Factors Affecting The Maximum Spreading Diameter of Chemically Modified Biomass Droplet On Urea Surface

by

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CERTIFICATION OF APPROVAL

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TRONOH, PERAK

May 2012

CERTIFICATE OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgments, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

MOHAMAD ASYRAF BIN MOHAMED

ABSTRACT

The investigation and research has been performed, studying the liquid behavior of chemically modified starch as the coating solution on urea surface with a CCD high speed camera. The main aim of this study is to analyze the important parameters or factors that will result the maximum spreading diameter of coating solutions on urea surface.

There are main several factors that lead to the expected result, which are the effect of droplet impact velocity and the droplet viscosity. Besides, the blending ratio also one of the factors can determine the spreading diameter. Different type of solutions can give the different characteristics, features and the value of parameters.

Since this project dealing with urea as the solid substrate, study on urea surface roughness and porosity is important in order to identify what are the behavior of droplet will lead to the maximum spreading diameter and coating uniformity.

ACKNOWLEDGEMENT

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Mohamad Asyraf bin Mohamed

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CHAPTER 1: INTRODUCTION

1.1. Project Background

Urea nowadays becomes the most important fertilizers in the agricultural sector. As the main purpose of addition of the fertilizers to the soil is a release nutrient necessary for plant growth. The fertilizer technology in agricultural sector has been improved until now to offer the better outcome since the demands increase.

But there is the limitation to their use because of the potential hazards of fertilizers to the environment (Zulhaimi, KuShaari, & Man, 2011). Urea placed on the soil surface or plant foliage may loose from 50% to 90% of its N as ammonia if not protected within a few hours of application (James, 2010).

As becoming an important part in urea as the fertilizer, the nutrient must be protected within the optimum range of time to reduce the nutrient releases. There are inventions were made in order to reduce the nutrient losses. One of them is Controlled Release Fertilizer (CRF). Coated controlled release urea mostly consists of quick release N source surrounded by a barrier that prevents the N from releasing rapidly into the environment.

There are several major types of materials used for coating. The first includes inorganic materials, such as sulfur, silicate, and phosphate. The second consists of thermosetting resins, such as urea–formaldehyde resin. The third includes thermoplastic resins, most of which are polyolefins and blended polyolefins (Ge, Wu, Shi, Yu, Wang, & Li, 2002). But there is an disadvantage by using these known coating agents in term of biodegradability. The new kind of coating material has to be developed to ensure the sustainable of environment.

The biomass composition provides an effective means to coat fertilizer and animal feed, such that resultant particles have good flow ability with the residual coating readily absorbed into environment (Schaafsma, Johannes, & Janssen, 2011).

1.2. Problem Statement

In agricultural lands, the loss of NH3 from surface-applied urea and micronutrient deficiencies are the two most common problems, which can be solved by using coated urea with coating solution for example micronutrients and biodegradable natural materials. These coatings can improve the nutrient status in the soil and simultaneously reduce nitrogen loss from urea (Junejo, Khanif, Dharejo, & Wan, 2011). There are a few inventions on the coating agents. But the known coating agents have their disadvantage which after the field application of the fertilizer, the coating agents will stay in the soil and accumulate there. This is because of the known coating agents are slowly degradable and this will lead to the environmental unsustainable since they often contain highly purified and processed compounds which many of them are synthetic.

As one of the solutions to overcome the above disadvantages is introduce the biomass composition as the coating agent for fertilizer since biomass is environmental friendly in terms of biodegradability and utilization of waste materials.

Since the main purpose of coating urea is to avoid the release of excess nitrous oxide from urea to environment, the study about the coating uniformity is crucial. It is because of the coating uniformity on urea surface will ensure and determined the necessary amount of urea released. So, in order to guarantee the good coating uniformity, the spreading behavior of a single droplet on urea surface is important to investigate.

1.3. Objectives and Scope of Study

- To study the effect of lignin composition and blending ratio on the coating solution viscosity.
- To study the effect of viscosity on the droplet spreading diameter.
- To investigate the effect of surface type which are non coated and coated urea on the droplet spreading diameter.

CHAPTER 2: LITERATURE REVIEW

2.1. Coating Urea

The problem regarding to the low nutrient uptake, the excess released of nitrous oxide to environment and uncontrolled release of nutrient become the common problem in agricultural sector in past years. The researchers provide coating as the solution as the main purpose of coating is to control the release of nutrient and in the same time will avoid the excess nutrient to environment. Become an important focus in agricultural sector in actually will offer urea as fertilizer the better space to improve. Most of us know that urea playing an important role in agricultural industry to increase the yield of plant production, but the introduction to coated urea actually provides much better result in term of production compare to non-coated urea. The study from University of Idaho show a steady but not excessive, supply of N is important for maximum tuber yield, size and solids, as well as minimal internal and external defects (Tysom, G.Hopkins, K.Shiffler, & Stephens).

The study of comparison between coated urea and uncoated urea in term of ammonia volatilization losses was done by Universiti Putra Malaysia in 2011. The result shows that the uncoated urea will release excessive ammonia in early stage of application compare to the coated-urea with different type of treatment (Junejo, Khanif, Dharejo, & Wan, 2011).

Table 1: Fertilizer treatments and the rate of application in each experiment

Treatment	Weight (g) of coating material per 100 g of urea	N applied in each study (µg g-1)
Experiment 1		
Urea (U)	100	400
Palm stearin coated urea (UPS1)	7	400
Palm stearin coated urea (UPS2)	10	400
Palm stearin coated urea (UPS3)	12	400
Agar coated urea (UAG 1%)	1	400
Agar coated urea (UAG 2%)	2	400
Gelatin coated urea (UG1%)	1	400
Gelatin coated urea (UG2%)	2	400
Experiment 2		
Urea (U)	5	400
Palm stearin +Cu coated urea (UPSCu)	5	400
Agar + Cu coated urea (UAGCu)	5	400
Gelatin + Cu coated urea (UGCu)	5	400
Cu coated urea (UCu)	5: 5 (Cu: Zn)	400
Cu + Zn coated urea (UCuZn)	5	400

