Design of an Intelligent Ammonia Collection Device System

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Abstract

This paper designs an intelligent ammonia collection and detection device based on solar power generation, which can detect the concentration of ammonia in real time and protect the health and safety of livestock. The system is composed of three parts. The front end collects ammonia concentration with data sensor, and then transmits the collected data to network server through wireless transmission equipment based on RS485 protocol. The back end analyzes ammonia concentration of farm in real time through special software, and carries out early warning and detection. A cylinder is designed for the intelligent ammonia collection and detection device. The upper side wall of the cylinder is symmetrically provided with a circular hole, the inner wall of the left circular hole is fixedly installed with a first one-way valve, the inner wall of the right circular hole is fixedly installed with a second one-way valve, the right wall of the cylinder is fixedly installed with an L-shaped pipe, and the ammonia detection sensor is built in.The system adopts the ammonia sensor based on RS485 communication protocol to collect and real-time detect the ambient air of animals in the farm, and through the setting of the height adjustment device, the air collection point can be adjusted high and low, so as to collect air samples of different heights, so that the ammonia of different heights in the farm can be collected and detected.The experiment shows that the intelligent ammonia collection and detection device can effectively and automatically detect the ammonia concentration, the system design is reliable, the algorithm is stable, and it is easy to realize and apply.

Keywords

Ammonia Collection; Detection Device; Ammonia Detection Sensor; Communication Protocol.

1. Introduction

In the breeding industry, after a period of time, the feces of all kinds of livestock will inevitably produce a certain amount of ammonia. High concentration of ammonia will affect the health and even death of livestock. Therefore, in the intelligent breeding, it is necessary to detect the ammonia concentration in real time. The power supply of various collection and detection devices becomes the main difficulty in the promotion of intelligent breeding technology.

On the one hand, the installation cost of power supply equipment in western rural areas is relatively high, and power failure often occurs. On the other hand, there is a great potential safety hazard in 220V power supply of breeding farms. Therefore, it is necessary to consider using solar power to solve the above problems. In this paper, we design an intelligent ammonia collection and detection device based on solar power generation.

2. Structure Design of the System

The intelligent ammonia collection and detection system of the farm is composed of three parts. The front end collects the ammonia concentration with the help of data sensors, and then transmits the collected data to the network server through wireless transmission equipment based on RS485 protocol. The back end analyzes the ammonia concentration of the farm in real time through special software, and gives early warning to ensure that the ammonia concentration of the farm reaches the specified range, and ensures the health and safety of livestock All.

The intelligent ammonia collection and detection system in the farm supports the smart phones, tablet computers and other mobile terminals to set up and monitor the system. The whole system uses sensor technology, Bluetooth technology and wireless 4G communication technology. The logical structure of the intelligent ammonia collection and detection system in the farm is shown in Figure 1.

The core of the intelligent collection and detection system of ammonia in the farm is the intelligent collector of ammonia concentration. The collector connects the ammonia detection sensor through the interface to collect the data of ammonia concentration in the farm. The data information collected by the system can be sent to the designated server through the designed network transmission device, and the user can view the data information at any time. At the same time, the system can display the ammonia concentration information collected at multiple points in a period of time to the user through fusion processing, so that the user can master the air condition of the whole farm at any time.

According to the user settings, the information collected by the intelligent ammonia collection and detector can be transmitted to the upper computer (monitoring host) for depth analysis at any time. In addition to various air detection sensors, the collector also has 4G communication module, clock, air temperature and humidity sensor and other facilities. Each time air information is collected, these environmental data can also be uploaded together as an aid for depth analysis. The collector is powered by rechargeable lithium battery or solar energy.

The upper computer of the intelligent ammonia collection and detection system in the farm is connected to the Internet. The information collected by the collector is transmitted to the data server through 4G communication for further processing. Because 4G communication is adopted, the collected information can be transmitted to the data server at any time no matter where the collector is located. There is a built-in database to store the collected information in order to carry out vertical and horizontal depth analysis of an area. Although the collector itself can complete all local operations, the system still supports Android based mobile intelligent terminal devices as the control and management facilities of the system. In the case of short distance, the collector can be set up and managed by Bluetooth communication; in the case of long distance, the collector can be controlled and managed by data server through Internet connection. The logic structure design of the intelligent ammonia collection and detection system in the farm is shown in Figure 1.
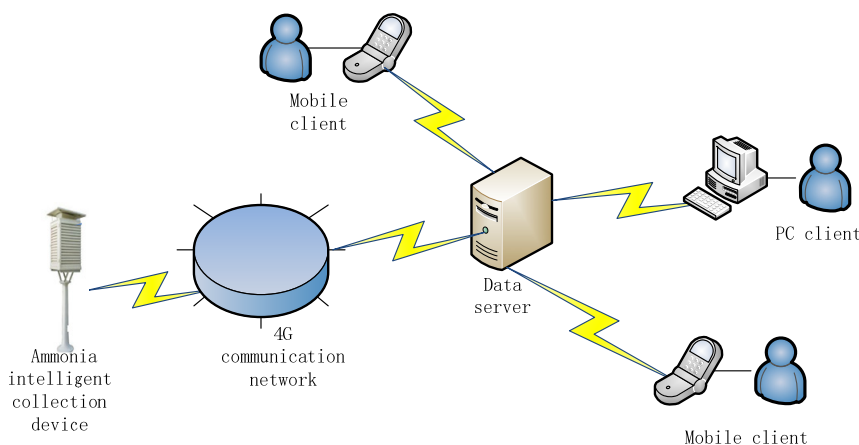

Fig 1. System logic structure

Compared with the prior art, the intelligent ammonia collection and detection device in the farm collects the ammonia containing air in the environment of the animals in the farm by setting the gas sampling bag to fill the gas in the farm and the structure of the built-in ammonia detection sensor, which is convenient for further detection and processing. The air collection point can be adjusted by setting the height adjustment device, It is convenient to collect the air at different heights, so that the ammonia gas at different heights in the farm can be collected, further ensuring the living environment of livestock in different growth periods, and by setting a fixed structure for the mouth of the gas sampling bag, the problem of accidental dropping of the gas sampling bag in the sampling process is avoided.

