Production of Carboxymethyl Cellulose (CMC) – Cat Litter Pellet

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***Abstract* — The purpose of this study is to determine the characteristic and affect of clumping agent which is carboxymethyl cellulose with nonionic bio surfactant in cellulose. Cellulose replaced chemical based cat litter pellet. As world is concern about the environmental issues, researchers tend to find alternative ways to replace nonrenewable sources which is chemical based cat litter pellet with cellulose. This is because the cellulose are environmental friendly as it is made from palm based. Unfortunately, cellulose has its own disadvantages which is it does not have the ability to clump with CMC. Most of the cat litter are made from both clay and silica based which also have several disadvantages such as high cost, cannot be decompose and also are not recommended to be flushed into sewage system and landfill. The general requirement for cat litter is it can wetted with urine and absorbs all the moisture absorption. In this experiment the material that are under studied are carboxymethyl cellulose and bio surfactant. Carboxymethyl cellulose used in this experiment is made up from oil palm empty fruit bunch (OPFEB). One type of bio surfactant used in this experiment is known as nonionic bio surfactant which is Tween80. Tween80 is used to improve the odor control and carboxymethyl cellulose as a clumping agent. There are 16 samples with different formulation ratio used in the clumping and hydration capacities tests for producing biodegradable cat litter. Based on the results, it appears that cellulose which made up from palm absorbed slightly more water and has a potential to be used as commercial cat litter. As a conclusion, the formulation ratio 1:1 for each volume of solution gave adequate clump strength and nice clumping as it would allow the cat owner to remove soiled clumps easily from a litter box without removing excessive amounts of unsoiled litter.**

***Keywords* — Cat Litter**
Cellulose
Hydration capacity
Surfactant

I. INTRODUCTION

Nowadays, among household popular pets throughout the world is the domestic cat which can be found in every place where people lived. Each day the average cat produce approximately 3 lbs. of fecal waste (Seemann & Rose, 2015) which give the annual fecal production of over 1.18 million metric tons (Dabritz, 2010). For this reason of the highest, there are many type of cat litter commercially available since 1940s to cater the high production of fecal waste.

One of the options for the best cat litter pellet is from biodegradable sources rather than clay-based and silica-based. Normally, animal litter which come from biodegradable sources consist of a variety of materials including sawdust, wheat, alfalfa, oat hulls, palm, corn cobs, peanut hulls or recycled paper waste (Steven F.Vaughn, Mark A.Berhow, & Edward Lee, 2011). In this study, cat litter pellet which made from palm based has been investigated. It does not contain any chemical additives and also give good odor control. Besides that, it is also dust free and non-toxic which can provide a healthier environment. Unfortunately, palm based cat litter do not clump easily and make it difficult to scoop.

Cellulose is a linear and high molecular weight polymer as well as natural, renewable and biodegradable material (Rachtanapun & Pornchai, 2009). One of the other options to convert the cellulose to derivatives by increase the cellulose pertinence. Nowadays, there could be applied in paper, food, pharmaceuticals, personal care, oil drilling and also detergents (Lou, Wei Qing Chin, & Dong Ping, 2014) due to its water soluble properties. Other than that, it also acts as a clumping agent animal litter and formed into pellets with other ingredients. Then, it will crumbled to improve absorption characteristics. In this study, one type of cellulose, CMC has been selected to be added to palm based cat litter so that the material could clump easily and improve the weakness of the cat litter. CMC also known as sodium cellulose glycolate, cellulose gum or sodium carboxymethyl cellulose. The characteristics of purified carboxymethyl cellulose is a white to cream color, tasteless, odorless and also free-flowing powder (Moses Onigbinde & Adeago Vivian, 2015). It is also water-soluble fiber at room temperature (Asep Handaya Saputra, Linnisa Qadhayana & Alia Badra Pitakola, 2014). CMC often blended with starch to provide desirable texture, enhanced product quality and stability, control moisture and loss water mobility (Bertuzzi, et al., 2007). Carboxymethyl cellulose was synthesized from diverse plant biomass which contain 40 - 50 % cellulose, 25 - 40 % hemicellulose and 15- 35 % lignin on a dry basis (Singh, 2012). The synthesis of carboxymethyl cellulose can come from any

agricultural waste cellulose source such as sago waste, sugar beet pulp stem and oil palm empty fruit bunch.

