

**THE USE OF NITROGEN
IN
MODIFYING STORAGE ENVIRONMENT**

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DEDICATION

This project is dedicated to the entire family of MAJIYA.

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My sincere thanks to Allah for guiding and blessing me throughout the period of this project.

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ABSTRACT

The urea fertiliser when subjected to heat at a controlled rate will release ammonia and carbon dioxide, when ammonia reacts with oxygen of the air, nitrogen will be generated. The nitrogen is necessary in inert atmosphere for storage.

This project is aimed at generating nitrogen which could be used for modified storage environment. The nitrogen generated is directly channelled into two different mud Rhumbu's which are filled with maize grain. One mud Rhumbu is filled with wet maize grain, the second. One with dried maize grain which is completely air-tight with rubber padded.

The two mud Rhumbu's were monitored during the storage period of one month. The result showed that there is reduction in weight from (200g-163g), moisture content increases from (22.69%-29.37%) and increase in temperature from (34.2⁰c-36.0⁰c) in the wet maize while the dried maize the moisture content increases from 14.94%-17.57% before and after nitrogen passage, the temperature increases from (35.0⁰c-36.3⁰c). The increase in the temperature was due to the hot nitrogen that was passed. These results shows that nitrogen in inert atmosphere can be used in a modified storage environment to stored both wet and dried maize sample for certain period of time without spoiling, the quality of the maize store is maintained, and no life insects found during storage, because of nitrogen and carbon dioxide inside the Rhumbu.

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NOTATIONS AND SYMBOLS

1. Ar.....Argon
2. Ba.....Barium
3. Br.....Bromine
4. C.....Carbon
5. Ca.....Calcium
6. Cl.....Chlorine
7. Cr.....Chromium
8. H.....Hydrogen
9. Mg.....Magnesium
10. Na.....Sodium
11. O.....Oxygen

SYMBOLS FOR COMPOUNDS

12. $\text{Ba}(\text{N}_3)_2$ Barium azide
13. $\text{Ca}(\text{OCl})_2$ Calcium hypochloride
14. $\text{Co}(\text{NH}_2)_2$ Carbamide (urea)
15. Cr_2O_3 Chromic Oxide
16. CO_2 Carbon dioxide
17. HCL..... Hydrochloric acid
18. H_2O Water
19. Mg_3N_2 Magnesium nitride
20. NaOBr..... Sodium hypobromide
21. NH_3 Ammonia
22. $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$ Ammonium dichloramate
23. NH_4NO_2 Ammonium nitrite

- | | | |
|-----|------------------------------|--------------------|
| 24. | NH_4Cl | Ammonium Chloride |
| 25. | N_2H_4 | Hydrazine |
| 26. | NO | Nitric Oxide |
| 27. | KClO_3 | Potassium Chlorite |

CHAPTER ONE

1.0 INTRODUCTION

1.1 JUSTIFICATION OF THE PROJECT

The importance of grain storage is to ensure steady supply throughout the year, to preserve surplus food produce for transport to a deficit area, and to serve as a reserve during times of food security and to use as seeds for the next planting season.

About 80% of the national agricultural production effort is undertaken by small and medium sized farmers whose skill in food storage and prevention of post-harvest losses are still at the rudimentary stage. National agricultural policy aims at providing food in adequate quantity and quality to keep pace with increasing population and urbanisation as well as extensive and diversified agro-based industrial activities.

The government has encourage increasing in food production by either going into direct food production or helping farmers to increase cultivated areas by setting up seventeen river basin development authorities, establishing agricultural development projects and getting involved in several world bank financed projects.

In 1977, the Nigerian store products research institute (NSPRI) was created whose aims is to Prevent stored grains from spoiling, allow the storage of seeds grains for longer period without the lose of quality.

There were four major methods of storage used in all parts of the country. They were the crib, mud Rhumbus, silo, and warehouse

storage methods. Their efficiencies varied from place to place and due to the climate and management skill.

Broad bent (1967) and Oyeniran (1973) that the traditional method of crib storage has been improved by the introduction of the modern crib for farmers, design by the Nigerian stored product Research institute (NSPRI). This method requires that the maize be harvested early at 25% moisture content, stored in cobs and dry to moisture content of 15% in 3-4 months. This reduces loses in the field due to birds and insects and also reduces the change of mould infection of the maize being stored is gradually reduced as soon as storage in the crib commence. The crib consists of a structure of rectangular plan, raised some centimetres above the ground, with sides made of wire netting and rein forced with wood. It is usually sited in a well sited in a well-ventilated area to facilitate aeration and drying of the maize.

In the Northern part of Nigerian grains are stored in a circular mud granary called Rhumbu. The mud Rhumbu are made from structure of 3.0-4.0 tons capacities constructed in Sokoto. Kano and Kastina state for storage of grains like millet, sorghum, and maize etc. Both in threshed and unthreshed condition. The structure is supported on stones pieces 15'-20' above the ground level. The roof is conical in shape and has an inlet opening of 800mm diameter at the centre for loading and unloading operations. This type of grains storage is not capable of protecting stored grain from insect infestation and studies have revealed extensive loses due to insect infestation of grain. Its major disadvantage is that insect control is difficult to carry out as it is inefficient. As a result Nigerian stored

product research institute (NSPRI) embarked on work to overcome these problems through innovative research. The walls were reinforced for strength with iron netting. The top was covered leaving only a manhole which has a tight-fitting (Lid) for filling-in the grains. A hole, which can effectively be plugged) was also made at the lower side of the cylindrical container. The legs are provided with rodent guards.

