The Physical Property Changes during Storage of 25-7-7 Analysis Grade of Suspension Fertilizer Processed by Luxen's Method

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Abstract

The production of 25-7-7 analysis grade of suspension fertilizer processed by Luxen's Method was investigated for some physical properties changes during various storage periods. The solid instead of liquid raw materials were used in the production. The experiment was designed in CRD consisting of six storage treatments; 0, 7, 15, 30, 90 and 180 days with 4 replicates. The total urea was provided for Urea 1 being fed in clear liquid mixed solution stage and Urea 2 being fed in suspended solution stage. The process was to add Urea 1, xanthan gum, KCl, MKP, and Urea 2, respectively, into the cylindrical glass bottle which was mounted to the adjustable speeds of mixer and presented water. The resulting 25-7-7 analysis grade of suspension fertilizers were stored undisturbed at normal room temperature for various storage periods and its physical properties were analyzed periodically. The analysis of variance was performed using R statistical program. The result showed that pH of the suspension fertilizer ranged between 5.5-5.6 and specific gravity ranged 1.249-1.274 during all storage periods and there was nosignificant difference. The fertilizer viscosity increased as the storage times increased. The stability and the pour-ability were significantly decreased as the storage times increased. However, after six months, both stability and pour-ability were found to be above acceptable level. The changes in salting-out were found to be no significant difference among various storage periods. The result showed that the suspension fertilizers which were produced by Luxen's method could maintain their appropriate physical properties during six months of storage times.

Keywords: fertilizer, Luxen's Method, physical property, suspension, storage periods

1. Introduction

At present, most of the suspension fertilizer plants have used liquid raw materials: anhydrous NH_3 (82% N) and aqueous NH_3 (20% N) as sources of nitrogen; ortho phosphoric acid (wet process 55% P_2O_5), super phosphoric acid (wet process 75% P_2O_5) and solid ammonium phosphate (MAP: 12-60-0) as sources of phosphorous; KCl (60% K_2O) as source of potash. Sources of suspending agents used for the suspension fertilizer production method (Achorn & Hargett, 1980) are clay, bentonite and gum. Thereby, the liquid starters for formulating suspension fertilizers, which are both NP base suspension fertilizers such as 8-24-0 (Wilbanks, 1967), 10-30-0 (Getsinger et. al., 1984), 9-32-0 (Mann et. al., 1983), 10-34-0, 12-40-0, 12-36-0 with ammonium lignosulfonate (Jones, 1978; Byrd & Scott, 1979; Burnell & Rylant, 1990) and UAN: 28-0-0, 30-0-0 and 32-0-0 (International Plant Nutrition Institute, 2012) are obtained. The other methods are simultaneous addition of fluorosilicic acid and suspending agents: clay for inhibiting large crystals of mono-ammoniun phosphate in the suspensions which were 12-12-12 (Mills, 1962), 14-14-14, 20-10-10 and 24-8-8 (Jones & Stinson, 1983; Dillard & Burnell, 1991), 11-39-0 (Wilbanks & Faulkner, 1980). Some methods are comprised of the reaction product of urea, sulfuric acid and phosphoric acid for 20-20-0, 10-37-0, 5-45-0 (Stoller & Hartung, 1982), 29-0-0-5S (TVA, 1985) and etc.

All production methods are in conventional suspension fertilizer plants that based on hot mix plant which is the

TVA three-stage continuous ammoniation. The acid is ammoniated in three stages, with precise temperature and pH control in each stage (Jones & Getsinger, 1979). When the ortho phosphoric acids are being fed into the tank reactor (also pipe reactor) by the connecting pipes, immediately, anhydrous NH_3 and potassium are being fed into them by the other connecting pipes also. The reaction would occur with high temperature which is more than 750 ^{0}C and certainly with high pressure. Thereby, it caused the risk of a massive explosion at the fertilizer plant that killed as many as 15 people and injured more than 160 in April 2013, in West, Texas. The explosion left large damaged areas and more than 150 damaged buildings.The disaster was not the first time but was the sixtieth time since 1953 (Mungin, 2013).

Moreover, the conventional plants are extensively complicated the handling of liquid raw materials. This is because of the use of many tanks and cooling tower complicates the production of UAN solutions because of potential explosive raw material such as ammonium nitrate. Such raw material is very difficult in seeking permit from the Ministry of Defense for the importation into Thailand as well as its high investment cost of corrosive maintenance.

