SUMMARY

UTILIZING STARCH AND CLAY MINERAL TO MAKE CONTROLLED RELEASE FERTILIZER

Author: Nguyen Viet Huy 12 Biology – Hanoi-Amsterdam High school for the gifted
Nguyen Doan Tung 11 Physical - Hanoi-Amsterdam High school for the gifted
Le Bao Trung 11 Physical - Hanoi-Amsterdam High school for the gifted

PART 1. INTRODUCTION

1.1. Real situation

Vietnam is a country with agriculture as an advantage. Every year millions of tons of agricultural products are produced to meet domestic demand and for export. In 2011, the quantity of fertilizer used in Vietnam was estimated at about 8.5-9 million tons, the total imported fertilizers of various kinds was approx. 2.5 - 3 million tons. Nevertheless, the coefficient of utilization of fertilizer in Vietnam and over the world as well is very low. According to the survey data of Department of Cultivation-Ministry of Agriculture and Rural Development, the coefficient of utilization of urea is 30-45%, phosphorus: 40-45%, potassium 40-50%, the remainder is lost due to objective causes such as residential rainwater overflowing increases the quantity of washed out fertilizer, high temperature speeds up dissolubility of fertilizers in water, the increased disintegration of **urease enzyme** results in higher evaporating capacity. The loss of fertilizer takes place chiefly with urea, the quantity of the washed out fertilizer may reach 12-25%.

The data above has shown that there should be a new kind of fertilizer so as to minimize washout and waste due to natural conditions and the farming methods in Vietnam.

A viable way of improving the coefficient of utilization of fertilizer while still minimizing risks of environmental pollution is the use of controlled release fertilizer.

For that reason, our research team has selected the subject:

"Utilizing starch and clay mineral to make Controlled Release Fertilizer"

1.2 Necessity

Successful manufacture of kinds of Controlled Release Fertilizer is being given special care and very promising. Fertilizers and nutrition in controlled release fertilizer are gradually released for crop plants to absorb, thus avoiding washout, evaporation of nutrition, saving labour and production expenses, minimizing risks of environmental pollution from water soluble fertilizers, reducing fertilizer loss and the number of times of putting down fertilizer.

At present, controlled release fertilizers are being under research in countries over the world. Nevertheless, the controlled release fertilizers being researched as such are the types which entail using expensive chemicals and by costly manufacturing methods that are only suitable for advanced countries, with high income. Whereas, the application of the same in Vietnam is very difficult, as our farmers' income is still very low. The pressing issue now is to obtain a type of controlled release fertilizer that uses cheap, easy to procure, environmentally friendly, manufactured in a simple manner, friendly towards farmers while still have the effect equal to that of other types of controlled release fertilizers.

1.3 Novelty

Controlled release fertilizer is no more a new issue, of which there have been numerous subjects or topics of study or research announced, nonetheless, these often used expensive materials and by methods with high, complicated engineering standard. In our subject, we use the types of materials and by the method or processing at a low cost price. After testing, we found out that starch denatured by javel water is easy and inexpensive yet the outcomes are equal to that of other starch denaturing methods.

The novelty of the subject is presented in the use of starch oxidized by javel water and the combination of the two materials of starch and clay mineral.

1.4 Objectives

- To research, survey the composition of the materials as constituents of controlled release fertilizer, i.e. Modified starch, bentonite (clay) mineral and NPK 16:16:8 fertilizer. On that basis to work out a formula with ratio of the constituents of the controlled release fertilizer.

- To study procedures for manufacturing controlled release fertilizer and to test on real crop plants.

PART 2. BACKGROUND

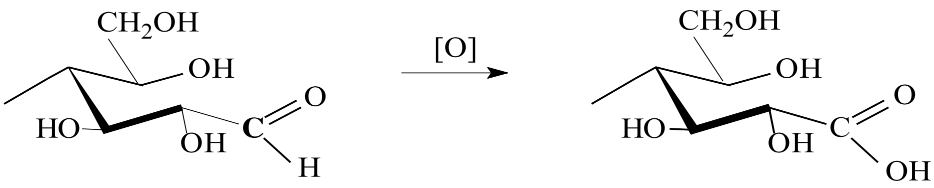
2.1 The oxidation of Starch by Sodium Hypochlorite