The metal silos are mainly used for shelled maize throughout the country by commercial units. It involves handling like shelling, drying and conveying into the silo. A lot of problems have been encountered with the silo especially in the humid south of the country. Heavy rain and morning condensation create so much dampness that it penetrates, into the grains through the joint of the metal walls. Also differences in day light and night temperatures result in moisture condensation inside the walls of the silo. The grains becoming damp and this results in increased heat generation and mould infestation as a result the grain cake-up and the surface layers rot or germinate. Losses by the silo technique have run as high as 22% which results from above causes.

The warehouse system is the most popular storage method for all the grains. The reason being that the farmers find it easier and quicker to build a warehouse than a silo. Another reason is the ease of transporting bags for marketing. The main factor that affects the storability of the grain bag is the housing or building for the bag warehouse.

Losses through this storage technique are mainly due to:-

- (a) The building design hampered rather than helping the control of the insect.
- (b) The roofs, walls, doors and windows not leak proof from water and in some cases the floors transmitted water vapour from the ground with which they were in contact.
- (c) The building allowed the entry of rats and mice.

Many researchers have alternative methods as ambient air drying and solar drying (Baker and Shove, 1977, Meyer et al 1975, Tredi 1974) that these methods are slow, micro-bial activity can be a problem.

Other techniques to prevent wet corn spoilage is creating Anaerobic condition in the storage bin. But, this method results in anaerobic fermentation (Christen and Kaufman 1969).

In 1967, Tuite et al who stored high moisture corn in atmospheric of zero to four percent oxygen (O_2) and thirty to sixty percent carbon dioxide (CO_2). They found that yeast were encouraged and mould inhibited as oxygen(O_2) was decreased and carbon dioxide (CO_2) increased.

Ammonia has been successfully used by some scientist (Bothast et al 1973: Lancaster et al 1977) used gaseous ammonia in the ambient air drying of high moisture corn to retard mould growth.

In the light of all above-mentioned studies. The aim of this project is the use of urea fertiliser as a source of nitrogen when nitrogen is generated, it could be used for modifying storage environment. The crystalline urea fertiliser reacts in solution as heat

is applied to release ammonia which in turn reacts with oxygen of the air to give nitrogen urea contains 45% to 46% by weight of nitrogen.

The generated nitrogen will be channelled into the mud Rhumbu which is made completely air tight. The Rhumbu should be provided with an opening on the top which is used for loading of the grains. The inert Rhumbu is provided with a rubber padded to provide air tightness when closed. Similarly an outlet for emptying the Rhumbu is provided with a rubber-padded gasket at the lower side of the cylindrical container.

The Rhumbu is connected with gas pipes which is used to introduce Nitrogen into the Rhumbu filled with grains, the gas inlet pipe is connected a source of Nitrogen (an inert gas) generated from urea and the gas outlet pipe is used to evacuate the air originally in the Rhumbu. The air in the Rhumbu which contains oxygen is purged out by replacing it with nitrogen until full replacement is achieved. The inlet and outlet pipes are connected to pressostates and valves which allow more gas into the Rhumbu automatically when the need arises. The grains inert atmosphere is kept in good condition for a period of time. This method has the following advantages.

- (i) "It is a no loss method" in the sense that the quality of all the grains stored is maintained.
- (ii) The grains can be preserved for a longer period and can expect better market value.
- (iii) It does not involve the use of chemical pesticide, hence the fear or anxiety expressed by a lot of people on chemically treated grain is eliminated.

(iv) No presence of life insects.

1.2 OBJECTIVE OF THE PROJECT

1. To determine the applicability of using urea as a source of nitrogen generation.
2. To determine the possibility of generating ammonia from urea fertiliser through heat application which in turns react with ambient air to release nitrogen as inert gas for modifying storage environment.
3. Whether nitrogen generated can help to store maize grain in modifying storage environment.
4. To assess the effect of nitrogen generated on wet and dry maize.

The scope of this project is limited to the use of urea fertiliser as the source of nitrogen generation, a further research is carried out to channel the generated nitrogen into two different mud Rhombus filled with wet and dry maize to modify the storage environment.

The study of this project should be encouraged as it could led to the modification of the existing native mud Rhumbu by incorporating control valves through which the nitrogen generated from urea will be introduced into the stored grains.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 HISTORICAL BACKGROUND OF NITROGEN AS AN INERT GAS

Twenty percent by volume of the atmospheres is oxygen. Most of the remaining is nitrogen, the reactive gas.

Nitrogen is present in living things as nitrogen containing Compounds called protein. If animal or vegetable materials are heated strongly they evolve steam, carbon dioxides and ammonia (nitrogen III hydride, NH_3).

Daniel Rutherford in 1772 allowed mice to breath in air under a belt-jar and removed the fixed air (CO_2) by washing the residue gas with caustic soda solution.

A gas remained which did not support combustion or respiration but, fixed air, was not absorbed by alkali or lime water.

In 1772, priestly burnt charcoal in a confined volume of air and absorbed the fixed air with alkali, also obtaining a "MEPHITIC air" which is called PHLOGISTICATED air. Both considered that the gas was common air saturated with phlogiston emitted by the animal or combustible body. Scheeles (1772) proved that air is a mixture of two gases, fire air which supports combustion and respiration, and foul air, which does not. Lavoisier (1775-1776) gave a decisive proof of this and called scheeles gas azote (Greek a, no; zoe, life) a name still used in France, the name nitrogen (Greek nitro, nitre) was suggested by Chaptal in 1790.

Atmospheric nitrogen was considered to be a pure substance until in 1894 Rayleigh and Ramsey found that it contains rather more than one percent by weight of an inert gas which unlike nitrogen, does not combine with heated magnesium. The inert gas, existence of which had been indicated by Cavendish in 1785 was called argon (Greek argon, sluggish,) Later experiment by Ramsey and Travers showed that the atmosphere contains trace of other inert gases helium, neon, krypton and xenon.