The main objective of this research is to improve the suspension fertilizer production method using solid instead of liquid raw materials. Xanthan gum is being used as raw material in suspension fertilizer production for obtaining appropriate suspension fertilizers in both chemical and physical properties.

2. Methods

In a number of unpublished preliminary investigations, the results showed that Luxen'smethod was significantly effective in the suspension fertilizer production. This could be attributed to following 4 factors;1) milled raw materials in particle size of more than 20 meshes, 2) appropriate speeds of agitator: 1280 rpm for clear liquid mixed solution stage and 2620rpm for suspended solution stage, 3) appropriate solution temperature of   30 to 40°C,   and 4) xanthan gum .suspension agent of 2.5%

Luxen's method was also used in present studies for the production of 25-7-7 analysis grades of suspension fertilizers .The experiment consisted of 6 storing factor periods of 0, 7, 15, 30, 90, and 180 days using CRD experimentaldesign with 4 replicates. The process was to add 72.1 g Urea 1 in clear liquid mixed solution stage with 1280 rpm speed, simultaneously, 5.5 g xanthan gum, 9.1 g KCl, 29.7 g MKP and 47.5 g Urea 2 in suspended solution stage with 2620 rpm speed, respectively, into the bottle which was mounted to the adjustable speeds of mixer and presented 56.1 g water (Table 1).

Table 1. Treatments, amounts of solid raw materials, storage periods for 25-7-7 analysis grade of suspension fertilizer

Amount of solid raw materials (gram)						Storage periods (day)					
water	U 1	gum	KCl	MKP	U 2	0	7	15	30	90	180
56.1	72.1	5.5	9.1	29.7	47.5	Tr1	Tr2	Tr3	Tr4	Tr5	Tr6

Note: U= milled urea, gum = xanthan gum, KCl = potassium chloride, MKP = mono potassium phosphate.

The suspensions were agitated for homogenization. The resulting 25-7-7 suspensions were stored undisturbed for various storing time periods at normal room temperature. The suspensions were then evaluated for the changes of physical properties using various equipments and calculations as follows: 1) the pH using portable pH meter, Checker® from USA, 2) specific gravity using specific gravity hydrometer, 3) stability using calculation of amounts of clear liquid (supernatant) on the top of the suspension fertilizer in a graduate cylinder after standing undisturbed for 24 hours (Browder & Ulmer, 1971), 4) pour-ability using calculation of amounts of the poured products and the remained products which were poured from the bottle after standing undisturbed for 24 hours (CIPAC 2009; Salladay & Kachelman, 1986), 5) viscosity using detecting with Brookfield digital viscometer (CIPAC 2009a; Davenport et. al., 1978), and 6) salting out using calculation of amounts of retained crystals of the product on the 20 mesh standard test sieve (CIPAC 2009b; Byrd & Scott, 1979). Analysis of variance was performed in R program for all raw data.

3. Results and Discussion

The results showed that all of 6 treatments of storing time periods were found to be non-caking, homogenized, suspended fertilizers. The suspensions were of xanthan gum suspended consisting of needle crystals in Urea 1 which were 100 μm width and 2,000 μm length, suspended KCl, suspended MKP and suspended Urea 2, (Figure
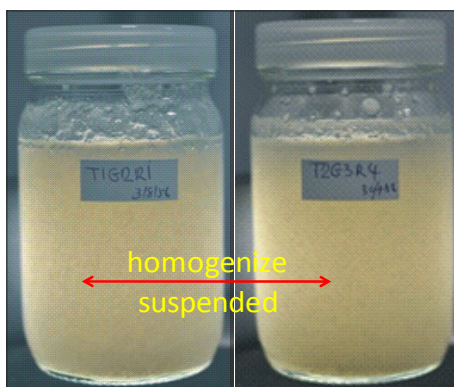
1, 2, 3 and 4).