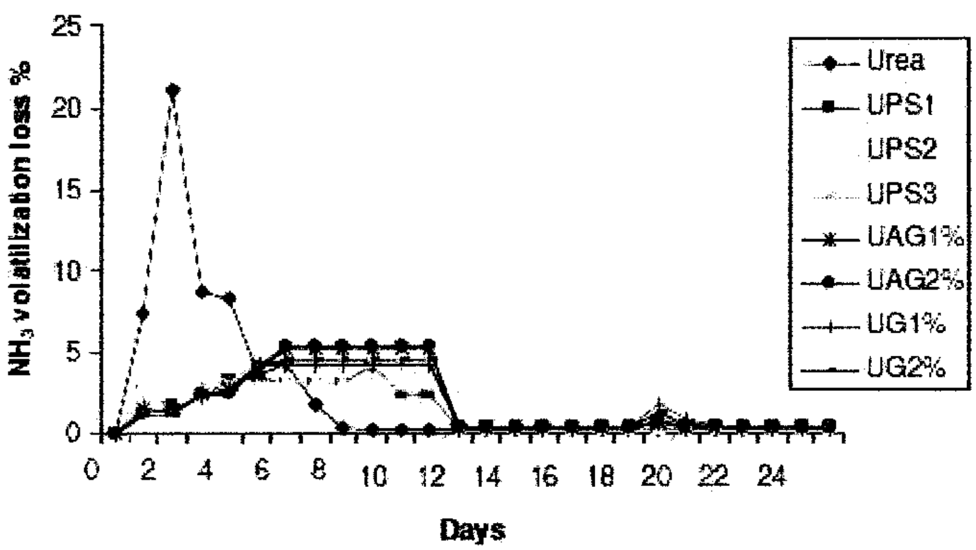


Figure 1: Daily Ammonia volatilization from experiment 1

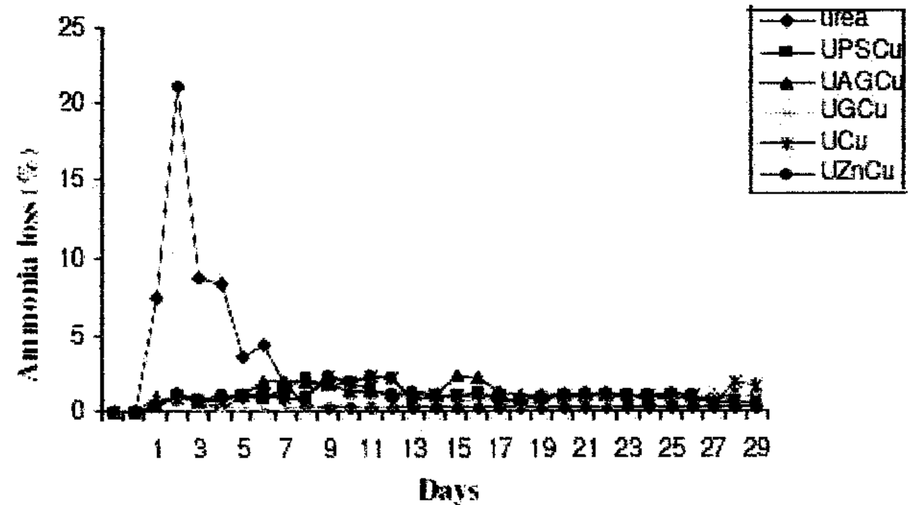


Figure 2: Daily Ammonia volatilization from experiment 2

There are two inventions were done in order to improve the better fertilizer in order to increase the nutrient uptake by plants either chemically to reduce their solubility or physically, for instance, by coating encapsulation. They are Slow Released Fertilizer (SRF) and Controlled Released Fertilizer (CRF). Which SRF are non-coated products that release the nutrient uncontrolled but slowly and CRF are generally coated products either with polymer or sulfur or a combination of both (Malveda, Francis, Ishikawa, & Janshekar, 2008). One of the main purposes of coating for fertilizers is exhibit good anti-caking properties. Caking is the agglomeration of fertilizer particle by adhesion at their point of contact to form a compact mass that is difficult to break up. The result stated that the caking has a negative influence on the flow ability of a fertilizer. Besides, coating is applied to the fertilizer to promote the maintenance of good physical conditions during storage and handling (Schaafsma, Johannes, & Janssen, 2011).

There are a lot of researches and studies have been done to provide the better result of coating quality on urea surface such as the modified coating solution. One of the disadvantages of the known coating agents for fertilizers is that they are not environmental friendly. Many of known coating agents often contain highly purified and processed compounds which possess a high carbon footprint since most of them are synthetic. To improve this circumstance, the research was done by providing a biomass as the new coating solution. Nowadays, the Polymer Coated Urea (PCU) is used to coat urea for improving nitrogen (N) use efficiency (NUE). PCU is urea coated in a plastic membrane. Released of the urea is controlled by diffusion through the membrane, and the rate is dependent on soil temperature which the higher temperature faster the release.

Large amounts of polymers are left as residue when nutrients are exhausted (Tomaszewska & Jarosiewicz, 2004). Biomass is one of the alternatives to replace PCU for coating urea. Not only has biodegradable characteristic, but bio mass is also less expensive compared to PCU. To make sure the high quality of coating uniformity, good wet ability and droplet spreading of coating is important (Zulhaimi, KuShaari, & Man, 2011). In this project, the study will focus on the factors affecting the maximum spreading diameter of modified biomass droplet; mixture of urea, starch and borate on urea surface.

2.2. Droplet Impact

The problem of a droplet impacting onto solid surface is a classical topic, and it is still currently of interest in wide industrial applications. Liquid droplet impact on solid surfaces plays an important role in many practical processes. As becoming one of the important parts in coating, the study of liquid droplet impact is very necessary in order to get the optimum result. The impact of liquid droplets on solid surfaces results in several outcomes, including spreading, recoil, and splashing of the droplets. When individual droplets make contact with a surface, there are 3 majors scenarios may occur which are spreading, splashing and rebounding. All these scenarios depend on the liquid and solid properties that are referred to biomass droplet and urea surface.

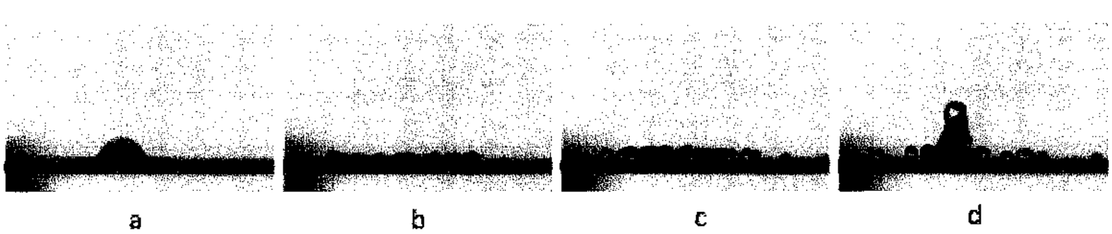


Figure 3: Droplet impact scenarios; a) initial stage, b) spreading, c) splashing, d) rebouncing

2.3. Spreading Diameter

One of the most important parameters in this study remains the maximum spreading diameter (d_{max}). One of the important information in droplet impact study is maximum spreading ratio, β_{max}. β_{max} is determined by division of maximum diameter of droplet during spreading (d_{max}) with diameter of liquid droplet before impact (D).