2.1.1 Menthod

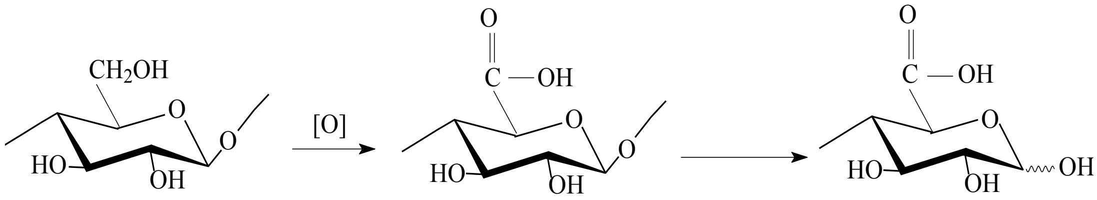
The oxidation of Starch by Sodium Hypochlorite is usually conducted by slurry method, the medium is sodium hypochlorite and the particulate is starch. By the end of reaction, modified starch will be washed and desiccated. During the course of reaction, several reactions occur which lead to the introduction of carbonyl and carboxyl groups and the degradation of starch molecules. Hypochlorite oxidation of starch is performed under conditions of mild to moderate alkalinity in order to favor production of carboxyl group which is a key component in stabilizing the viscosity of starch dispersion.

The oxidation of starch can occur in several ways:

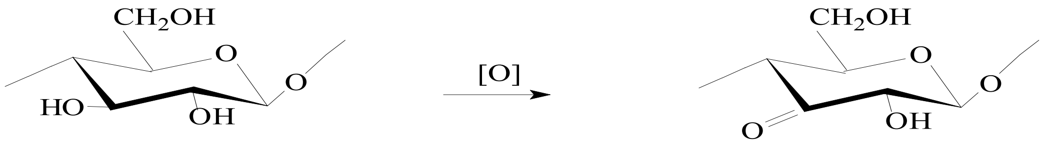
+ An organic compound: Andehyde is oxidized to cacboxyl



+ An organic compound: Hydroxymethyl at C6 is oxidized to cacboxyl



+ An organic compound: Hydroxyl is oxidized to ketone. This reaction usually occur with –OH group oxidized to cacbonyl.



2.1.2 Properties

Smaller volume, uniform particle size, shorter circuit.

Higher polarity

Lower Gelatinization temperature

Good solubility in water

The ability to classify and high stability

2.2. Bentonite Clay

2.2.1 Structure

Montmorillonite is an aggregate of lamellar platelets, packed together by electrochemical forces and containing interposition water. Each platelet consists of three sandwich-arranged layers: a central octahedral alumina (Al2O3) layer, and two tetrahedral silica (SiO2) layers. The silicon ion and the aluminium ion often undergo isomorphous substitutions by lower valence metals, such as magnesium and iron. In turn, these substitutions lead to a charge imbalance, compensated by exchangeable cations, in particular calcium (Ca^{2+}), magnesium (Mg^{2+}) and sodium (Na^{+}) ions, together with water molecules bonded together by ion-dipole forces. These ions, with no more place inside the reticular structure, migrate to the external silica layers and are the main cause of hydration in the crystal lattice. Therefore, each platelet can be assumed to have the following general formulation: **$[(Si^{Al})4\ (Al^{FeMg})2\ O10\ (OH)2\ ]2 \cdot Mn \cdot mH2O$** where the first member in brackets refers to isomorphic constitutions in the tetrahedral layers, the second member refers to isomorphic constitutions in the octahedral layer; and M and mH2O symbols refer to exchangeable cations and interposition water, respectively. Every clay has a constant, maximum amount of exchangeable cations, as indicated by its cation exchange capacity (CEC), measured in milliequivalents per gram (meq/g) or, more frequently, per 100 grams (meq/100g). Bentonite CEC varies depending on the level of isomorphous substitutions occurred within the lattice. From a chemical point of view, bentonites can be distinguished depending on the quantity and quality of exchangeable bases: in particular, we have calcium bentonites and sodium bentonites, when the prevailing exchangeable cation is calcium or sodium, respectively. The largest deposits on earth contain calcium bentonites, which, however, have less hydration and swelling capacity than sodium bentonites.