Figure 1. non-caking, homogenized and suspended fertilizers
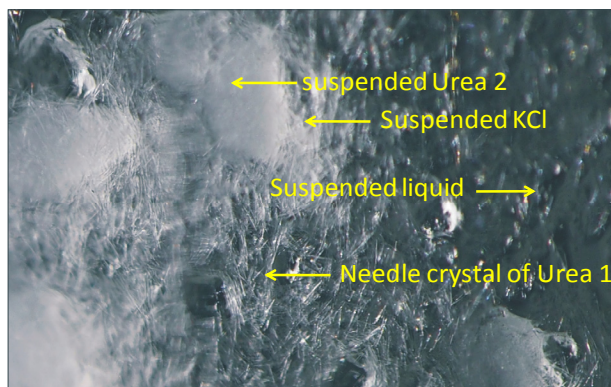

Figure 2. the magnified picuture of the composition of 25-7-7 suspension fertilizer

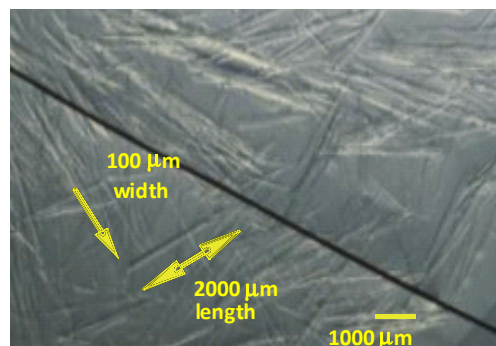Figure 3. m agnified picture of the composition of 25-7-7 suspension fertilizer

Figure 4. measured needle crystals of Urea 1 fron 25-7-7 suspension fertilizer

It could be described that 72.1 g Urea 1 were completely dissolved in 61.6 g water treated by the temperatures of $30^{o}C$ to $40^{o}C$ in the first stage. By then, the solutions had become saturated solutions. The suspending agent: 5.5 g xanthan gum was fed into those solutions and the viscosity of solutions was affected [3 dimension networks of xanthan gum solution (Figure 5) with suspension properties (Wolf *et. al.*, 1985). Further addition of 9.1 g KCl, 29.7 g MKP and 47.5 g Urea 2 were fed into the saturated suspension solutions in the second stage, respectively. All of them could be completely dissolved little by little and the remaining parts were non-dissolved which were held up (they were attracted to xanthan gum by van der Waals force, Figure 5) by xanthan gum in the saturated suspension solutions. At the same time, the saturated suspension solutions had become the super saturated suspension solutions. Crystallization of Urea 1 crystals by large number of molecular formation was observed in that suspensions and these molecular crystals were formed by van der Waals force: Cohesive force (Chemistry.s.c.chula, 2012). According to the super saturated suspension solutions which had suspension property, Urea 1 molecules and the crystals of Urea 1 were surrounded by xanthan gum (they were also attracted to xanthan gum by van der Waals force in 3 dimension networks of xanthan gum solution, Figure 5). They couldn't lump together. The formation of the gelatinous molecules of Urea 1 in form of long crystals (large crystal growth) were limited affecting the formation of the more shorten (needle) crystals of Urea 1 (100 μm width and 2000 μm length in needle crystals of Urea 1 as Figure 4) in the suspended solution instead. The suspensions were homogenized and suspended with no sediment and no caking (Figure 1). This pathway was in line with that of Mier's theory (Khanam, 2007), van der Waals force and suspension property of Xanthan gum. This research result was similar to the previous researches which were found that the suspension fertilizers must be consisted of suspending agents: attapulgite, sepiolite, sodium bentonite and polysaccharides (Makower & Kohn, 1962; Fox & Oldland, 1976; Salladay *et. al.*, 1984; Colegrove, 1984; Wolf *et. al.*, 1985; Fraley & Rogers, 1997).

3.1 Structure of Suspension Fertilizer

The structure of 25-7-7 analysis grade of suspension fertilizer (Figure 3) was found to be consisted of water, xanthan gum, non-dissolved raw materials (Urea 2, MKP and KCl) and needle crystals of Urea 1. All of the materials were linked together with various attractive forces as the proposed structure in Figure 3. After the feeding of Xanthan gum into the Urea 1 solution in clear liquid mixed solution stage (the first stage), the linkage with water molecules were formed in the solution with hydrogen bond. The formation of 3 dimension networks of xanthan gum solution occurred with 5 types of attraction forces. At the finished process, the bond formations were going to occur, simultaneously. Each xanthan gum portion could be previously cross- linked together each by covalent bond (at C1-C4 of β-D-glucose 2 molecules) in 3 positions in forming big agglomerate (Anil. 2012). Water molecules could be attracted to xanthan gum by hydrogen bonds for the formation of 3 dimension networks of xanthan gum solution which were deranged (entanglement). The 4 carboxyl groups on xanthan gum could be attracted by each xanthan gum and some non-dissolved raw materials. The non-dissolved raw materials could be attracted among them by Intermolecular force and many hydroxyl groups on xanthan gum could be attracted by some non-dissolved raw materials (NQF-AGRO, 2001; Aimtrakarn et al., 2011). All of these attraction forces, van der Waals force with weakly cross-linked forces, had affected on viscosity and suspended solution suspended the non-dissolved raw materials for non-sedimentation. All of 6 treatments in this research were significantly different inthe physical properties except pH and specific gravity (Table 2).