β_{max} has been determined independently by several authors using various numerical methods and commercial software which incorporate some specialized interface tracking schemes to model the deforming liquid. There are conflicts in reports on the physical parameters that contribute toward the determination β_{max}. Bennet and Poulikakos investigated some models for predicting β_{max} where four models were selected from previous studies. It was concluded that two of the models selected were inadequate in predicting β_{max}. One of the models by Madejski was then employed for improvement as they believed that such a model provides the best for the viscous energy dissipation term in terms of surface energy.

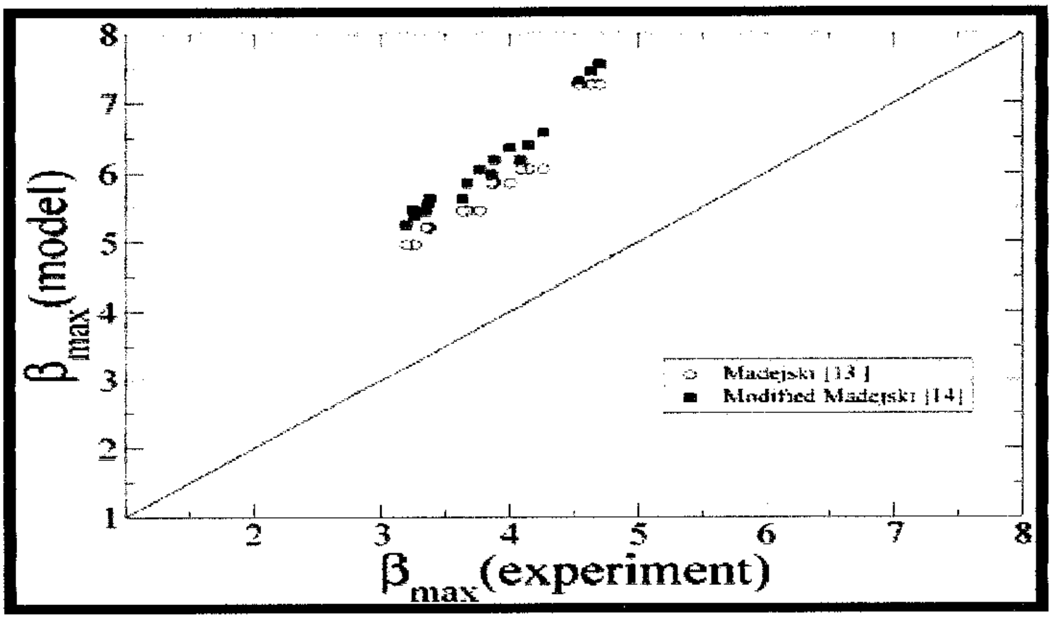


Figure 4: Droplet impact scenarios; a) initial stage, b) spreading, c) splashing,

Their study focus on the effect of surface tension and vicious energy dissipation in terminating the spread of a liquid droplet during the splat- quench solidification process and, hence in determining the maximum spreading factor (Ukiwe & Y.Kwok, 2005).

There are factors affecting the spreading of liquid droplet on the solid surface. The most important factors are the liquid properties (density, surface tension and viscosity), the solid surface characteristic (contact angle and roughness), the drop impact velocity and surface inclination. The research was done by Sikalo in 2005 using different characteristic of liquids with varying in surface tension and viscosity and the result showed that the drop volume, the surface inclination and impact velocity give a significant effect on the drop dynamics and the regimes of drop impact. In 2000 Fukai and Kang and Lee investigated the dependence of advancing and receding contact angles on the wall temperature and the contact line velocity experimentally. Fukai also has done the investigation 1995 for surfaces in different wettablities and shows that the effect of impact velocity on the droplet spreading was more pronounced when the wetting was limited and the other observation also shows that the impact velocity greatly influences the droplet spreading behavior. The incorporation of advancing and receding angles in the numerical model with adaptive mesh refinement improved their predictions (Lunkad, Buwa, & Nigam, 2007).

2.4. Spreading Behavior over Porous Surface

Since porous is one of the urea's surface characteristic, the spreading behavior of liquid on porous surface is very important to investigate. Spreading of liquid over porous solid surfaces is very crucial in several fundamental and technological scenarios including packed bed adsorbers, trickle bed reactors, coating and printing or painting of porous surfaces. The study by Davis and Hocking in 1999 and 2000 provided a framework to look at the competition between the imbibation by the pores and spreading to determine the lifetime of drops over porous bases. Recent efforts by Starov at 2002 and 2003 have also provided a valuable insight into the mechanics of the process based on Brinkman's equations for description of flow inside the porous layer and by lubrication and continuum theory for liquid drop flow over it (R.N.Maiti, R.Arora, R.Khanna, & Nigam, 2004).

The works reported presents a numerical model to study the dynamics of the impact/absorption of a liquid droplet on a porous medium. As depicted in Figure 5, this problem addresses a more complicated set of physical phenomena than impingement on non-permeable surfaces, since at the same time that the axial momentum of the droplet is transformed to radial momentum, the pressure at the impact point also forces the liquid to move through the permeable surface and into the substrate. Furthermore, capillary effects and wettability tend to draw the liquid into the porous substrate.

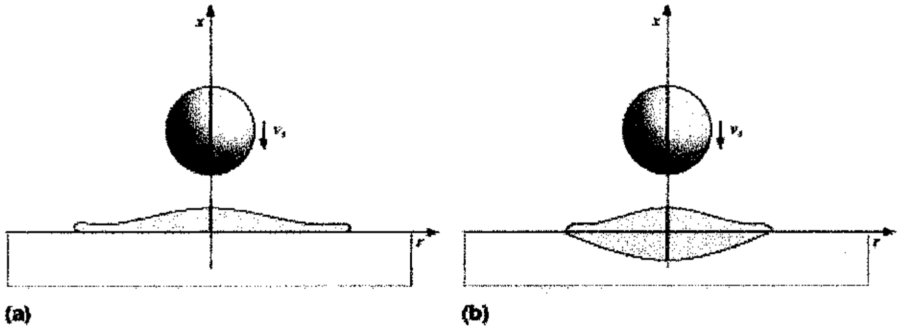


Figure 5: Schematic representation of the droplet impingement problem: (a) impingement on a non-permeable flat surface and (b) impingement on a permeable flat surface (Jr, Griffiths, & M.Santos, 2003)

Accordingly, there are three main issues that need to be addressed in order to obtain a mathematical description of the phenomenon: (i) the fluid flow outside and inside the porous medium, (ii) the flow through the atmosphere/porous medium interface, and (iii) the treatment of the free surface of the liquid droplet (Jr, Griffiths, & M.Santos, 2003).

