Effect of Inlet Temperature and Flow Rate Towards Produce 2% Carboxymetyl Cellulose Spray Dried Powder

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Abstract – Carboxymethyl cellulose (CMC) can be synthesized from waste such as empty fruit bunch or sago pulp and is commonly used in detergent and pharmaceutical product. Currently, CMC is delivered in liquid and fibre condition which incurred high cost and difficult to handle. Thus, CMC needs to be converted to powder form for ease handling. A study was done to determine the suitable inlet temperature and flow rate of producing 2% CMC powder by using spray dryer. Results showed the high inlet temperature and low flow rate of pump recovered more powder than low inlet temperature and high flow rate. Then, the research were scale up at pilot plant by using parameters that have been obtained in bench scale. Powder obtained from scale up process were analyzed and it was found that the powder produced at high temperature and low flow rate have low moisture content, low viscosity and less yellowness index (YI) compared with TL100 given by the industry. As a conclusion, high temperature and low flow rate of speed pump are suitable to recover 2% CMC solution synthesized from empty fruit bunch

Keywords – Carboxymthyl cellulose (CMC), empty fruit Bunch (EFB), Spray Drying

INTRODUCTION

Carboxymethy cellulose (CMC) is one of type cellulose modification and comes from the nature. CMC is applied widely because of its low toxicity and easy to handle. The application is gluten free in food product, tooth paste, detergent and thickening agent in pharmaceutical product (Pushpamalar V. et al., 2006; Yang F. et al., 2009; Nadezhada R. et al., 2014; Chng L. M., 2010). CMC can be found from waste such as sago pulp and empty fruits bunch (EFB), commonly produce in liquid form or fiber condition. In this condition, the cost of production is higher because of the transportation cost and maintaining the concentration and condition. In order to overcome this problem, the CMC form was changed from liquid or fiber form to powder form. The changes of CMC form is by spray drying process.

Spray drying is a process where powder products are produce based on the material's physical and chemical properties (Patel R. P., et. al., 2009). The principle of spray drying is to separate the solute or suspension as a solid and solvent into vapor. The application that use spray drying is the material has heat sensitive especially food and drug. It is because, the spray dryer has the ability to produce powder with specific particle size and reduce the moisture content. The advantages of these spray drying method is can operate in large amount of capacity, the dried product characteristic remain constant along constant drying condition and the operation is continuous process and flexibility (Parikh. D. M., 2014). In addition, the suitable temperature for CMC to become a powder is important because of the purity of CMC. If the temperature used is higher or lower than meting point, the purity of CMC will be affected. The potential speed pumps of spray dryer for the CMC become the powder and if the speed is fast, it will affect the powder moisture.

METHODOLOGY

Material

2% CMC solution were obtained from by Waris Nove Sdn. Bhd.. The solution was produced from empty fruit bunch, Malaysia Palm Oil Board.

Spray drying process

The 2% of CMC solution were dried using spray dryer Laboratory plant spray dryer, SD-Basic, at different inlet temperature and speed pump. The volume of the sample is remaining constant which is 500 mL for every experiment. The powder recovery were weight along the each part of spray dryer (chamber, cyclone, waste collector, and sample collector) and seal, avoid from open air. In pilot plant scale, the solution was dried using Anhydro spray dryer at 160 °C and 15 rpm with 10 kg of sample. The powder recovery was weighted and seal, avoid from open air. The time taken is record to find the flow rate of speed pump.

Moisture content

CMC powder from pilot plant and industry (TL100) were weight accurately 5 g in a pantry dish. Dry it for 4 hour at 105 ± 3 °C by oven. Then, cool it down in desiccators for 30 min and weight it again (CPKelco, 2009).

$$Moisture\,\% = \frac{A - B}{A} \times 100\%$$

Where: A = weight of the original sample, g

B = weight of dried sample, g

Viscosity

CMC powder from pilot plant and industry (TL100) is determining in 2% concentration. The powders were mixed slowly with into distilled water and stir until the powders completely dissolve. Stabilize the temperature of the solution at 25 ± 0.5 °C. Viscosity was measured by Brookefield viscosity meter. The speed is 150 rpm with spindle number 2 (CPKelco, 2009).