The composition of air freed from moisture and carbon dioxide is roughly four volumes of nitrogen to one volume of oxygen, the exact figure (Leduce 1986) are:-

	<u>By weight</u>	<u>By volume</u>
Nitrogen	75.5	78.06
Oxygen	23.2	21.00
Argon etc	1.3	0.94

The very nearly constant composition of dry atmospheric air was proved by Cavendish in 1783 (20.833 vols of oxygen and 79.167 vols of nitrogen and argon).

Benedict (1912) and carpenter (1937) found that the volume percentages of oxygen (20.939) and carbon dioxide (0.031) in uncontaminated are very constant.

2.2 CHEMISTRY AND METHODS OF NITROGEN PRODUCTION

2.2.1 PREPARATION OF NITROGEN FROM THE ATMOSPHERE

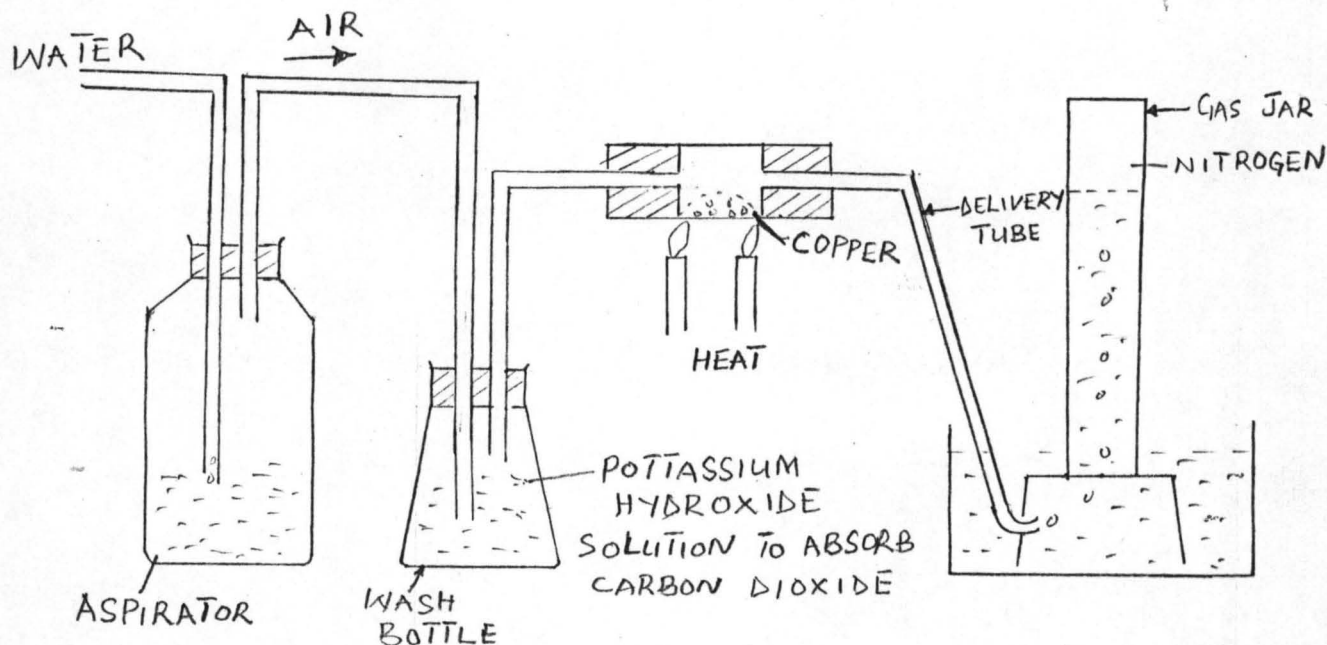


Fig. 1 Preparation of Nitrogen from the atmosphere

Atmospheric nitrogen can be obtained by removal of oxygen and carbon dioxide from air.

Drop water into a large bottle of aspirator so as to displace air and pass this first through potassium hydroxide solution to remove carbon dioxide (as potassium carbonate) and then over hot copper to remove oxygen (as copper ii oxide). Nitrogen remains and is collected over water.

2.2.2 INDUSTRIAL OR COMMERCIAL PREPARATION OF NITROGEN

Industrially nitrogen is obtained from the atmosphere by compressing the air to about ten atmospheres after filtration to remove

dust, the air is now freed from carbon dioxide (CO_2) and moisture and further compressed to about 200 atmospheres after cooling to room temperature sudden expansion result. In a further cooling of the gas the cooled air is now recycled and a further drop in temperature takes place on expansion. Eventually the air become so cold that it liquefies, fractional distillation gives gaseous nitrogen boiling point- 196°c (which is usually contaminated with argon and a little oxygen boiling point- 183°c (fig 2)