2.2.2 Properties

Water absorption and swelling A fundamental property of bentonite is to absorb water and expand

Viscosity and thixotropy of aqueous suspensionswhen bentonite is dispersed in water, highly stable colloidal suspensions are formed with high viscosity and thixotropy. At high enough concentrations, these suspensions begin to take on the characteristics of a gel.

Colloidal and waterproofing propertieswhen water is absorbed by bentonite, a semisolid gel is formed with strong hydrostatic pressure resistance

- ***Agriculture*** Bentonite is used as an ion exchanger for soil improvement and conditioning. It is also used for gardening in soil compounds and mixtures to absorb humidity, and as a carrier for various herbicides and pesticides.

PART 3. MATERIALS AND METHODOLOGY

3.1 Materials:

- Cassava starch (Ha Tay Food Company);
- Javel water **sodium-hypochlorite** (Viet Tri Commercial Plant);
- Bentonite clay mineral (Vietnam);
- Lam Thao NPK fertilizer (nutrition content N-P-K is 16-16-8);
- **Clohydric acid liquid** HCl 36% (China)

3.2 Methodology

Surveying ratio of constituents of controlled release fertilizer

a. Surveying effect of starch denaturing time

Using clay ratio: unchanged fertilizer 1:1. Ratio of denatured starch is 3, change the denaturing time to find the best denaturing period.

b. Surveying effect of the ratio of clay mineral/ fertilizer

Take the outcome from the experiment above, retain the ratio of denatured starch of 3 unchanged. Change the ratio of clay mineral / fertilizer to find the best ratio.

c. Surveying effect of starch content

Continue using the outcomes of the two experiments above. Change the ratio of denatured starch to find the best ratio.

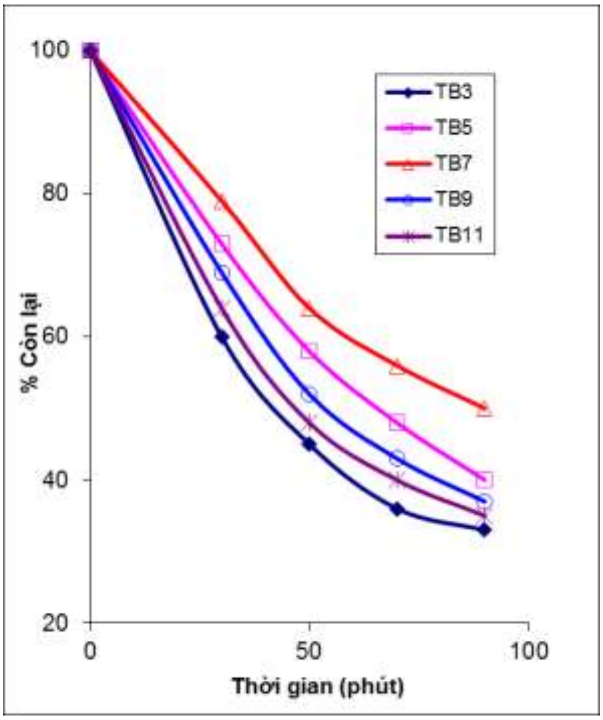
d. Surveying nutrition release degree

The nutrition factor to be surveyed is the NH_4^+ ion concentration, use the *Kjeldah approach*. By converting all the N forms in the liquid obtained to the $N\text{-}NH_4^+$ form with thick H_2SO_4, $CuSO_4$ and K_2SO_4 catalyst combination (ratio 1:9), we shall quantify N available in the liquid.

PART 4 OUTCOMES AND DISCUSSIONS:

4.1 Outcomes of surveying effect of starch denaturing time:

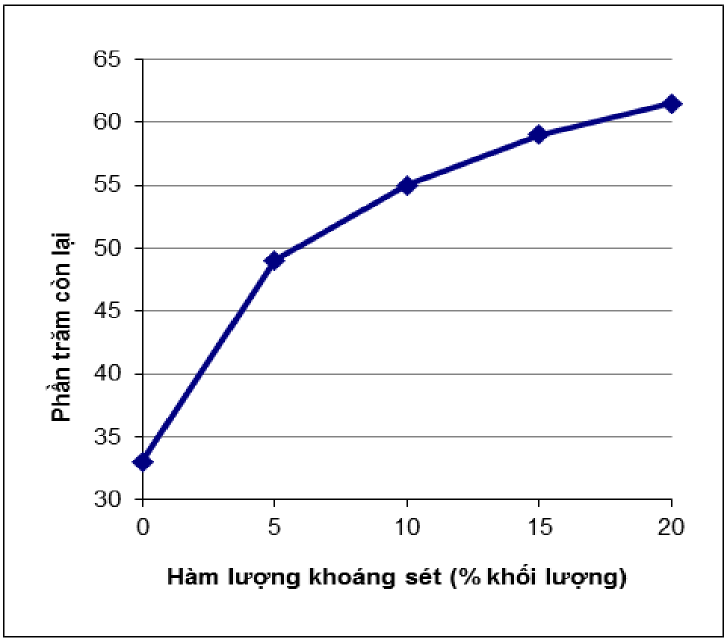
Thời gian khuấy (phút)	3 ngày	5 ngày	7 ngày	9 ngày	11 ngày
0	100	100	100	100	100
30	60	73	79	69	64
50	45	58	64	52	48
70	36	48	56	43	40
90	33	40	50	37	35



The outcomes have shown that starch denaturing time has direct effect on the binding agent of starch and the disintegration rate of controlled release fertilizer. Compared with the samples of using denatured starch with time between 3 - 7 days, increase in the denaturing time will increase the content of the carboxyl group in starch thus strengthening the binding capacity with clay mineral and fertilizer. When continuing to increase starch denaturing time between 7-11 days, we can observe a rise in the fertilizer disintegration degree, this can be explained that once the starch denaturing time is too long, the starch molecule circuit shall be cut small, since starch molecule mass is low, it is easy to dissolve in water, thus decreasing the binding capacity. The outcomes have shown that the sample of controlled release fertilizer that uses denatured starch in a period of 7 days has the lowest disintegration rate after 70 minutes. The maximal starch denaturing time is 7 days.

4.2 Outcomes of surveying effect of clay mineral – fertilizer ratio:

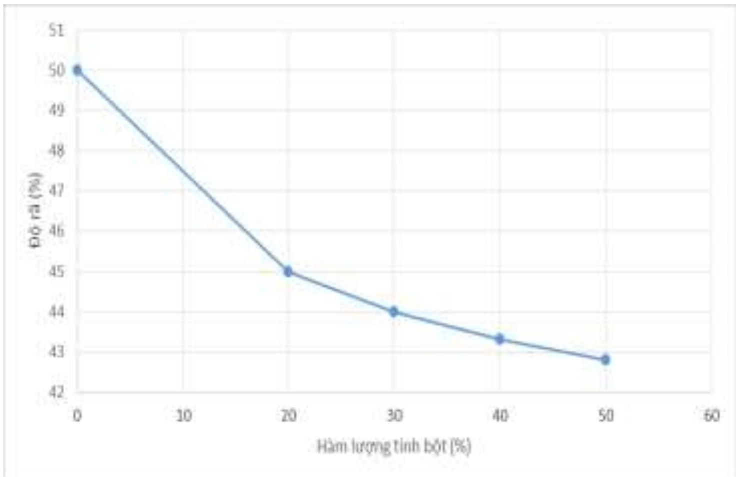
Hàm lượng khoáng sét (%)	Độ rã (%)	Còn lại (%)
0	67	33
5	51	49
10	45	55
15	41	59
20	38.5	61.5



The outcomes have shown that when clay mineral content is increased, the fertilizer disintegration rate will decrease, this is due to the ability of clay mineral to react with fertilizer to strengthen material structure, the increase in the clay mineral will decrease the nutrition content in the fertilizer thereby influencing product value. Therefore, the clay mineral content of 5% is the best choice for the quality and value of controlled release fertilizer.