Table 2. The physical properties of 25-7-7 analysis grade of suspension fertilizer during storage periods

Storage time	Physical property					
	pH	S.G.	Viscosity (mPa.s[1])	Stability (%[2])	Pour-ability (%[3])	Salting out (%[4])
Tr1(0 d)	5.6	1.263	1445 d[5]	100.0 a[5]	3.19 c[5]	0
Tr2(7 d)	5.5	1.274	1887 d	100.0 a	3.29 c	0
Tr3(15 d)	5.5	1.252	2832 c	99.62 b	4.09 b	0
Tr4(30 d)	5.6	1.267	3196 c	98.75 c	4.50 ab	0
Tr5(90 d)	5.5	1.257	15195 b	98.66 cd	4.71 ab	0
Tr6(180 d)	5.5	1.249	16361 a	98.54 d	4.97 a	0
F-Test	ns	ns	*	*	*	ns
C.V. (%)	2.3	1.1	6.2	0.15	10.2	

Note: SG= specific gravity.

[1] by Brook field viscometer, spindle # 3 and 4, 30 rpm, time 2 minute.

[2] % of the apparent solids.

[3] % of the remaining products.

[4] % of the retained crystals on the 20 mesh screen of test sieve.

[5] Means in a column followed by the same letter are not significantly different.

* significantly different, ns = non-significantly different, according to LSD ($P < 0.05$).

3.2 pH and Specific Gravity (SG)

From Table 2, the pH and specific gravity properties among all 6 treatments showed non-significantly difference varying from 5.5 to 5.6 and 1.249 to 1.274, respectively. It indicated that all of storage periods did not affect on pH and specific gravity of the suspensions because there was no chemical reaction of the solid raw materials in the process and the same rates of raw materials in their components which affected on the same total amount of Hydrogen ion: H^+ in the suspensions. Furthermore, for this new suspension fertilizer production method, the so many high as pH of the products were not major appropriateness like as a pH of 25-7-7 analysis grade of suspension fertilizer being imported by Captain Fertilizer Co., Ltd. was 7.2 which was evaluated by Department of agriculture (Captain Fertilizers, 2012), and the previous researches of Kendrick (1974) found that the pH of suspension fertilizers were more than pH 5.9 which affected on more crystals of DAP, less than pH 5.9 which affected on more MAP which could grow up in large crystals. Miller (1962) found that the proper pH of the