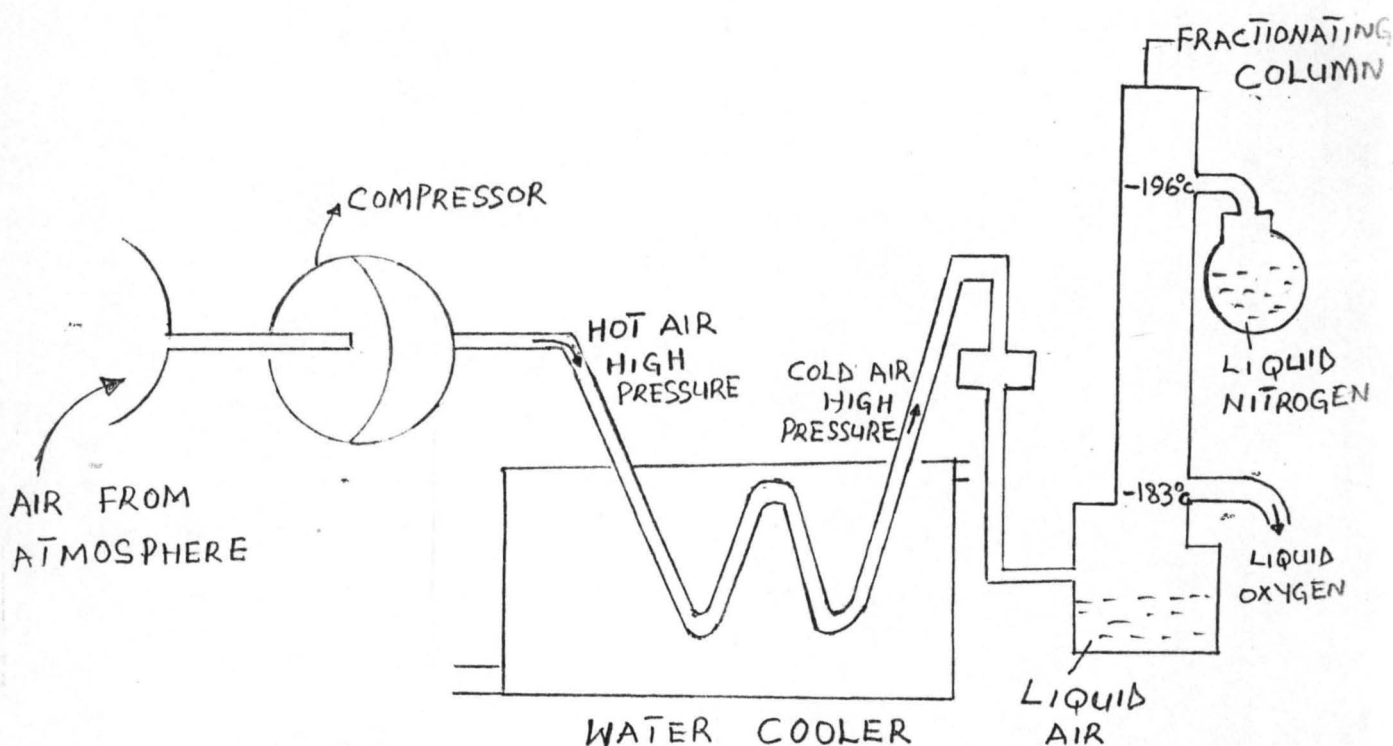


Fig2. Industrial Manufacture of Nitrogen

2.2.3 PREPARATION OF NITROGEN FROM COMPOUNDS

Nitrogen is prepared in the laboratory by methods mostly depending on the oxidation of ammonia, the hydrogen being removed and the nitrogen set free.

1. When chlorine gas is passed into, or bromine is added to concentrated ammonia solution, nitrogen is evolved.



The reaction with Bromine being similar cation. In the case of chlorine, the reaction is vigorous, flashes of light being seen in a darkened room. Care should be taken to keep the ammonia in excess otherwise the very explosive liquid nitrogen trichloride NCl_3 is formed.

2. Instead of free chlorine a thin paste of 40gms of bleaching powder containing Calcium hypochlorite Ca(OCl)_2 may be run through a thistle funnel into 100ml of concentrated ammonia solution warmed in a flask (explosion have been reported).



Instead of bromine, sodium hypobromite solution (6ml of bromine freshly dissolved in cold solution of 10gm of sodium hydroxide in 100ml of water is drop in to concentrated ammonia solution.



Nitrogen is also evolved by the action of alkaline hypobromite solution on urea



This gas contains a trace of nitrous oxide N_2O which is removed by passing over red copper.

3. When red crystal of ammonium dichromate are gently heated they decompose violently with flashes of light, nitrogen and steam are evolved and a voluminous green residue of chromic oxide is left.



4. The most convenient method of preparing nitrogen is to heat a solution containing ammonium nitrite, made by dissolving equimolecular amounts of sodium Nitrite and ammonium chloride or sulphate in water.



The gas evolved is washed with dilute sulphuric acid to remove ammonia and collected over water.

5. Pure nitrogen is obtained by passing a mixture of nitric oxide and ammonia gas over red hot copper.



6. Very pure nitrogen is evolved on heating barium azide in an evacuated apparatus.



This preparation does not involve (an oxidation of ammonia)

Nitrogen gas may be dried by calcium chloride, concentrated sulphuric acid or phosphorous pentoxide, and collected over mercury. Compressed nitrogen in grey cylinders may be bought, it usually contains a little oxygen which may be taken out by passing over copper turnings heated to bright redness.

2.3 PROPERTIES OF NITROGEN

2.3.1 PHYSICAL PROPERTIES

1. Nitrogen is a colourless, odourless gas with no taste.
2. Practically insoluble in water
3. It has a freezing point of 63k and a boiling point of 77k.

2.3.2 CHEMICAL PROPERTIES

1. Nitrogen is very reactive
2. It neither burns nor supports combustion and is not attacked by the usual chemical agent
3. It is not poisonous
4. It does not turn lime water milky
5. It has no action on litmus.

2.4 APPLICATION OF NITROGEN

Nitrogen forms three well-defined compounds with hydrogen, ammonia NH_3 , Hydrazine N_2H_4 and hydrazoic acid N_3H . Ammonia and hydrazine are basic substances combining with acids to form ammonium and hydrazine salts. E.g NH_3CL or $\text{N}_2\text{H}_5\text{CL}$ and $\text{N}_2\text{H}_4, 2\text{HCL}$ or $\text{N}_2\text{H}_6\text{CL}_2$ and $\text{N}_2\text{H}_4, 2\text{HCL}$ or $\text{N}_2\text{H}_6\text{CL}_2$.