2.5. Coating Uniformity

The coating uniformity onto the urea surface actually playing an important role in order to determine the quality amount of nutrient released from urea. Besides, the efficiency of urea applied on the soil depends on it.

Uniformity becomes the most important parameters associated with coating operations. Coating uniformity is split into two categories which are Mass Distribution of Coating Material and Coating Material Morphology. Details about the categorization as illustrated in Figure 6 (Turton, 2006).

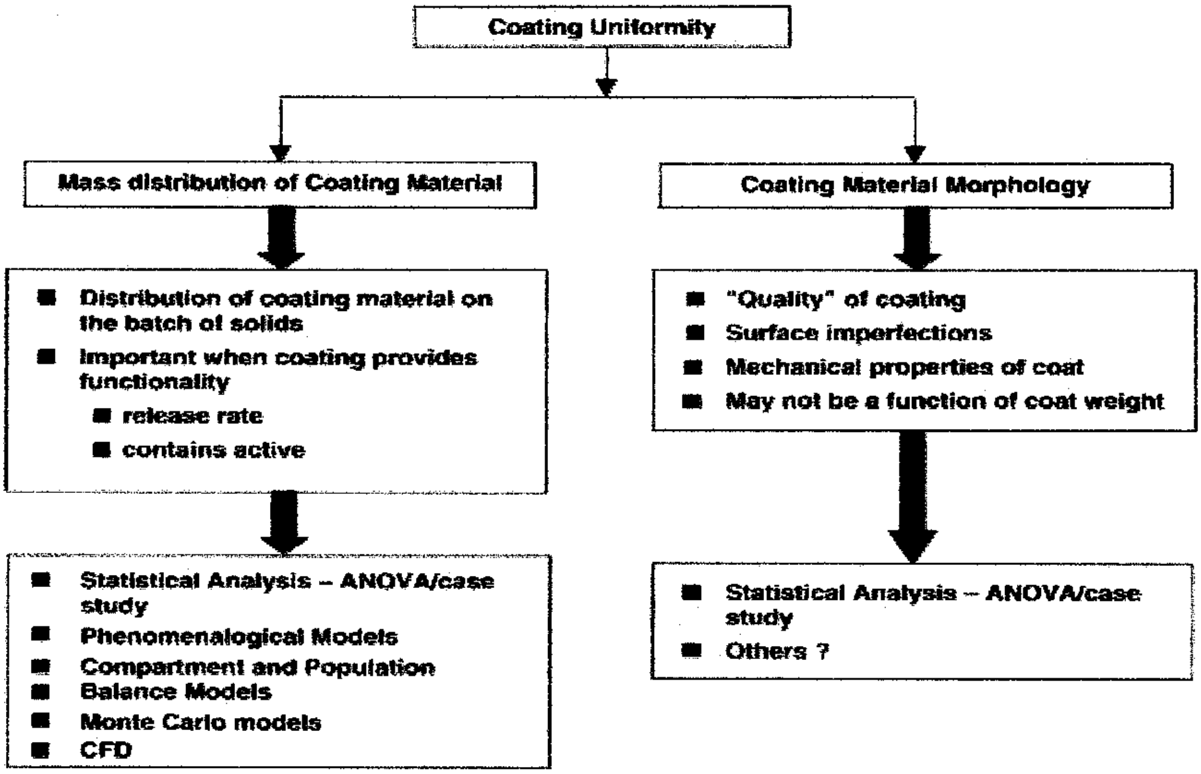


Figure 6: Modeling efforts to describe coating uniformity (Turton, 2006)

In order to understand better the factors affecting coating uniformity, it is crucial to investigate the particle behavior in the particular column, especially in the spray region. The study done by U. Mann, E.J. Crosby, M. Robinovitch showed that such circulating systems can be characterized by two main factors, namely the coating-per-pass distribution and the total number of passes distribution. They determined that as coating time increases, the distribution of the number of passes becomes Gaussian and the mean and variance are dependent on the mean and variance of the cycle time distribution. Cheng, Turton and Shelukar in 2000 showed that product coating uniformity is influenced most by the coating-per-pass distribution and that the circulation time distribution plays a less important role. Magnetic-tracing and dye-tracing techniques were used to quantify these two parameters. Shelukar found that the coating-per-pass distribution contributes more than 75% to the total-coating uniformity. They postulated that the broad coating-per-pass distribution was due to differences in the distance of tablets from the spray, pulsing flow of tablets, and tablet-to-tablet sheltering. This was confirmed with high-speed video imaging (KuShaari, Pandey, Song, & Turton, 2006).

2.6. Viscosity affects the spreading diameter

The main focus in this study is on how the solution composition will affect the spreading diameter. 6 types of coating solutions with different composition are used to investigate their behavior on urea surface. The result shows that the solution with low viscosity will high in spreading diameter. Previous study done by R. Riobo, M. Marengo and C. Tropea regarding to the effect of viscosity. The conclusion in this study stated that the low the viscosity will leads to high spreading diameter.