appropriate suspension fertilizers varied from 7.5 to 8, the more than pH 8 affected on decreased solubility of nutrients and tended to salting out. The new production method had no chemical reaction of solid raw materials in process similar to that produced by conventional method. However, it involved in solubility of raw materials and property of suspending agent: xanthan gum. The pH of 5.5 to 5.6 of the products was compatible to other agricultural chemicals. The specific gravity's measurements had indicated many things about the relative compositions of fluid fertilizers when correlated with other data for the particular solution or suspension. They are commonly made at $25^{\circ}C$ and are useful in adjusting the calibrated application equipment to obtain accurate application rates for the particular fluid fertilizers (Wolf et. al., 1985). The 25-7-7 analysis grade of suspension fertilizers in this research had specific gravities of 1.249 to 1.274 in compare with that imported by Captain Fertilizer Co., Ltd. with 1.29 which was evaluated by the Department of Agriculture (Captain Fertilizers, 2012).
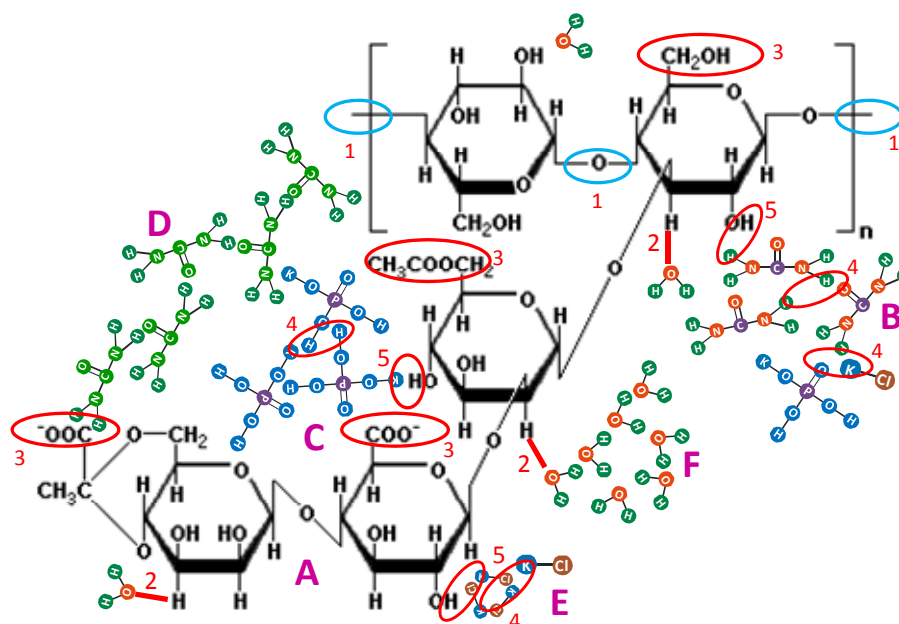

Figure 5   Structure of suspension fertilizer, linkage among xanthan gum, H2O, non-dissolved raw materials:

Urea 2, KH2PO4 and KCl and needle crystals of Urea 1, A = xanthan gum, B = Urea 2,

C = KH2PO4, D = needle crystals of Urea1, E = KCl, F = H2O, 1 = covalent bond, van der Waals

force: 2 = hydrogen bond, 3 = carboxyl group, 4 = intermolecular force, 5 = hydroxyl group

3.3 Viscosities

All of 6 treatments, storing periods, there was a significant difference among various viscosities that varied from 1445 to16361 mPa.s (Table 2). The results showed that the suspensions stored within 7 days gave the lowest viscosity, 1887 mPa.s, the suspensions stored at interval between 15-30 days gave medium viscosity, 3196 mPa.s and the suspensions stored at interval between 90-180 days showed high viscosity of 16361 m Pa.s. It could be noticeable that increasing stored periods affected on increasing viscosities. These were illustrated by structure of suspension fertilizer in Figure 5.

3.4 Structure of Suspension Fertilizer

In 25-7-7 analysis grade of suspension fertilizer (Figure 5), they were consisted of water, xanthan gum, non-dissolved raw materials (Urea 2, MKP and KCl) and needle crystals of Urea 1. All of them linked together with variously attractive forces. After the Xanthan gums were fed into the Urea 1 solution in clear liquid mixed solution stage, they linked to water molecules in the solution with hydrogen bond to form in 3 dimension networks of xanthan gum solution. As processing, the suspensions consising of xanthan gums, dissolved and non-dissolved raw materials were being agitated. The chains of polymer could not form in high three dimensional networks immediately. They were ordered arrangement which affected on low physical forces (intermolecular force, Van der Waals force and hydrogen bond) in the suspensions. Therefore, the measured