Some of the hydrogen of ammonia and hydrazine may however be replaced by alkali metals forming e.g NaNH_2 and $\text{H}_2\text{N.NHNa}$, hydrazoic acid is an acid dissolving metals and forming salts e.g NaN_3 . It combines with ammonia and with hydrazine to form the compounds NH_4N_3 (or N_4H_4) and $\text{N}_2\text{H}_5\text{N}_3$ (or N_5H_5) respectively.

The ion N_3 is univalent nitrogen when sparked with hydrogen forms ammonia.

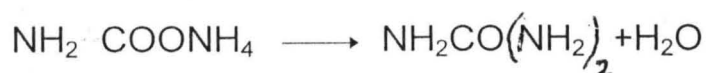
$N_2 + 3H_2 \rightleftharpoons 2NH_3$ (Regnault, 1840,) deville (1864) pointed out that electric spark both form and decompose ammonia.

The reaction is reversible and a state of equilibrium is set up in which 6% of NH_3 exists with 94% of the uncombined gases.

A very important application of nitrogen is in the inert atmospheric storage for which the project is being carried out to generate nitrogen which is an inert gas could be used to modify storage environment.

2.5. UREA PRODUCTION AND ITS IMPORTANCE

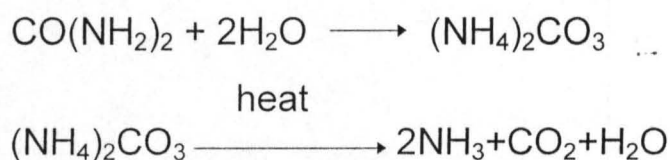
Urea is a white, crystalline organic chemical that in the pure form, contain 47% to 48% percent nitrogen. The material is used as an ingredient in the manufacture of paints, glues, plastics, paper, textiles, feeds, weed-control chemicals. The fertiliser grade is a water soluble acid forming material containing about 45% nitrogen. It has replaced ammonium nitrate as the worlds leading solid nitrogen fertiliser because of its economy of production higher nutrient content and fewer pollution problems during manufacture. It is prepared by reacting ammonia (NH_3) and carbon dioxide (CO_2) gas under very high pressure in the presence of a catalyst. The reactions are represented in the following equations:-



Great care must be taken in the final production stage to prevent formation of biuret, which if present in large quantities is damaging to growing plants. Urea readily absorbs moisture, the solid fertiliser product in the market is granulated and flows evenly through ordinary fertiliser distributors.

2.6 PRODUCTION OF NITROGEN FROM UREA

When crystalline urea is dissolved in water, the solution is ammonium carbonate which when heated yields ammonia, carbon dioxide and water.

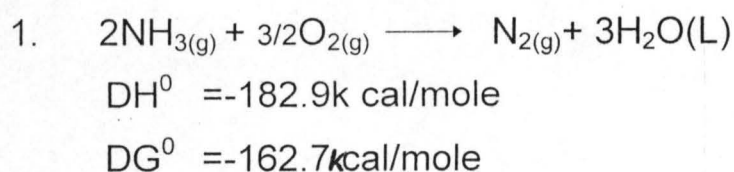


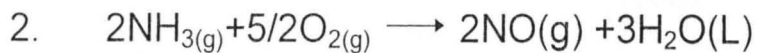
The ammonia released from the above reaction is of importance in the generation of nitrogen. This is made possible by channelling the released ammonia into another chamber where oxygen is introduced to react with the ammonia to give off nitrogen.

Ammonia at room temperature is stable with respect to decomposition into N_2 and H_2 (DG^0 form = $-4.0\text{k cal/mole NH}_3$), however, when mixed with oxygen (or air) ammonia tends to undergo spontaneous oxidation.

Forming water and either NO or N_2 or both. At 25°C and 1 atm.

We have





$$\Delta H^{\circ} = -139.7 \text{ k cal/mole}$$

$$\Delta G^{\circ} = -120.7 \text{ kcal/mole}$$

As the ΔG° values show, both reactions are thermodynamically favourable, although the one that produces N_2 is more favourable than the one that yields NO . At room temperature both reactions take place very slowly that no dic: table amounts of the products are found but at temperature of about 500°C they proceed at an appreciable rate. If at the temperature both reactions are allowed to reach equilibrium a greater amount of N_2 than NO will form.

However, by carrying out oxidation of NH_3 in the presence of a catalyst of platinum gauze, the reaction of NH_3 with O_2 yields principally NO because the platinum catalyst accelerates reaction 1 more than reaction 2. Therefore if the reaction is to favour N_2 , Platinum gauze catalyst is not needed the mixture of NH_3 and air heated to 500°C under industrial set up will yield more of N_2 and the products are then cooled by passing through a condenser and separation takes place from the reaction mixture before equilibrium has time to be established. Notice that under these conditions the rate factor determines the reactive quantities of NO and N_2 production rather than the free energy factor.

CHAPTER THREE

3.0 **METHODOLOGY**

3.1 TEST APPARATUS

The test apparatus used to generate nitrogen for modifying storage environment is shown schematically in figure 3 and figure 4 is the photograph of the set up as the experiment progresses.

It consist of two heating bouncing burners, conical flask with two openings one for the thermometer inlet to regulate the temperature, and outlet to lead out the ammonia liberated through the delivery tube and hose pipe to the gas jar. The second conical flask contain potassium chlorate $KClO_3$ which when heated will release oxygen to the gas jar through the delivery tube and hose pipe.