The other material that has been selected to be added to process the clumping cat litter is surfactant. Surfactant is made up from natural resources or petroleum. It can be divided to four types of surfactant which are anionic, cationic, nonionic and zwitterionic. The highest demand surfactant due to its biodegradable properties and eco-friendly is the nonionic bio surfactant. The aim of using nonionic bio surfactant in cat litter is to increase the rate of moisture absorption and also to improve the odor control.

There are three types of cat litter pellet which are clay based, silica gel crystals and also biodegradable cat litter. Each with different properties that may appeal to both owners and felines. There are a few disadvantages of using the clay based and silica gel crystals. One of the disadvantages of using both of these materials is its cost. They are more expensive than biodegradable cat litter pellet. It cannot be decomposed and not recommended to be flushed due to the litter tend to expand when getting moisturized. Other than that, the cat might swallow and inhaled the particles which will post danger to the cat.

The purpose of this study is to do the formulate cat litter which consists of carboxymethyl cellulose CMC, nonionic bio surfactant in cellulose. It is a preliminary study on characteristic and affect of clumping agent between CMC and nonionic bio surfactant in cellulose.

II. METHODOLOGY

A. Materials

Carboxymethyl cellulose was purchased from Waris Nove Sdn Bhd, Kuantan. The cellulose which used for coating is from the palm. For this experiment, the cellulose act as cat litter pellet. Nonionic bio surfactant used is Tween80. The chemical uses in this experiment is ammonia solution.

B. Coating Cat Litter

The cellulose from Waris Nove Sdn Bhd were sieved by using sieve shaker for 20 minutes to find the suitable diameter (710 Micron, 600 Micron, 250 Micron and 180 Micron). The diameter with the highest quantity of cellulose were chosen for this research. The CMC solution was prepared and later was added to Tween80 nonionic bio surfactant and the weight of total mixture was 3 g. Then, CMC was diluted to 100ml. Then the solution was stirred until it gave clear solution for 24 hours. The formulation ratio were then prepared for the volume of solution which each sample were 25 mL, 50 mL,75 mL and 100mL respectively as shown in table. The CMC percentage solution that has already prepared was used as a volume of solution for CMC. Each sample of 25 g of cellulose was prepared and mixed with the formulation ratio. Then, the sample was placed into a drying oven at 30 ℃ for 24 hours.

Table 1: Formulation ratio between nonionic surfactant and carboxymethyl cellulose

Formulation Ratio											
25 Ml			50 mL			75 mL			100mL		
Ratio	$V_{TWEEN80}$	V_{THH}	Ratio	$V_{TWEEN80}$	V_{THH}	Ratio	$V_{TWEEN80}$	V_{THH}	Ratio	$V_{TWEEN80}$	V_{THH}
1:1	12.50	12.50	1:1	25.00	25.00	1:1	37.50	37.50	1:1	50.0	50.0
1:2	8.33	16.67	1:2	16.67	33.33	1:2	25.00	50.00	1:2	33.33	66.67
1:3	6.25	18.75	1:3	12.50	37.50	1:3	18.75	56.25	1:3	25.0	75.0
1:4	5.00	20.00	1:4	10.00	40.00	1:4	15.00	60.00	1:4	20.0	80.0