viscosities by Brookfield Viscometer at initial time were low. When the suspensions were stored (the agitating removed) at various periods, 0, 7, 15, 30, 90 and 180 days, the bond formations were going to occur in xanthan gum solution. More physical forces among them affected on formation of big agglomerates (high entanglement density) of three dimensional networks which were deranged because the suspensions were non-Newtonian fluids and pseudo-plastic fluid which affected on Thixotropic Flow Behavior (Aimtrakarn et al., 2011). So the high entanglement density of xanthan gum polymer was depended on the increasing storage periods (Thixotropic Flow Behavior) which was in line with the research of Sawyer, Jr (1991) who found that viscosity increased along the increasing storage time. The stored periods affected on both high viscosity and suspended solution which suspended the non-dissolved raw materials for non-sediment. So the measured viscosities at variously given periods were high and in line with the research of Sawyer (1991) who found that treated suspension fertilizer by some shear stress could reduce viscosity to a low level. Aimtrakarn et al. (2011) also noted that in Thixotropic Flow Behavior, it took more times to reversion of big agglomerates by random Brownian movement. Therefore, the measured viscosity was detected by using more shear rates in Brookfield viscometer which affected on high viscosity because of all of the attractive forces being destroyed by the more shear rates. In this investigation, it was found that the storing period within 7 days was the appropriate treatment because the viscosities of 1445 and 1887 mPa.s could be obtained and in line with the research of Salladay & Kachelman (1986) who found that viscosity was depended on analysis grade of suspension fertilizers and concentrations of suspending agent, which were 100-2000 mPa.s in appropriate limits.

3.5 Stability

All of 6 treatments gave 98.54 to 100% apparent solids at various storage periods (Table 2) and showed significantly different. The apparent solids of 100% indicated that there was no any volume of clear liquid on the top of the suspension (0% supernatant) but the 98.54% apparent solids could contain 1.46% supernatant. This investigation found that the storing period of 0, 7, 15, 30, 90, and 180 days gave the stability of apparent solid of 100% (0% supernatant), 100% (0% supernatant), 99.62% (0.38% supernatant), 98.75% (1.25% supernatant), 98.66% (1.34% supernatant) and 98.54% (1.46% supernatant), respectively. It could be noticeable that long stored periods affected on low % apparent solids of suspensions (high % supernatant). The results were comparable to the acceptable limits of stability in that the suspensions stored within 7 days showed excellent stability. Furthermore, the suspensions stored at interval between 15-180 days gave very good stability (Browder & Ulmer, 1971). These were described by structure of suspension fertilizer in Figure 5.

From Figure 5, there were 5 types of attraction forces (1 = covalent bond, van der Waals force: 2 = hydrogen bond, 3 = carboxyl group, 4 = intermolecular force, 5 = hydroxyl group) in the structure of suspension fertilizer. All of components were weakly cross linked among them by those attraction forces in the suspension. According to gravitational force and long storage period, the finished products being stored undisturbed for various long periods, the hydrogen bonds (Figure 5) which cross linked between water molecules and xanthan gums were destroyed by gravitational forces. The separated water molecules floated on the top of the suspensions. The longer storage periods resulted in obtaining more separated water molecules and more clear liquids observed at the top of suspension. Moreover, the unpublished preliminary investigation in suspending agents, the results showed the suitable concentration of suspending agents would affect on the appropriate supernatant in suspensions. The research of Sawyer Jr (1991) who found that the shrinkage of gel and insufficient of suspending agents affected on supernatant in the suspension.

3.6 Pour-Ability

All 6 treatments in Table 2 showed significant difference in pour-ability, varying from 3.19 to 4.97 % of the remaining products. The average of the remaining products was 4.13%. This investigation found that the storing periods of 0, 7, 15, 30, 90, and 180 days gave pour-ability of 3.19%, 3.29%, 4.09%, 4.50%, 4.71%, and 4.97%, respectively. It resulted in affecting on low pour-ability of suspensions (high % the remaining products). The suspensions with high treated Xanthan gums were clearly difficult in pouring because of its high viscous liquids (high viscosity). So, more products were always stuck on the wall of the bottle which affects on the more % the remaining products. The results were comparable to acceptable limits of pour-ability of not more than 5% of the remaining products (CIPAC MT 148, 2009; Salladay and Kachelman, 1986).These could be described by the structure of suspension fertilizer shown in Figure 5.

Figure 5 showed that there were 5 types of attraction forces (1 = covalent bond, van der Waals force: 2 = hydrogen bond, 3 = carboxyl group, 4 = intermolecular force, 5 = hydroxyl group) in the structure of suspension fertilizer. All of components were weakly cross linked among them by those attraction forces in the suspension. The suspension fertilizer was non-Newtonian fluid and pseudo-plastic fluid type (Aimtrakarn et al., 2011) which