In the gas jar ammonia react with oxygen to generate nitrogen. The generated nitrogen is channelled directly into the mud Rhombus which contain maize grain.

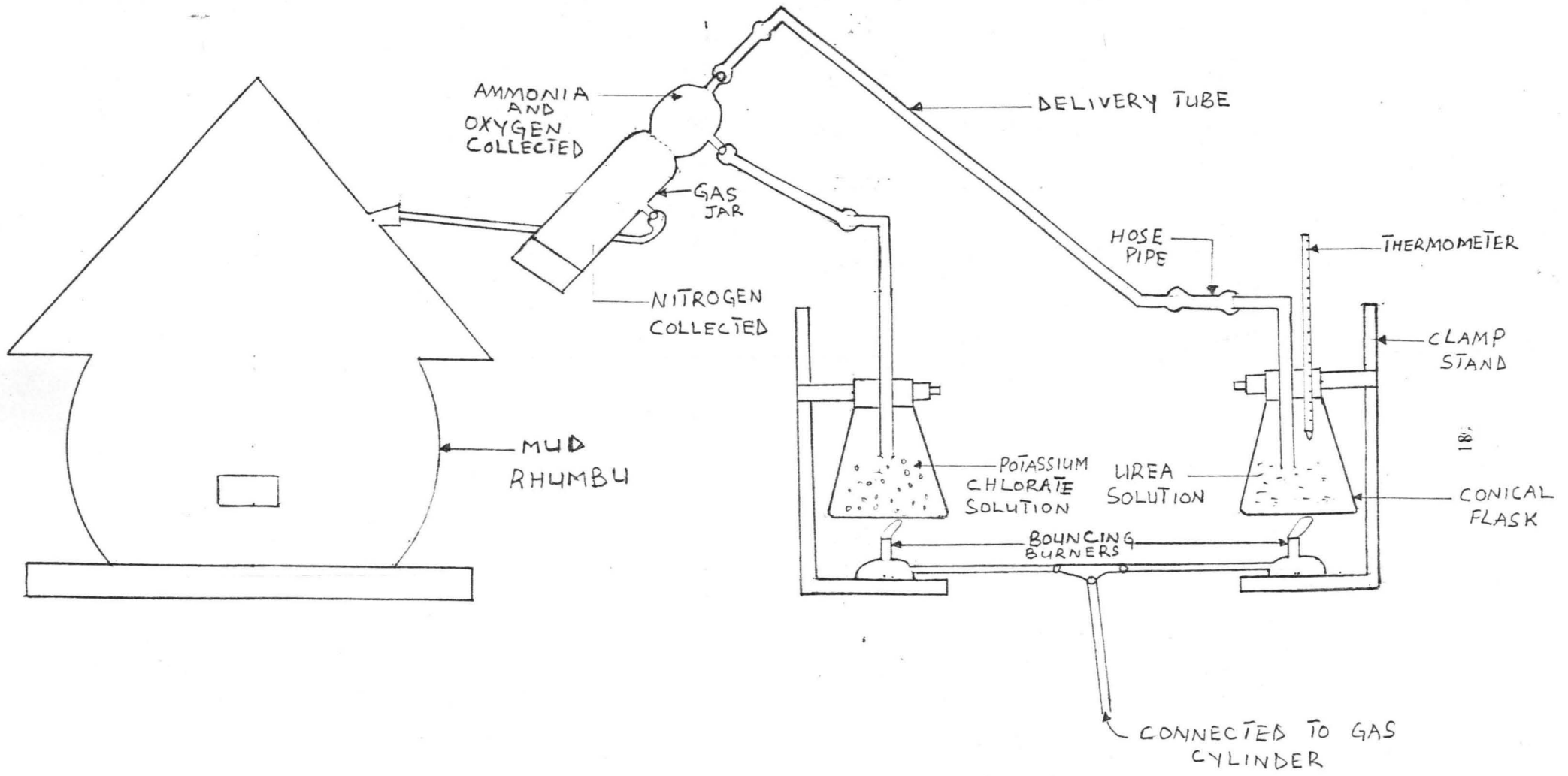
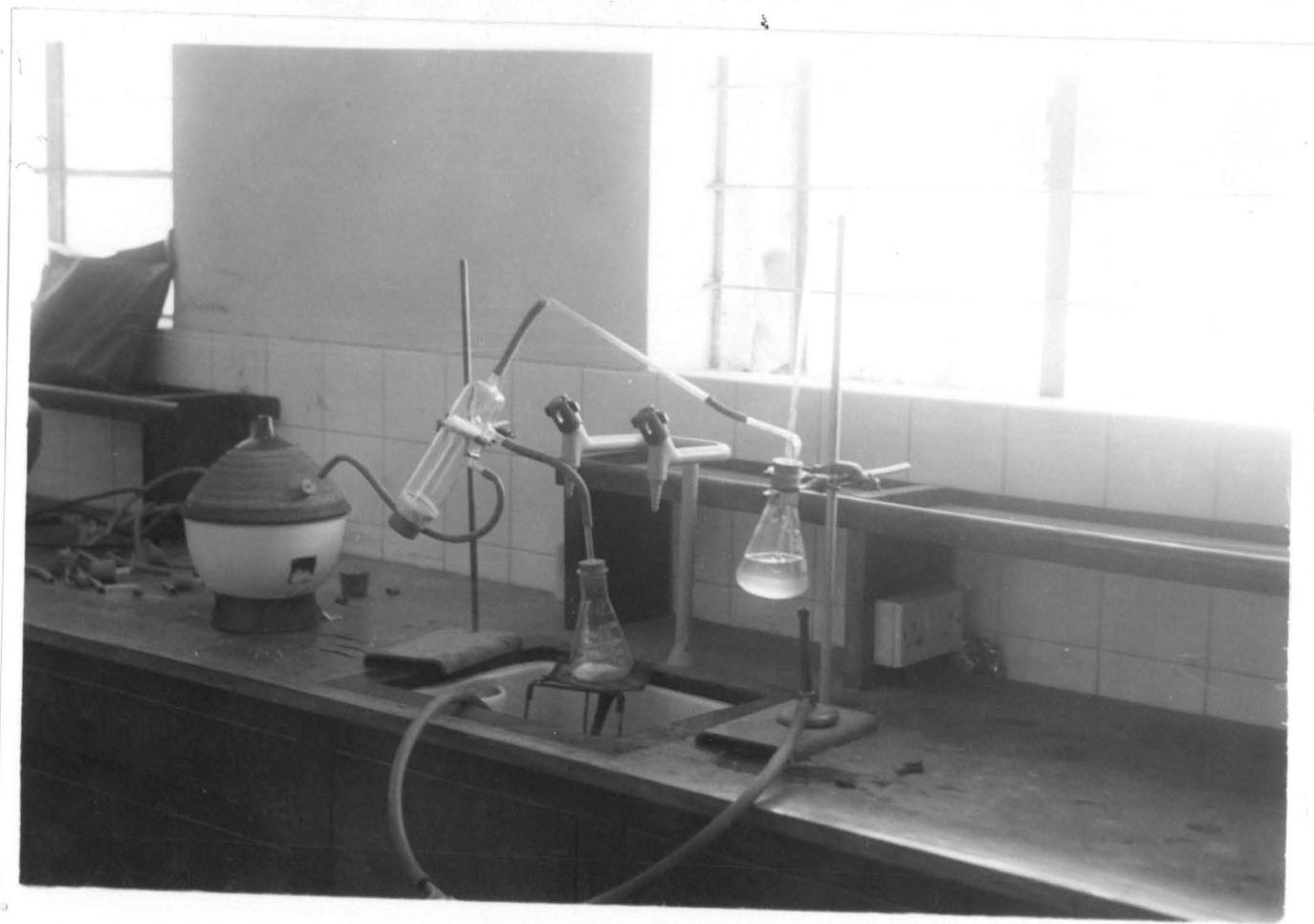