Color Analysis

CMC powder from pilot plant and industry (TL100) were measured with calorimeter. The sample were placed on white standard plate (L = 96.86, a = - 0.02, b = 1.99) and L, a, and b color value were measured. L value range from 0 (black) to 100 (white); a value range from – 80 (greenness) to 70 (redness); b value range from – 80 (blueness) to 70 (yellowness). All measurement were performed in three replicates. Total color difference (ΔE), yellowness index (YI) and whiteness index (WI) were calculated as (Babak G., et. al., 2010).

$$\Delta E = \left[\left(L_{standard} - L_{sample}\right)^2 + \left(a_{standard} - a_{sample}\right)^2 + \left(b_{standard} - b_{sample}\right)^2\right]^{0.5}$$

$$YI = 142.86\ {}^{b}/_{L}\ ;\ WI = 100 - [(100 - L)^2 + a^2 + b^2]^{0.5}$$

Particle Distribution Analysis

CMC powder from pilot plant and industry (TL100) were weight accurately 2 g in a pantry dish. The powder analyze by Malvern Particle Size Analyzer (Mastersizer 2000). The refractive index of 2% CMC is 1.330 from commercial CMC powder as a standard (AQUALON, 1999)

RESULTS AND DISCUSSION

Powder recovery

Figure 1 shows the results of temperature and flow rate to produce powder. Its show that the powders recover at 160 °C has produced more powder than 120°C. The total powder produce at 120 and 160 °C is 1.12 and 3.30 g. Meanwhile, at 3 rpm of speed pump with show the highest powder produce for both temperatures. The total powders produce at 3 rpm is 2.04 g. However, at temperature 160 °C show the higher production of CMC powder at 3 rpm with second longest time to finish the solution. The time taken is 4029 s (1.07.09 hr). The flow rate of higher production of powder is 0.1241 mL/s. As conclusion, the inlet temperature and flow rate to produce 2% CMC powder is 160 °C and 0.1241 mL/s (3 rpm speed pump). The inlet temperature and flow rate to produce 2% CMC powder is between the ranges of previous study (.

From the inlet temperature, the experiment was continuing at pilot plant to identify the inlet temperature can operate at pilot scale before entry the industry scale. The powder recovery is 28.34 g from 10 L (10, 000 mL) of 2% CMC solution and the flow rate is 1.85 mL/s (6.66 L/hr). The speed pump used is 15 rpm and the blower is at 50%. The speed pump used is 5 times higher than laboratory scale because of the size of chamber is bigger.

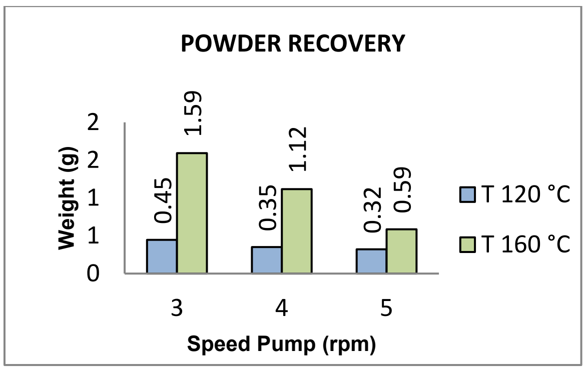

Figure 1 Powder recovery at 120 and 160 °C on different flow rate of speed pump.

Moisture content

Table 1 show the results of moisture content from 2% CMC powder (pilot plant) and TL100. The commercial moisture content of CMC powder is between 6.98 to 8.5 % (SIDLEY CHE., 2013). From the results the TL100 and 2% CMC powder, the moisture content between the ranges of commercial standard. TL 100 powder have loss more moisture content compare to 2% CMC powder which is 0.405 g and 2% CMC powder is 0.375 g. Since the solution are not mixes with other reagent such as maltodextrin, the percent of moisture content is below than 10% because maltodextrin have effect on inlet temperature of spray dryer. The powder produce from spray dry pilot plant contain less moisture compare to industry (TL100). This is because, the moisture content depends on the inlet temperature of spray dry (Vaibhav P. et. al., 2014). The inlet temperature is a driving force for moisture to evaporate during spray dry process. Higher inlet temperature is good for heat transfer of the powder.