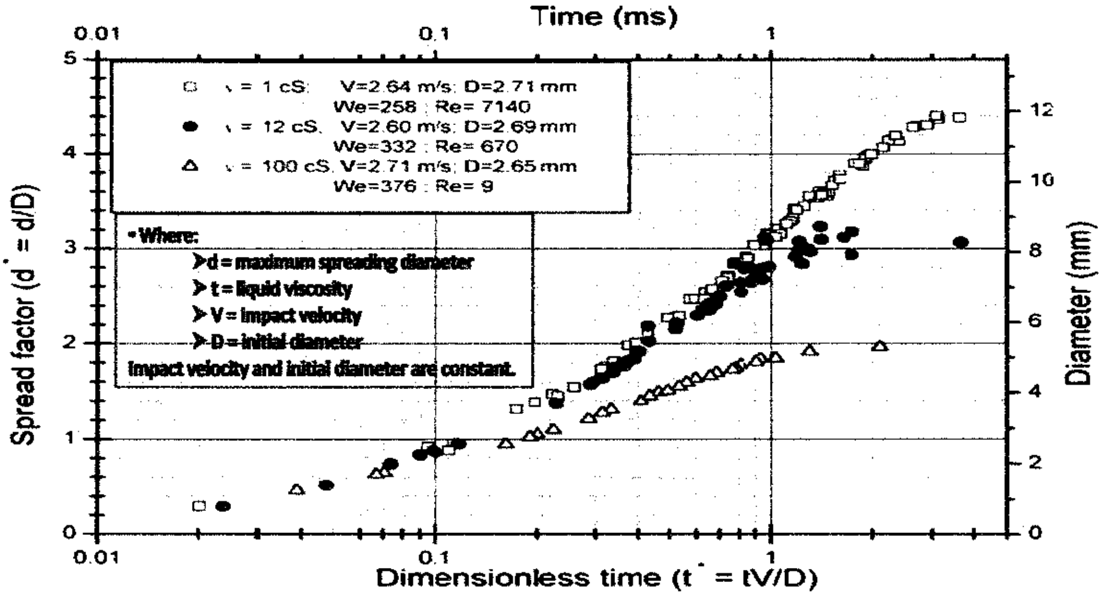


Figure 7: Influence of liquid viscosity in dimensional and dimensionless form at constant V and D

2.7. Droplet impact velocity affects the spreading diameter.

By finding the optimum value of droplet impact velocity, the maximum spreading diameter can be identified. The droplet impact velocity gives high influence in order to determine the spreading diameter. It can be conclude that, high value of droplet impact velocity will result in high spreading diameter. By using the result from the previous study, Figure 9 will going to be the expected result for this project.

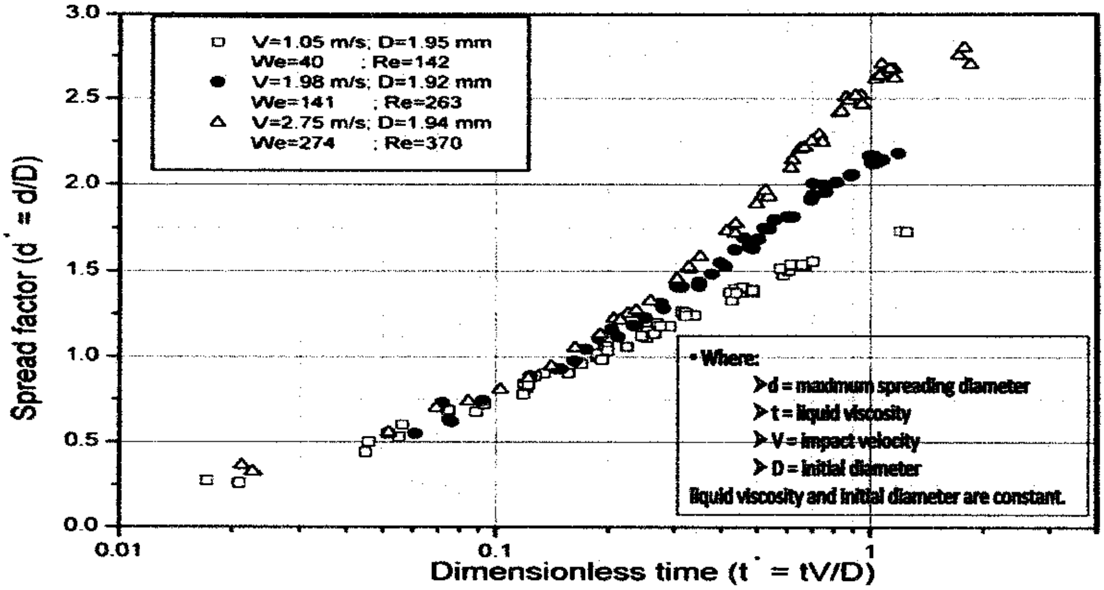


Figure 8: Influence of droplet impact velocity in dimensional and dimensionless form for glycerine at viscosity 20 cS

CHAPTER 3: METHODOLOGY

3.1. The Preparation of Coating Solution

In this study, the modified starch solution is used as the coating solution. The compositions are well mixed with different blending ratio as shown in Table 2.

Solution	Starch (g)	Urea (g)	Borate (g)	Lignin (g)	Blue dye
1	50	20	4.5	-	✓
2	50	20	3.5	-	✓
3	50	20	2.5	-	✓
4	50	20	4.5	3.92	-
5	50	20	4.5	8.28	-
6	50	20	4.5	10.862	-

Table 2: The coating solutions in g/1000ml solution of water

Procedure preparation of the modified starch solution:

1. Weighed 5g of tapioca starch into round bottom flask and add 100mL deionized water.
2. Placed the round bottom flask on hot plate stirrer for 30mins for solution to mix. The solution must be reacting at 80°C.
3. After 30mins, add borate, urea and lignin into the solution and leave for another 3hours.
4. For solution 1,2 and 3 add the blue dye after 2 hours and 30 minutes the experiment starts.
5. Leave the solution cool to room temperature.

Temperature of the solution : 80°C – 100 °C

Melting point : 0°C

Boiling point : 100°C

Preheating temperature : 80°C – 120 °C

For solution 1, 2 and 3 the additional of blue dye is very important as to indicate the coating droplet when it dropped onto the urea surface. The reason behind this application is, the solution 1, 2, 3 and the urea surface are colorless, and so the additional of blue dye is to enhance the droplet structure on urea surface.

For solution 4, 5 and 6 the additional of blue dye is unnecessary because of the application of lignin will give the solutions appear in brown.

3.2. Experiment equipment setup

A high-speed digital camera with a high-speed consecutive shooting rate up to 3000 frames per seconds in JPEG format will be used to capture a series of liquid droplet-solid flow structure, where chemical modified biomass as the liquid droplet and urea flat surface as the solid.