C. Clumping test of cat litter formulations

Initially, 5g coated cellulose of each sample was placed into glass petri dish. Then, 5 mL of 121 mM Ammonia solution was dripped onto the dish. The sample then was placed in a dryer at 30℃ for 24 hours. Then, clumping percentage of the sample was calculated. The data is then tabulated and analyzed. Clumping percentage was calculated as follows:

$$Clumping\ percentage = \frac{Weight\ of\ clump}{5\ g} \times 100$$

D. Hydration Capacities of cat litter formulations

Hydration capacity which is defined as the ability of a solid matrix to absorb liquids was calculated by using weight balance. 1g sample of coated cellulose were placed in conical flask. Then, 10 ml of distilled water was added to each tube and the samples were shaken on an orbital shaker set at 250 rpm for 15 minutes. The tubes were then centrifuged for 15 minutes at 1000 x g. The wet sample was then carefully poured into a beaker and the tubes weighed. The hydration capacity was determine by using the formula shown below for each sample and the data is tabulated.

$$Hydration\ Capacity = \frac{Weight\ of\ the\ tube\ and\ wet\ sample - weight\ of\ the\ tube}{Dry\ sample\ weight}$$

III. RESULTS AND DISCUSSION

A. Result of clumping percentage and hydration capacities from cellulose formulation

From the sieving experiment, the best sieve size for the cellulose is 710 Micron and Figure 1 shows that the cellulose were separated by using sieve shaker and the fractions were separated into large (remained on the top of the sieve which was 710 Micron) and small (passed through another sieve was 600 Micron, 250 Micron and 180 Micron). This size has been used for the experiment and cellulose is the raw material used in this experiment. Later, carboxymethyl cellulose solution and Tween80 nonionic bio surfactant were added to the raw material.

Figure 1: Cellulose before clumping

Clumping percentage and hydration capacities for the mixture were shown in Table 2 and 3. The experiment is focusing more on quantitative result rather than qualitative. Based on Table 2 and Table 3 for the formulation ratio 1:1 shows that it gave the lowest rate of hydration capacities but give the highest percentage of clumping cellulose compared to the other formulation ratio. Besides that, the cellulose sample formed nice clumps which it is not easy to break down.

Table 2: Clumping percentage of cellulose formulations

Formulation Ratio			
25 ml			
Ratio	$V_{Tween80}$	V_{THH}	Clumping Percentage (%)
1:1	12.50	12.50	47.30
1:2	8.33	16.67	44.20
1:3	6.25	18.75	39.18
1:4	5.00	20.00	37.60

Formulation Ratio			
50 ml			
Ratio	$V_{Tween80}$	V_{THH}	Clumping Percentage (%)
1:1	25.00	25.00	52.14
1:2	16.67	33.33	52.08
1:3	12.50	37.50	40.74
1:4	10.00	40.00	47.56

Formulation Ratio			
75 ml			
Ratio	$V_{Tween80}$	V_{THH}	Clumping Percentage (%)
1:1	37.50	37.50	53.80
1:2	25.00	50.00	53.42
1:3	18.75	56.25	49.81
1:4	15.00	60.00	43.74

Formulation Ratio			
100 ml			
Ratio	$V_{Tween80}$	V_{THH}	Clumping Percentage (%)
1:1	50.00	50.00	67.47
1:2	33.33	66.67	62.57
1:3	25.00	75.00	55.30
1:4	20.00	80.00	54.62