FIGURE 3: SCHEMATIC DIAGRAM OF EQUIPMENT FOR THE GENERATION OF NITROGEN FOR MODIFYING STORAGE ENVIRONMENT.



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FIGURE 4: A PHOTOGRAPH OF THE SET UP APPARATUS FOR GENERATION OF NITROGEN FOR MODIFYING STORAGE ENVIRONMENT.

3.2 REAGENTS

The main reagents in this project is urea, water and oxygen for the purpose of this project, 25kg of urea fertiliser is bought and oxygen is supplied by heating potassium chlorites to release oxygen.

Water is used to dissolve the urea, and the quantity of water used to dissolve the urea is measured with a glass beaker.

3.3 PROCEDURE TO GENERATE NITROGEN

An empty conical flask was firstly weighed on electric weighing balance. Some quantity of urea were measured and some water added to make a solution, which is poured into the conical flask.

The two heating bouncing burners are connected to gas cylinder. When heat is applied to the conical flask containing the urea solution, as the heating continues the thermometer begin to rise in temperature that is from room temperature of 27⁰c to 90⁰c as the urea solution reaches its boiling point gas was observed to come out from the delivery tube and when red litmus paper was put into the out coming gas it turned blue indicating that the gas coming out was an alkaline gas known as ammonia which is liberated through the delivery tube to the gas jar. At the gas jar ammonia gas reacts with oxygen of the potassium chlorate and release nitrogen and water in form of steam which is seen at the gas jar. The steam condenses at the first section of the gas jar while the nitrogen passes into the second section of the gas jar which is connected to hose pipe and then channelled directly into the mud Rhumbu which contain maize grain.

The preliminary test running helped in knowing the parameter that need to be controlled during the experiment. From observation, it was noticed that the urea solution should not be allowed to reach 100°C as this causes the steam from urea solution to rise into the delivery tube this disturb the reaction between ammonia and oxygen.

Therefore there is need to control the experiment by not allowing the heating to reach 100°C. Once the thermometer in the conical flask reaches 90°C the gas cylinder is switched off.

The nitrogen generated was directly channelled into two different Mud Rhumbus that contain wet and dry maize grain, this was done to know whether the nitrogen generated will help store the maize for some days for observation.

3.4 PROCEDURE IN DETERMINATION OF MOISTURE CONTENT OF WET AND DRIED MAIZE USING PROTIMETER GRAINMASTER

1. Switch on the instrument
2. Place the grinded sample on grain cup (aluminium tube) on the electrode to from the cell.
3. To select a crop. First, press the button, then press the appropriate numbers and then press 'enter', the crop will appear on the left of the display.
4. Remove the lid of electric grinder, ensure the grinding compartment is clean.
5. Pour the sample into the grinder using the measuring spoon.
6. Replace grind lid and grind the sample for five seconds.

7. Pour the ground sample into the cell.
8. Place the compressor over the cell by locating it on the three screw heads turn it clockwise until the clutch slips and the 'clicks' are heard.
9. To enter the memory and to display the result, press 'Enter'. A 30 seconds delay will enable the temperature equilibrium with the temperature of the grain. When this stage has been reached, there will be no further change in the temperature displayed.
10. Using the same, it is not possible to obtain a further display of the result. Instead the words 'old sample' will appear.

