faster compared to larger size particles. The connection between the size of particle and acceleration is described clearly in Stokes-Einstein law [4], as shown in equation (1).

$$D = \frac{K_b T}{6\pi\eta R_h} \quad (1)$$

Where R_h = hydrodynamic radius, D=diffusion coefficient of particles, T=temperature, K_b=Boltzmann constant and η=dynamic viscosity of the continuous phase. In the present study, using known polystyrene latex nanoparticles (60nm and 100nm) the temperature affecting the size was monitored. The DLS measurement was carried out at five different points of temperature, which are ranging from 20 - 40°C.

II. METHODOLOGY

A. Instrumentation setting

DLS analysis were performed using a Zetasizer, Model ZEN 3600, Nanoseries, Malvern Instruments. The measurement of the particle size was conducted using laser at fixed angle of 173° with 633nm of wavelength.

B. Nanoparticle preparation

The suspension of polystyrene latex nanoparticles with mean diameter of 60 nm and 100 nm were used in this study (Thermo Scientific). The samples were prepared with 1 drop of polystyrene latex nanoparticles and diluted in 1ml of filtered aqueous 10 mM sodium chloride (NaCl) in a polystyrene cuvette. The analysis was performed at five different point of temperature at 20°C, 25°C, 30°C, 35°C and 40°C. Measurements were repeated three times in order to determine the standard deviation and measurement of uncertainty for 60nm and 100nm of polystyrene latex nanoparticles.

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III. RESULTS AND DISCUSSION

The particles size measurement was performed using 60 nm and 100 nm polystyrene latex nanoparticles. Five different point of temperature setting were used to analyze the dynamic light scattering, which are 20°C, 25°C, 30°C, 35°C and 40°C. Figure 1 show the calculated diameters of the polystyrene latex nanoparticles 60nm were 63.9±5.5, 66.4±5.4, 69.1±5.4, 69.2±5.4 and 70.3±5.4 nm for temperature 20°C, 25°C, 30°C, 35°C and 40°C, respectively. Meanwhile, the calculated diameters of polystyrene latex nanoparticles 100nm were 102.3±6.7, 104.4±6.6, 105.4±6.6, 108.2±6.6 and 108.7±6.6 nm for temperature 20°C, 25°C, 30°C, 35°C and 40°C, respectively are shown in Figure 2. Figure 3 indicates that the size of 60nm and 100nm polystyrene latex nanoparticles increased according to the increment of the temperature in DLS system. Both nanosphere fall in the acceptable hydrodynamic diameter range for 20, 35 and 30ºC experimental reading. However, the hydrodynamic diameter for 35 and 40ºC of 60nm and 100nm nanosphere was out of range. The increasing hydrodynamic diameter is due to the effect of increasing temperature, which increases the colliding particles. The collision requires high quantity of energy for an efficient collision. Therefore, there will be more particles with higher activation energy [5]. According to Stokes-Einstein Law, during the increased in temperature all other constant will remain same except for temperature will change. The increment of the temperature is directly proportional to the hydrodynamic diameter of the particles [4]. Besides, the nanoparticle size enlargement occurs by one of two processes. The first process is Ostwald ripening which is known for soluble materials, where the rate of growth of large particles are dependent to the smaller particle dissolution [1]. The second process is oriented attachment, which is known for soluble crystals, where the size of the particle is dependent to the fusion of the smaller particles [6]. Furthermore, both above processes are dependent on the temperature. The effect of temperature on Ostwald ripening process is dependent to three factors, which are coefficient of growth rate, solubility and interfacial energy. Meanwhile, in the process of oriented attachment the effect of temperature is dependent to the surface energy and interphase boundary [7].

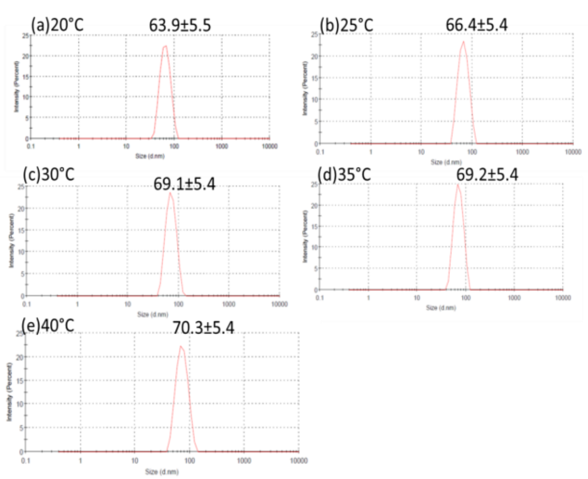

Fig. 1. Particles size analyzer graph for 60nm

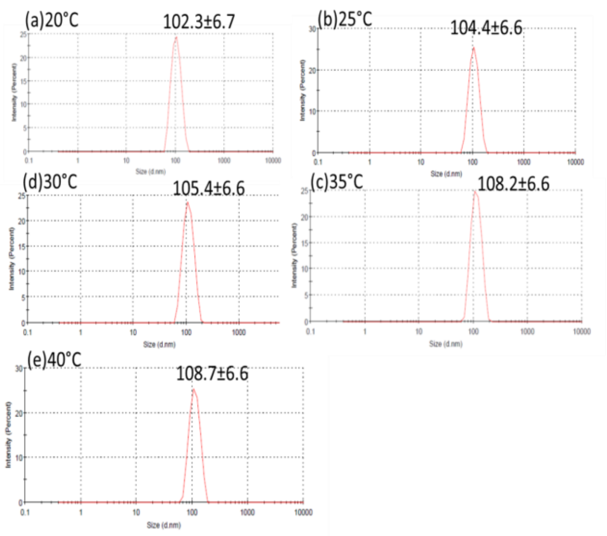

Fig. 2. Particles size analyzer graph for 100nm

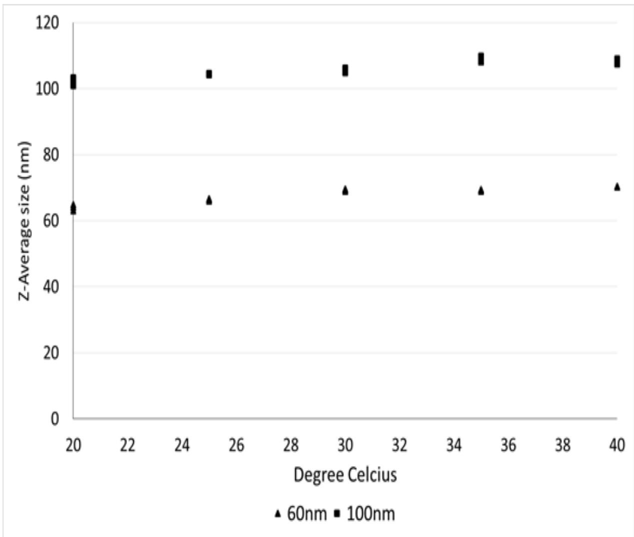

Fig. 3. Verifying the temperature stability of the DLS

IV. CONCLUSION

As in summary, using the DLS the size of 60 and 100nm of polystyrene latex nanoparticles increased with the increase of temperature from 20, 25, 30, 35 and 40°C. The optimal temperature is 25ºC as it mimics the standard temperature in a laboratory. The obtained hydrodynamic diameter for 60nm and 100nm nanosphere was acceptable and within the acceptance criteria.

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