Figure 2: Graph of clumping percentage of cellulose formulation

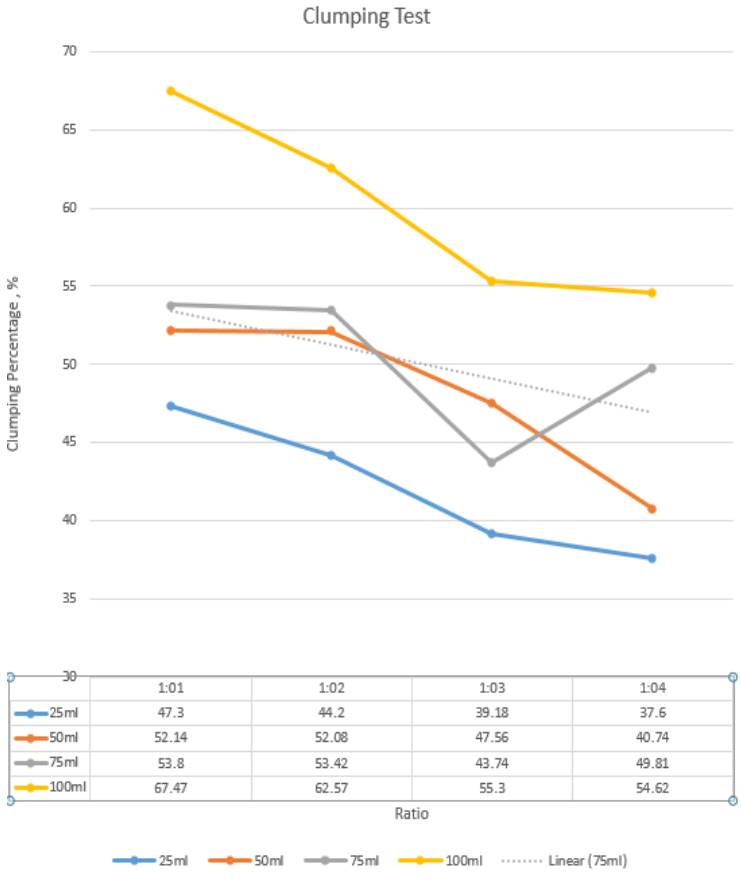


Figure 3: Sample of clumping cellulose after in drying oven for 24 hours

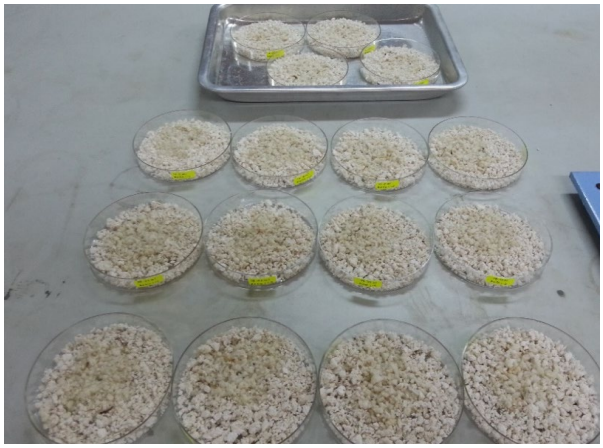


Figure 4: Clumped cellulose

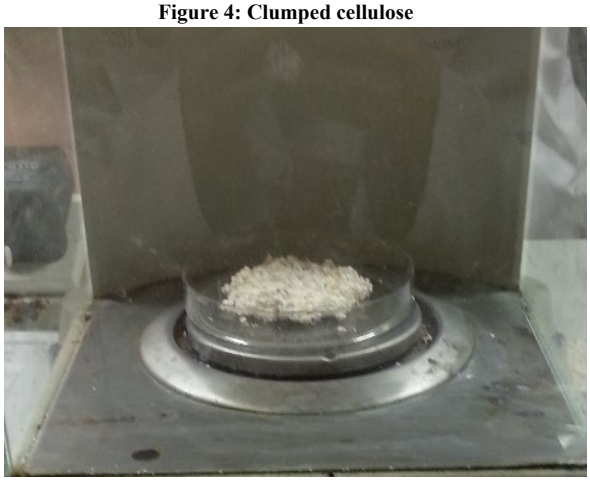


Table 3: Hydration capacity of cellulose formulation

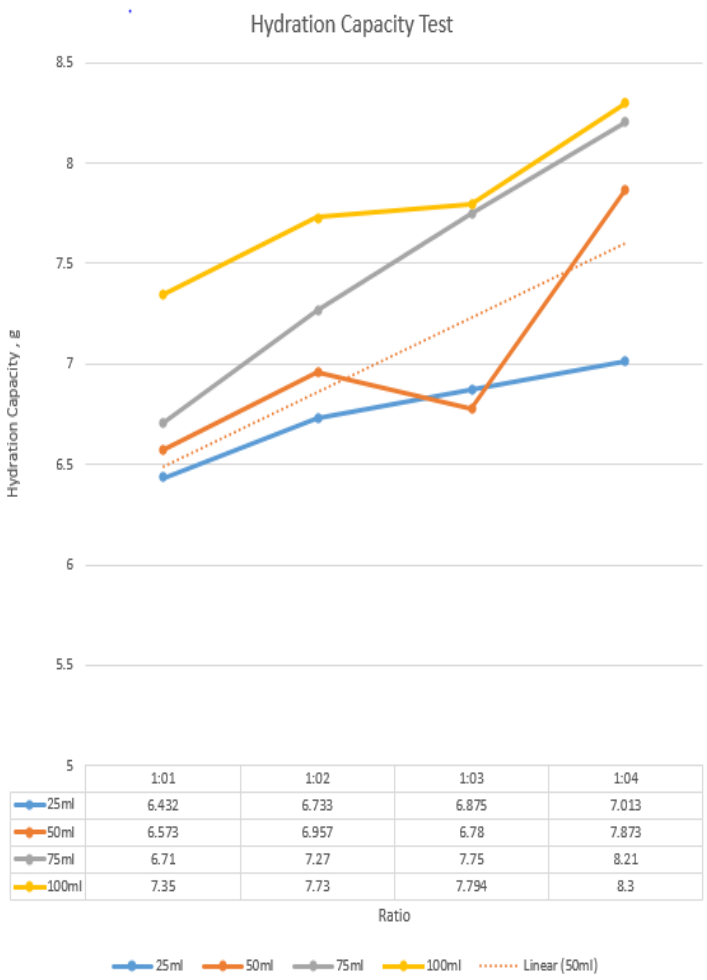
Formulation Ratio			
25 ml			
Ratio	$V_{Tween80}$	V_{THH}	Hydration Capacity , g
1:1	12.50	12.50	6.432
1:2	8.33	16.67	6.733
1:3	6.25	18.75	6.875
1:4	5.00	20.00	7.013

Formulation Ratio			
50 ml			
Ratio	$V_{Tween80}$	V_{THH}	Hydration Capacity , g
1:1	25.00	25.00	6.573
1:2	16.67	33.33	6.957
1:3	12.50	37.50	6.780
1:4	10.00	40.00	7.873

Formulation Ratio			
75 ml			
Ratio	$V_{Tween80}$	V_{THH}	Hydration Capacity , g
1:1	37.50	37.50	6.710
1:2	25.00	50.00	7.270
1:3	18.75	56.25	7.750
1:4	15.00	60.00	8.210

Formulation Ratio			
100 ml			
Ratio	$V_{Tween80}$	V_{THH}	Hydration Capacity , g
1:1	50.00	50.00	7.350
1:2	6.733	6.957	7.730
1:3	6.875	6.780	7.794
1:4	7.013	7.873	8.300

Figure 5: Graph of hydration capacity of cellulose formulation



The graph in Figure 2 shows that slightly decrease in clumping percentage numbers when volume of Tween80 decrease and volume of carboxymethyl cellulose solution increase. However,

from the graph in Figure 5 shows that increase rapidly in hydration capacities rate from each cellulose formulations.

For the formulation ratio of 1:2 of each volume of solution, the cellulose formed large amount of mass which stayed together fairly and it give the next highest percentage as shown in Table 2. At the formulation ratio 1:3, show that the cellulose that absorbed Ammonia solution formed nice clumps which broke down only slightly. Next for the formulation ratio 1:4, most of the clumps also fell apart slightly and it makes the clumps formed in small amount of mass. However, the graph on Fig 2 show that at 75 ml volume solution, the clumping percentage increase significantly from the formulation ratio 1:3 by 43.74 % to the formulation ratio 1:4 by 49.81 %. It has been found that the formulation ratio 1:1 gave adequate and nice clumping as it would allow the cat owner to remove soiled clumps easily from a litter box without removing excessive amounts of unsoiled litter. From the previous research it has been found that the carboxymethyl cellulose can act as the coatings in the cat litter, the formation of emulsions and suspensions and for water retention.