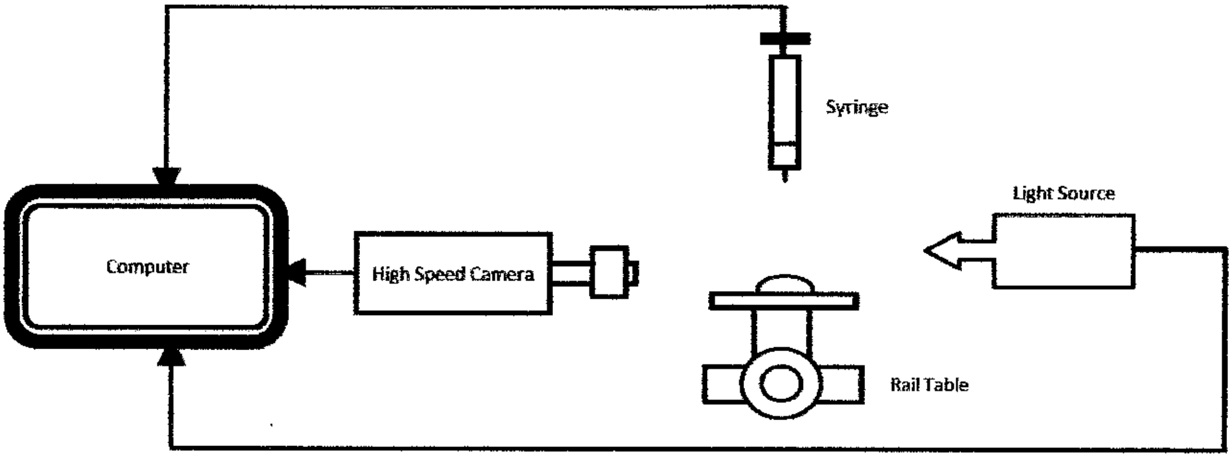
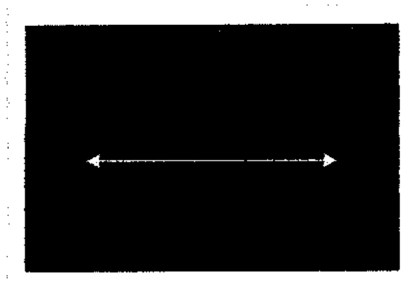
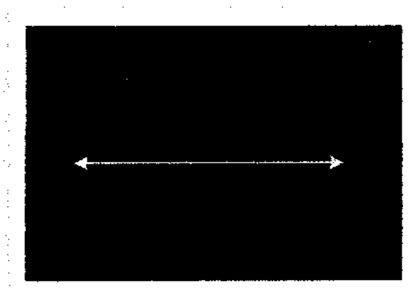


Figure 9: General experiment equipment setup

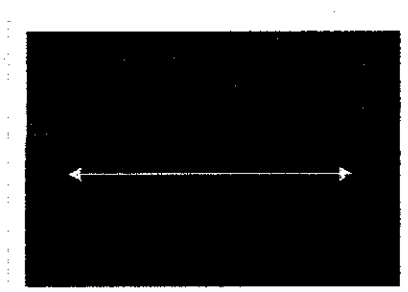
In this study, the setup is 200 frames per second for the duration of 20 seconds. In order to define the behavior of the droplet, we split the time frame in 5 seconds. Which it means, the observation of the droplet behavior take place at initial, 1st second, 5 second, 10 second and 15 second. The diameter of the droplet at particular second will be measured and analyzed.



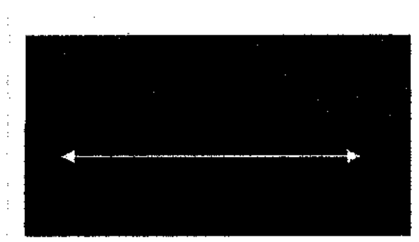
D_1



D_5



D_{10}



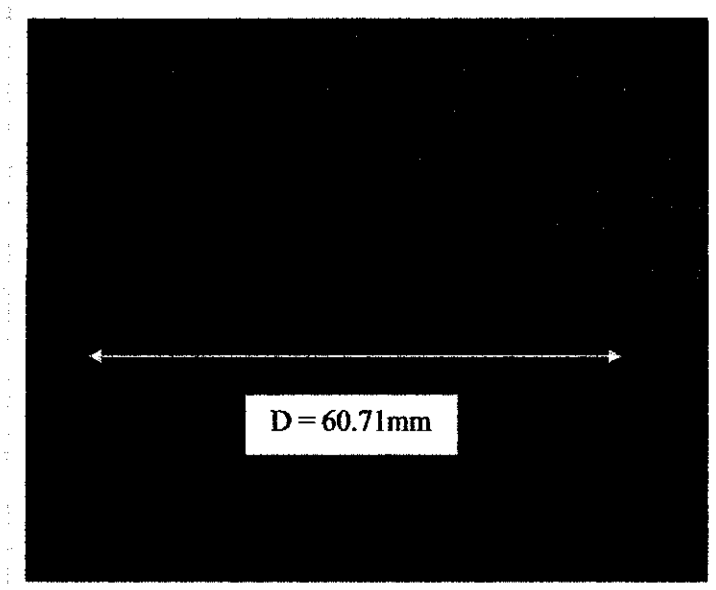
D_{15}

Figure 10: Example of droplet behavior captured by high speed camera

3.3. Diameter Calculation

In this study, the method used to calculate the diameter is by using the scaling technique to compare the length in image captured (1mm:10mm).

Example:



6.71mm (real measurement) = 60.71mm (in image captured)

3.4. Experiment Matrix

	Type of Surface	Type of Solution
Experiment 1	Coated urea	Solution 1
		Solution 2
		Solution 3
	Coated urea	Solution 4
		Solution 5
		Solution 6

	Type of Surface	Type of Solution
Experiment 2	Non coated urea	Solution 1
		Solution 2
		Solution 3
	Non coated urea	Solution 4
		Solution 5
		Solution 6

All the solutions in this experiment are varies with coating formulation, viscosity and type of surface. We split the experiment into two parts, which are experiment 1 and experiment 2.