affect on thixotropic behavior in suspension. As the suspensions being agitated in the suspended solution stage, they exhibited low viscosities because of 3 dimension networks of xanthan gum solution being ranged (low entanglement density of xanthan gum polymer). Then, at the finished process (the agitating removed), the bond formations being occurred, it took more times to rebuild high 3-dimension networks (big agglomerates or high entanglement density) like as recovery in thixotropic behavior in suspension. Therefore, the high pour-ability (low % the remaining products) being evaluated at initial time was received. These were in line with the research of Sawyer (1991) who found that a treated suspension fertilizer by some shear stress affected on being reduced viscosity to low one and Aimtrakarn et al., (2011) who noted that in Thixotropic Flow Behavior, it took more times to reversion of big agglomerates by random Brownian movement. The high employment in treated Xanthan gums which were employed in suspension fertilizers affected on high entanglement density of xanthan gum polymer (high 3 dimension network) and high viscosity because of cross linkage between the xanthan gums and the components in suspensions by more van der Waals forces (Figure 5). These researches were related to 24-8-8 grade of suspension which was made from liquid raw materials: 12-38-0, UAN (32%N), KCl, 1% clay, 0.3% H_2SiF_6 gave low viscosity: 300-800 cps which affected on high pour-ability (0% the remaining products) (Jones & Stinson, 1983).

3.7 Salting Out

All of treatments in Table 2 gave 0% retained crystal on the 20 mesh screen sieve, which were non-significantly different. The 0% salting out meant there were no any retained crystals on 20 mesh screen of the test sieve. All treatments were appropriate suspensions that could be compared with the acceptable limits: maximum 2% retained crystals on a 20 mesh sieve (CIPAC, 2009b; Byrd & Scott, 1979). They were described that all of treatments were treated by Luxen's method that were the temperature of solution: 30 to 40°C, the milled raw materials in particle size of more than 20 meshes, and the suspending agent: 2.5% xanthan gum. That temperature: 30 to 40°C affected on the small crystals of nutrient materials in suspension which related to many researches of Slack & Walters (1963); Kendrick (1974); Fox & Oldland (1976) who found that the temperature of solution 29°C, 38°C and 70 to 82°C affected on the small crystals of nutrient materials in the suspension fertilizers, respectively.Furthermore, Johnson & Huber (1991) who found that a suspension with sufficient gel strength would support the solids contained in the suspension preventing them from setting out. So the suitable suspending agent found in this research was 2.5% xanthan gum in the suspensions which gave 0% retained crystal on the 20 mesh screen sieve at various storage periods. The particle size of raw materials contributes to less salting out. In these researches, more than 20 meshes milled raw materials were enough to be employed in the process which affected on 0% retained crystal on the 20 mesh screen sieve. They were related to Sawyer (1991); Aijala & Ahlnas (1998) who found that the appropriate particle size of raw materials were 35 meshes and 18-140 meshes, respectively, that affected on the less salting out. Moreover, the particle size of milled raw materials which was more than 20 meshes and could be trapped by hollows of 3 dimension network of xanthan gum solution (NQF-AGRO, 2001; Aimtrakarn et al., 2011) affected on less than weakly intermolecular force which were the electrostatic attraction, van der Waals force and hydrogen bond. The large particle size affects on more strongly intermolecular force than small particle size (Sirimungkala, 2012; Anuragudom, 2012). Chance of formation in large agglomerates from the non-dissolved raw materials is less because of less than weakly intermolecular force in them. Nevertheless, the raw material composition of 25-7-7 at 30 to 40°C in these researches, which was 54.3% urea, 4.13% KCl and 13.5% MKP were related to the raw material composition of 21-7-7 at 29°C which was not greater than in each of 57.6% urea, 28.3% KCl, 21.1% MKP respectively, which non-affecting on salting out (Wolf et. al., 1985) and 24-8-8 grade of suspension which was made from liquid raw materials: APP (12-38-0), UAN (32% N), KCl, 1% clay, 0.3% H2SiF6 gave low viscosity: 300-800 mPa.s which affected on 0% salting out (Jones & Stinson, 1983).

4. Conclusion

The 25-7-7 analysis grade of suspension fertilizers processed by Luxen's method was a non-Newtonian fluid, pseudoplastic fluid type, thixotropy, pH: 5.6, and specific gravity: 1.274. The storage periods affected on viscosity that increased along with increasing storage periods. They also affected on very good to excellent stability and acceptation in both pour-ability and salting out. Thereby, they had high efficiency in physical properties within 180 days of storage time period at normal room temperature.

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