3.4.1 PROCEDURE IN GETTING THE MOISTURE CONTENT

An empty Rhumbu was firstly weighed on electronic weighing balance its weight recorded as W_1 . The sample to be weighed (wet maize) was put into the Rhumbu before nitrogen was passed, reweighed on the same weighing balance, this was taken down as W_2 . The weight of the wet maize sample with empty Rhumbu after nitrogen passage was also recorded as W_3 .

CALCULATION TO MOISTURE CONTENT FOR WET MAIZE SAMPLE

Weight of empty Rhumbu (W_1) = 2100g

Weight of wet maize sample = 200g

Weight of empty Rhumbu + sample weight before nitrogen was passed (W_2) = 2300g

Weight of empty Rhumbu + sample weight after nitrogen passage
(W₃) = 2263g.

Weight of Nitrogen in the sample = W₂-W₃
= 2300g-2263=37g

Weight of the wet maize after nitrogen passage = W₃-W₁
=2263g-2100g=163g

moisture content (M.C) before nitrogen passage

$$= \frac{W_2 - W_3 \times 100}{W_3 - W_1}$$

$$= \frac{2300 - 2263 \times 100}{2263 - 2100}$$

$$= \frac{37 \times 100}{163}$$

$$= 22.69\%$$

CALCULATION OF MOISTURE CONTENT OF THE DRIED MAIZE SAMPLE

The following procedure is followed as in the case of wet maize sample.

Weight of Rhumbu (W₁) = 2100g

Weight of Dried maize sample = 200g

Weight of empty Rhumbu + sample weight before nitrogen was passed (W₂) = 2300g.

Weight of empty Rhumbu + sample weight after nitrogen passage

$$(W_3) = 2274g.$$

Weight of the dried maize after nitrogen passage.

$$= W_3 - W_1$$

$$= 2274g - 2100g = 174g$$

Moisture content (M.C) before nitrogen passage

$$= \frac{W_2 - W_3 \times 100}{W_3 - W_1}$$

$$= \frac{2300 - 2274 \times 100}{2274 - 2100}$$

$$= \frac{26 \times 100}{174}$$
$$14.94\%$$

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

TABLE 1: Result obtained for wet maize sample.

Types of storage	Weight before nitrogen passage (g)	Weight after nitrogen passage (g)	Moisture content before nitrogen passage %	Temp before nitrogen passage °c	Moisture content after nitrogen passage %	Temp after nitrogen passage °c	Duration of storage
Prototype Mud Rhumbu	200	163	22.69	34.2	29.37	36.0	1month

TABLE 2: Result obtained for Dried maize sample.

Types of storage	Weight before nitrogen passage (g)	Weight after nitrogen passage (g)	Moisture content before nitrogen passage %	Temp before nitrogen passage °c	Moisture content after nitrogen passage %	Temp after nitrogen passage °c	Duration of storage
Prototype mud Rhumbu	200	174	14.94	35.0	17.57	36.3	1Month

4.1 DISCUSSION

The results of the experiment is shown in table 1 and table 2 respectively.

From table 1, it shows that nitrogen is more effective in the wet maize sample than in the dried maize sample, as a result the moisture content of the wet maize sample increases from 22.69% before nitrogen was passed to 29.37% after the passage of nitrogen. The temperature also increases from 34.2⁰c before nitrogen passage to 36.0⁰c after nitrogen Passage. The increase in moisture content and is because of water vapour that condences inside the Rhumbu

the temperature was because of the hot nitrogen that was passed. There was drastical reduction in weight of the wet and dry maize sample.

From table 2, the moisture content of the dried maize sample increases from 14.94% before nitrogen was passed to 17.57% after the passage of Nitrogen . The temperature also increase from 35.0⁰c to 36.3⁰c the increase in temperature was because of the hot nitrogen that was passed.

Both results from this experiment shows that nitrogen in inert atmosphere can be used in a modified storage environment to stored both wet and dried maize sample for longer period of time without spoiling of the grain and the quality of the grains stored was maintained. No life insects and no mould were found during storage. The efficiency of the Rhumbu is quite high with low percentage loss because it can maintain constant temperature inside the Rhumbu. The problems posed by conventional silo storage of grains includes insects infestation, not airtight, condensation, moulds causes grains to lump together, otherwise known as "caking" of the grains. Such grains eventually get discoloured and useless. One difference between the conventional silo and inert nitrogen in a modified storage environment is that the environment of the grains within the mud Rhumbu is made inert by purging it with nitrogen, such environment makes it completely impossible for insects, moulds, rodents, etc. to live and hence deterioration which normally resulted from them is removed. Chemicals, for protecting grains are also not needed.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

The performance of existing on farm grain storage structures was not satisfactory as such there was a substantial loss of food grains both in quantity and quality while in storage. But based on the experimental analysis made on this project nitrogen in inert atmosphere can be used in a modified storage environment to stored both wet and dried maize for certain period of time without the loss of quality and quantity of the grain. With this type of storage system, there is adequate air-tightness, no damage due to insects, storage losses is low or negligible and the grains can be preserved for longer periods and have better market value. Some of the advantages gained from this project are:

- (i) The experience gained from the project will be very useful in similar larger project which individuals or government may embark upon in the future.
- (ii) It is also a contribution towards preservation of food production.

5.1 RECOMMENDATION

In the light of the forgone analysis and evaluation of the storage techniques practised in the country, the following recommendations are made.

1. The use of nitrogen in the mud Rhumbu method of grain storage should be encouraged and adapted for large scale storage in the country.

2. Both the Federal and State governments should be recommended to adopt this type of storage system.
3. This types project could led to the modification of the existing Native mud Rhumbu by in corporating control valves through which the nitrogen generated from urea will be introduced into the store grains.

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