CHAPTER 4: RESULT AND DISCUSSION

4.1. Experiment 1

The parameters are as follows:

a) Surface: Coated urea with 5g starch, 2g urea and 0.25g borate.
b) Coating solution:

Table 3: List of experiment 1 solution

Solution	Starch (g)	Urea (g)	Borate (g)	Lignin (g)	Blue dye
1	50	20	4.5	-	✓
2	50	20	3.5	-	✓
3	50	20	2.5	-	✓
4	50	20	4.5	3.92	-
5	50	20	4.5	8.28	-
6	50	20	4.5	10.862	-
7	50	20	3.5	3.87	-
8	50	20	3.5	8.17	-

c) Temperature: 25°C

Result:

i. Solution 1

$D_0 = 3.9$mm

t (s)	D_t (mm)	D_t/D_0 (mm)
0	3.9	1
1	4.1	1.05128
5	4.256	1.09128
10	6	1.53846
15	6.71	1.72051

i. Solution 2

$D_0 = 4.1mm$

t (s)	D_t (mm)	D_t/D_0 (mm)
0	4.1	1
1	4.2	1.02439
5	4.24	1.03415
10	5.35	1.30488
15	5.8	1.41463

ii. Solution 3

$D_0 = 4mm$

t (s)	D_t (mm)	D_t/D_0 (mm)
0	4	1
1	4.1	1.025
5	4.134	1.0335
10	4.8	1.2
15	5.13	1.2825

ii. Solution 4

$D_0 = 3.8mm$

t (s)	D_t (mm)	D_t/D_0 (mm)
0	3.8	1
1	4.1	1.07895
5	5.256	1.38316
10	6.8	1.78947
15	7.1	1.86842

iii. Solution 5

$D_0 = 4mm$

t (s)	D_t (mm)	D_t/D_0 (mm)
0	4	1
1	4.398	1.0995
5	5.7	1.425
10	7.187	1.79675
15	7.5	1.875

iv. Solution 6

$D_0 = 3.8mm$

t (s)	D_t (mm)	D_t (mm)
0	3.8	1
1	4.2	1.10526
5	5.8	1.52632
10	7.3	1.92105
15	7.6	2

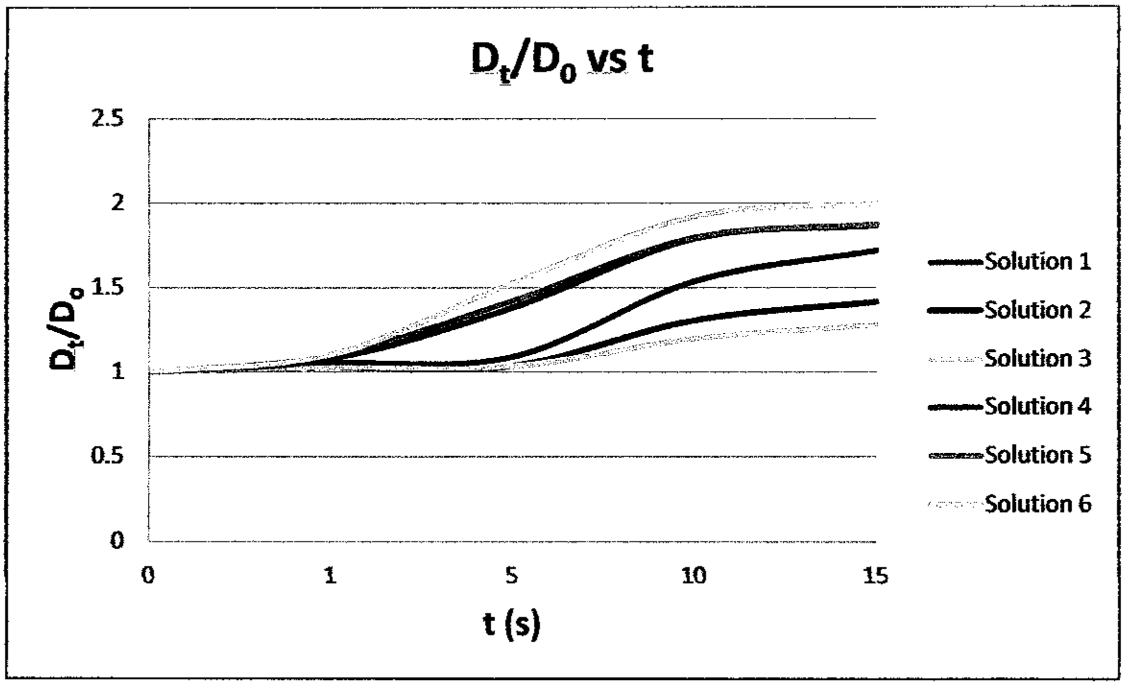


Figure 11 : Experiment 1 graph

Different solution will gives different value of spreading factor. In the graph above shows that Solution 6 forms highest in spreading factor D_t/D_0. On the other hand Solution 3 forms lowest in spreading factor D_t/D_0.

The solution composition and the value of viscosity play an important role in order to determine the spreading factor. In this experiment the solution high in lignin composition will result in high spreading diameter. It is because of the composition of lignin will decrease the value of solution viscosity.

4.2. Experiment 2

The parameters are as follows:

a) Surface: Non coated urea.

b) Coating solution: Solution:

Table 4: List of experiment 2 solution

Solution	Starch (g)	Urea (g)	Borate (g)	Lignin (g)	Blue dye
1	50	20	4.5	-	✓
2	50	20	3.5	-	✓
3	50	20	2.5	-	✓
4	50	20	4.5	3.92	-
5	50	20	4.5	8.28	-
6	50	20	4.5	10.862	-
7	50	20	3.5	3.87	-
8	50	20	3.5	8.17	-

c) Temperature: 25°C

Result:

i. Solution 1

$D_0 = 3.9$mm

t (s)	D_t (mm)	D_t/D_0 (mm)
0	3.9	1
1	4	1.02564103
5	4.2	1.07692308
10	5.5	1.41025641
15	6	1.53846154

ii. Solution 2

$D_0 = 4.1mm$

t (s)	D_t (mm)	D_t/D_0 (mm)
0	4.1	1
1	4.156	1.01365854
5	4.2	1.02439024
10	5.143	1.25439024
15	5.5	1.34146341

iii. Solution 3

$D_0 = 4mm$

t (s)	D_t (mm)	D_t/D_0 (mm)
0	4	1
1	4.044	1.011
5	4.134	1.0335
10	4.6	1.15
15	5.11	1.2775

iv. Solution 4

$D_0 = 3.8mm$

t (s)	D_t (mm)	D_t/D_0 (mm)
0	3.8	1
1	4.1	1.0789474
5	5.2	1.3684211
10	6.5	1.7105263
15	6.8	1.7894737

v. Solution 5

$D_0 = 4mm$

t (s)	D_t (mm)	D_t/D_0 (mm)
0	4	1
1	4.32	1.08
5	5.5	1.375
10	6.854	1.7135
15	7.3	1.825

vi. Solution 6

$D_0 = 3.8mm$

t (s)	D_t (mm)	D_t/D_0 (mm)
0	3.8	1
1	4.18	1.1
5	5.6	1.4736842
10	6.7	1.7631579
15	7.4	1.9473684