4.3 Outcomes of surveying effect of starch content:

%Tinh bột	Còn lại %	Độ rã %
0	50	50
20	55	45
30	56	44
40	56.7	43.3
50	57.2	42.8



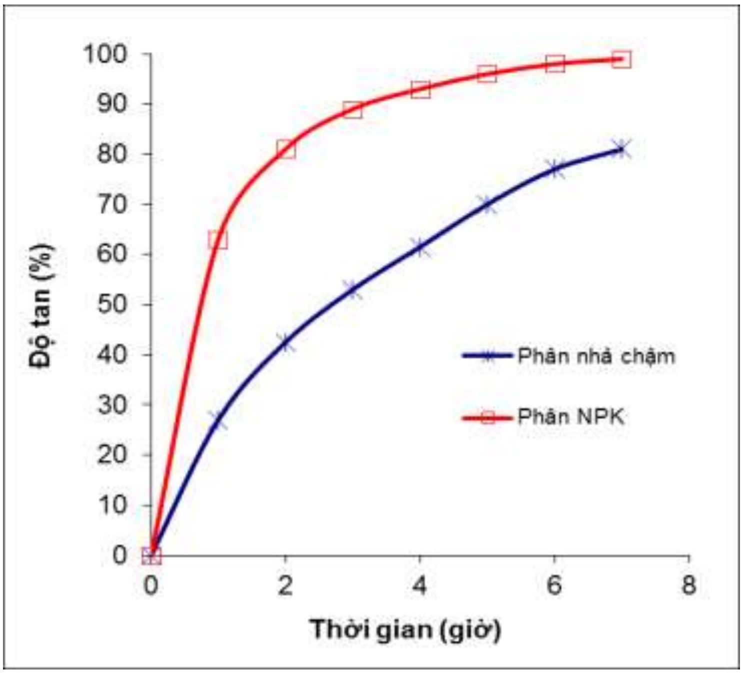
The outcomes have shown that starch content has effect on product disintegration rate. When starch content is increased, the binding capacity of starch content is increased, too but controlled release fertilizer disintegration rate is decreased. The graph indicates that when starch content is over 30%, there is not much change in the fertilizer disintegration rate. Starch content of 30% is a suitable choice for the controlled release fertilizer meaning process.

Based on the experimental outcomes above, we have provided the following as the most suitable composition ratio for controlled released fertilizer:

- NPK fertilizer: 93.5% of the total volume
- Clay mineral: 5% of the total volume
- Denatured starch after 7 days: 1.5% of the total volume

4.4 Outcomes of surveying effect of release degree of controlled release fertilizer

Giờ khuấy	Nhả chậm	Thường
0	0	0
1	27	63
2	42.5	81
3	53	89
4	61.5	93
5	70	96
6	77	98
7	81	99



PART 5
CONCLUSIONS AND ORIENTATION:

5.1 Conclusions

- The most proper moisture for pill press is 13% of the total volume.
- The most proper ratio among the 3 materials as constituents of controlled release fertilizer pill is:
- NPK fertilizer: 93.5% of the total volume
- Clay mineral: 5% of the total volume
- Denatured starch after 7 days: 1.5% of the total volume
- It's possible to demonstrate that nutrition release degree of controlled release fertilizer is more preeminent than that of the normal Lam Thao NPK fertilizer.

5.2 Orientation:

Future research orientation:

- To surveying the disintegration degree of controlled release fertilizer in the soil environment
- To conduct survey on crop plants to test the performance of the utilization of controlled release fertilizer
- To select proper material resources to purchase and determine economic value brought about by controlled released fertilizer along with production cost price;
- To continue researching manufacture of controlled release fertilizer in relation with other chemical fertilizers (such as Urea, Potassium…)


Washing the Sodium Hypochlorite from the oxidized starch

Oxidized Starch after washing

Drying Oxidized starch

Gelatinizing


Mixing the materials, preparing for pelleting

Verified model


Controlled Release Fertilizer

HASEF
HANOI SCIENCE AND ENGINEERING FAIR

CỘNG HÒA XÃ HỘI CHỦ NGHĨA VIỆT NAM
Độc lập - Tự do - Hạnh phúc

CHỨNG NHẬN

Em Nguyễn Đoàn Tùng
Nguyễn Việt Huy
Lê Bảo Trung

HỌC SINH TRƯỜNG THPT HÀ NỘI-AMSTERDAM-CẦU GIẤY

Đã tham gia đề tài : Sử dụng tinh bột và khoáng sét để sản xuất phân bón nhả chậm

Đạt giải: *Ba lĩnh vực Khoa học thực vật*

CUỘC THI KHOA HỌC, KỸ THUẬT
DÀNH CHO HỌC SINH TRUNG HỌC THÀNH PHỐ HÀ NỘI LẦN THỨ BA

Hà Nội, ngày 26 tháng 12 năm 2013
GIÁM ĐỐC
SỞ GIÁO DỤC VÀ ĐÀO TẠO HÀ NỘI

SỞ GIÁO DỤC VÀ ĐÀO TẠO

Nguyễn Hữu Độ