B. Comparison of clumping percentage and hydration capacities between previous and current study

Extracted dried distillers grains (x-DDGs) and cellulose which made up from palm could be formulated as cat litter but each method used different clumping agent. However both of these materials gave the same desirable physical properties to the commercial cat litter. From the previous study, the extracted dried distiller's grains (x-DDGs) had excellent water absorption compared to unextracted dried distillers gains. The problem when using unextracted (DDGs) is because it has a distinctive odor of fermentation when dry which becomes increasingly more intense upon wetting (Steven F.Vaughn, Mark A.Berhow, & Edward Lee, 2011). These compounds are made up from whole kernel corn. As the level of guar gum increased, the hydration capacities decreased slightly. Based on the study, the clumping agent used was carboxymethyl cellulose. It is also water-soluble fiber at room temperature (Asep Handaya Saputra, Linnisa Qadhayana, & Alia Badra Pitakola, 2014). Cellulose made up from palm which act as a cat litter also absorbed water but only slightly. From the result of the study, at the formulation ratio of 1:1 for each volume solution shows the lowest hydration capacities compared with other formulation.

But for each volume solution as the level of carboxymethyl cellulose increase and nonionic bio surfactant decrease, the hydration capacities increase. Next, based on the previous study showed that the clumping percentage increased dramatically as glycerol and guar gum was added. So, it was decided that at the second ratio (25.0 g) of glycerol and guar is the lowest level necessary to provide adequate clumping. But from the result of the current study showed that at the formulation ratio 1:1 gave adequate and nice clumping as it would allow the cat owner to remove soiled clumps easily from a litter box and make sure that the cat has a thoroughly fresh supply of litter. There are other process for binding between CMC and surfactant based on the previous research. According to (AT Tyowua, 2012), using conductometric method, it is found that the lowest concentration between the CMC and ionic surfactant gave the positive influence in KCI solution due to the tendency of the hydrocarbon chains to remove themselves from water.

IV. Conclusion

Carboxymethyl cellulose has derived from cellulose which made from water soluble by a chemical reaction. The application for carboxymethyl cellulose is widely used in paper, food, pharmaceuticals, personal care, oil drilling and detergents. The synthesis of CMC which can reduce cost come from agricultural waste cellulose sources such as oil palm empty fruit bunches. In this study, the compound was used as clumping agent in cat litter pellet. Other ingredient used to clump the cellulose together was nonionic bio surfactant. Based on the experiment, the result indicated that the cellulose with the formulation selected has excellent potential as biodegradable cat litter. It can be concluded that the formulation ratio 1:1 for each volume of solution gave adequate clump strength and nice clumping as it would allow the cat owner to remove soiled clumps easily from a litter box without removing excessive amounts of unsoiled litter. Besides that, it has been found that the carboxymethyl cellulose CMC is suitable to be used as clumping agent as it is non-toxic and safe to animal.

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V. Recommendation

Although the research has reached its aims, there were some recommendations suggest for this research project. The recommendation for this study is previous study involves the copper sulfate to test the effect on the odor volatile absorption by litter formulation. To study this effect is by using the 3-mercapto-3-methyl-1-butanol which is not commercially available. But then the nonionic bio surfactant also has a same purpose which is to improve the odor control and increase the rate of moisture absorption.

Next, according to the present study indicate that all samples were test for only three times for hydration capacity and clumping percentage. And according to other researchers, all of these samples need to run in quadruplicate for hydration capacity. However, based on one month to run the experiment, the result for clumping and hydration capacity test give the effective result.

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