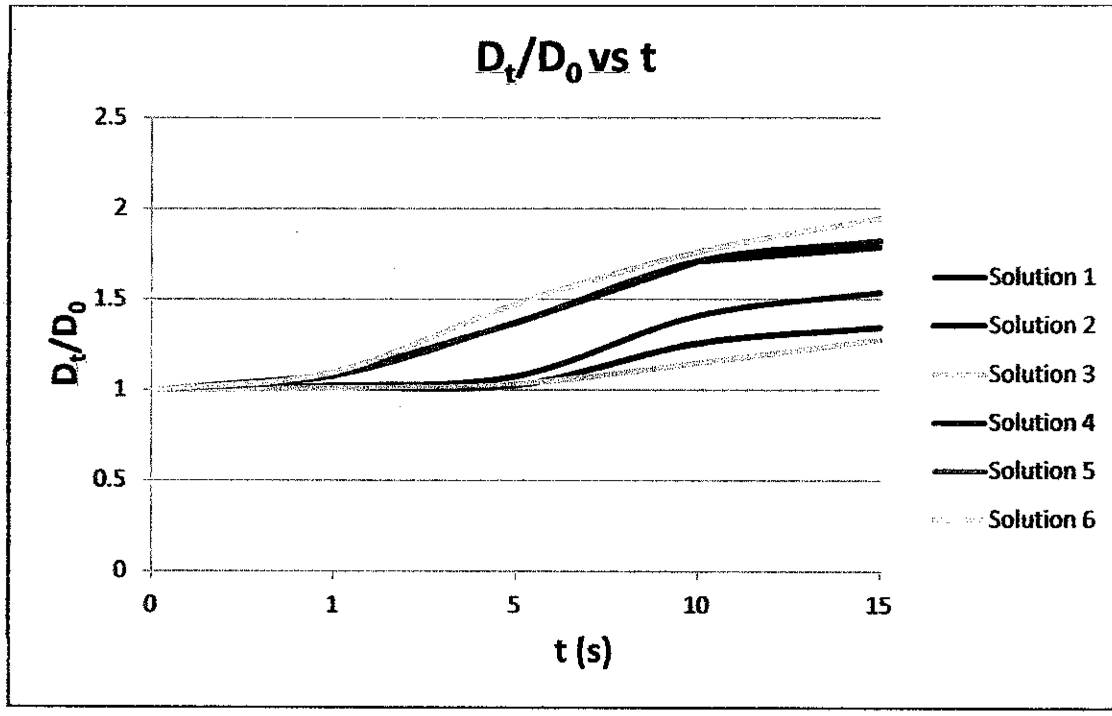


Figure 12: Experiment 2 graph

Different solution will gives different value of spreading factor. In the graph above shows that Solution 6 forms highest in spreading factor D_t/D_0. On the other hand Solution 3 forms lowest in spreading factor D_t/D_0.

The solution composition and the value of viscosity play an important role in order to determine the spreading factor. In this experiment the solution high in lignin composition will result in high spreading diameter. It is because of the composition of lignin will decrease the value of solution viscosity.

Besides, the composition of borate also affects the value spreading factor. In this graph shows that Solution 1 spreads widest compare to Solution 2 and 3, since the Solution 1 high in. It is because of the composition of borate will decrease the solution viscosity.

Other than solution characteristics, the surface type also becomes an important parameter to be study. In this experiment, there are two types of surface which are non coated urea and coated urea. The coated surface shows that all 6 solutions spread widest compare to non coated surface. The reason is, the coated surface gives less friction effect compare to non coated surface.

CHAPTER 5: CONCLUSION AND RECOMMENDATION

As become one of the important part in agricultural sector, urea as fertilizer has a lot of space of improvement. One if the improvement is the introduction of coated-urea. The yield of plant production has increased since the present of coating technology as one of the solution. The study on coating will provide more advantages in future in order to improve the current result.

5.1. Effect of lignin composition

In this scope of study lignin composition plays an important role in order to determine the value of spreading factor. The result shows that the solution high in lignin composition will spread widest compare to solution low in lignin composition. As the conclusion, an increase of lignin composition will increase the spreading diameter. One of the main factor is the additional of lignin will decrease the viscosity of particular solution.

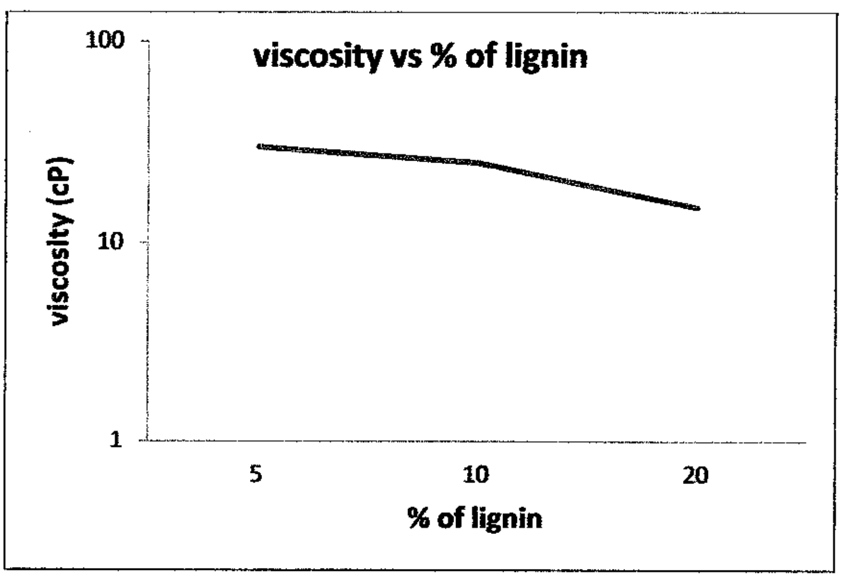


Figure 13: Viscosity vs composition of lignin

5.2. Effect of surface type

The different in solid surface type will result in different value of spreading ratio. The porosity and surface smoothness are very important factor in order to determine the spreading diameter.

In this study, there are two types of surface were investigated which are the coated urea and non coated urea surface. Each of type will show different result. The result shows that the coated surface will offer high in droplet spreading diameter compare to non coated surface.

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APPENDICES

No	Week / Detail	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Project Work Continue (create geometry and mesh file)														
2	Project Work														
3	Submission of Progress Report								●						
4	Project Work														
5	Project Work Continue (collect all data and analyze data)														
6	Poster Exhibition											●			
7	Submission of Dissertation (soft bound)												●		
8	Oral Presentation													●	
9	Submission of Project Dissertation (Hard Bound)														●