Table 1: Moisture content for 2% CMC powder (pilot plant) and TL100

Type	Weight (g)		Moisture Content (%)
	Initial (A)	Final (B)	
TL100	5	4.595	8.1
2% CMC	5	4.625	7.5

Viscosity

Table 2 shows the results of viscosity for 2% TL100 and 2% CMC (before and after spray dry). Viscosity is to determine the condition of fluid. If the solution is higher viscosity, solution is in thick or sticky condition (Fang Y. G., et. al., 2009).

Table 2: Viscosity for 2% TL100 and 2% CMC (before and after spray dry)

Type	Speed Pump (rpm)	Viscosity (mPa.s)
2% TL100	150	187.6
2% CMC (Before)	150	110.4
2% CMC (After)	150	111.4

From the table 2, 2% CMC before and after spray dry is 110.4 and 111.4 mPa.s. The solution is not sticky or thick. However the 2% CMC (after spray dry) solution were compare with TL100, the viscosity is higher and the condition is thick. The viscosity of solution is effect by the inlet temperature of spray dry. If the temperature is higher, the viscosity will decrease (CPKelco, 2009). In addition, the viscosity is lower because of the moisture content is lower.

Color

Table 3 shows the results of color for 2% CMC and TL100 powder. Based on L value, the TL100 is lower than 2% CMC powder which is 90.16, it show the powder is less white than 2% CMC powder. The a value show the negative value on 2% CMC powder means the powder less greenness and b of 2% value are also less than TL 100.

Table 3: Comparison of color for 2% CMC powder (pilot plant) and TL100

Type	L	a	b	YI	ΔE	WI
2% CMC	94.75	-0.18	3.02	4.55	2.35	93.94
TL100	90.16	0.35	9.05	14.34	9.74	86.63

The YI and ΔE value of TL100 is higher than 2% CMC powder by 14.34 and 9.74. Its mean the TL 100 is slightly yellow compare to 2% CMC powder. Meanwhile WI shows the whiteness index of 2% CMC powder is high than TL 100 and almost 100 (L value) by 93.94. It shows the 2% CMC powder is white and the inlet temperature to produce 2% CMC powder is suitable. Color can be an important factor to customers acceptance of both editable and inedible powder (Babak G. et. al.,2010)

Particle Size

Figure 2 show the particle sizes between 2% CMC pilot plant powder and CMC TL 100. At 2% concentration, 2% CMC shows its have large particle size compare to TL 100. The diameter range of 2% CMC is 118.465 µm to 574.951 µm, while TL100 is 81.813 µm to 293.854 µm. The particle size increase as the temperature increasing.

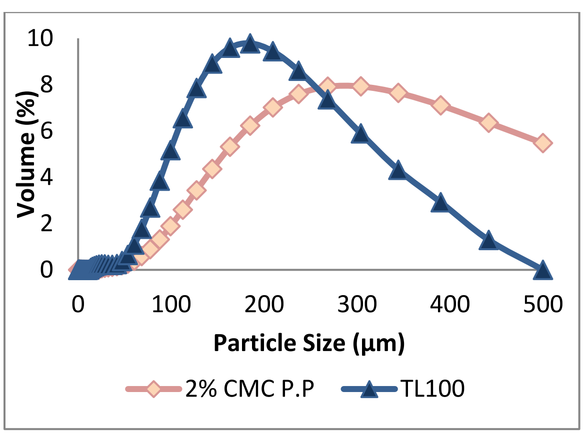

Figure 2: Comparison of particle size of 2% CMC (Pilot Plant) and CMC TL 100.

CONCLUSION

The aim of this study was to determine the inlet temperature and flow rate of 2% CMC powder recovery. 2% CMC solution were spray dried in a bench top spray dryer in order to determine the suitable temperature and flow rate, and in pilot plant scale to determine the maximum powder recovery and duration. Powder from the pilot plant scale shows the inlet temperature 160 °C, is suitable to be applied because the analysis showed that the powder produced have less moisture content, low viscosity, white and large size of particle. In future study, the industrial scale laboratory may require in order to support the production rate with minimum duration to produce powder.

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