3. System Hardware Design

3.1 Structure Design of Collector

Based on the intelligent ammonia collection and detection device in the breeding farm of solar power generation, a cylinder is designed, the upper end and side wall of the cylinder are symmetrically provided with a circular hole, the inner wall of the circular hole on the left side is fixedly installed with a first one-way valve, the inner wall of the circular hole on the right side is fixedly installed with a second one-way valve, the right wall of the cylinder is fixedly installed with an L-shaped pipe, and the L-shaped pipe is connected with the right circular hole, and the L-shaped pipe is fixedly installed with the right circular hole The outer wall of the upper port of the shaped tube is clamped with a gas sampling bag, the lower side wall of the cylinder is embedded with an electromagnet, the lower side wall of the inner cavity of the cylinder is fixedly installed with one end of the spring, the other end of the spring is fixedly installed with an iron plate, and the upper part of the iron plate is installed with an ammonia sensor based on RS485 communication, the outer wall of the iron plate is fixedly installed with a rubber sleeve, and the rubber sleeve slides The lower side wall of the cylinder is fixedly installed with a height adjusting device, the side wall of the cylinder is fixedly installed with a solar cell panel, the side wall of the cylinder is fixedly installed with a battery, and the solar cell panel is electrically connected with the battery.
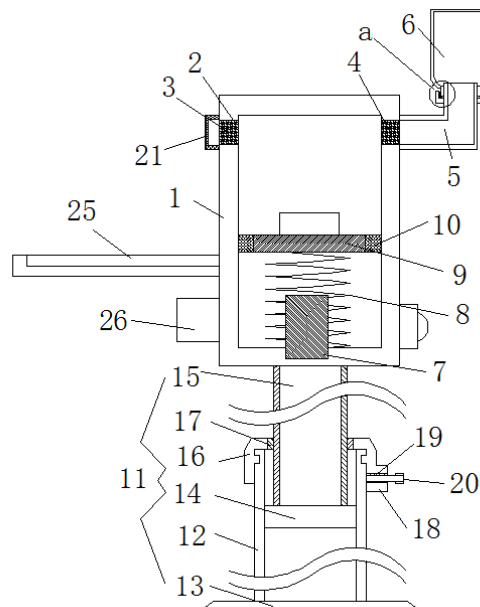

Fig 2. Structure of collector

The height adjusting device of the intelligent ammonia collection and detection device in the farm includes a support cylinder, the inner wall of the support cylinder is slidably connected with a square block, the upper side wall of the square block is fixedly installed with a threaded column, and the threaded column is fixedly connected with the lower side wall of the cylinder, the upper outer side

wall of the support cylinder is rotationally connected with a rotating disk, the upper side wall of the rotating disk is provided with a threaded hole, and the threaded hole Inner wall stud of. The lower side wall of the support cylinder is fixedly installed with a support plate.

The outer wall of the lower end of the rotating plate of the intelligent ammonia collection and detection device in the farm is integrally formed with a mounting protrusion, the outer wall of the mounting protrusion is provided with a second threaded hole, the inner wall of the second threaded hole is connected with a screw, and the outer wall of the left circular hole is fixedly installed with a dust-proof net. At the same time, the outer wall of the right end of the L-shaped tube is integrally formed with an annular protrusion, the inner wall of the upper end of the annular protrusion is provided with an annular groove, the inner wall of the annular groove is fixedly installed with a rubber ring, and the rubber ring is closely connected with the bottle mouth of the gas sampling bag. The structure design of the collector is shown in Figure 2.

In the structural diagram of collector 2, 1 is cylinder, 2 is round hole, 3 is the first one-way valve, 4 is the second one-way valve, 5 is L-shaped pipe, 6 is gas sampling bag, 7 is electromagnet, 8 is spring, 9 is iron plate, 10 is rubber sleeve, 11 is height adjusting device, 12 is supporting cylinder, 13 is supporting plate, 14 is square block with sliding connection of inner wall, 15 is threaded column, 16 is rotating plate, 17 is threaded hole, 18 is Mounting protrusion, 19 is the second threaded hole, 20 is the screw, 21 is the dust screen, 22 is the ring protrusion, 23 is the ring groove, 24 is the rubber ring, 25 is the solar panel, 26 is the battery.

The working principle of intelligent ammonia collection and detection device in the farm is as follows:

When the ammonia collection and detection device in the farm is working, adjust the height of the adjusting device 11 according to the height of the breathing position of the livestock, so that the height of the round hole 2 is the height of the animal's breathing. Just hold the screw 20 and turn the rotating disk 16. When the height is determined, turn the screw 20 to make it close to the outer wall of the supporting cylinder 12. Turn on the switch to electrify the electromagnet 7 and attract the electromagnet 7 and the iron plate 9. Because of the rubber The rubber sleeve 10 is slidably connected to the inner cavity of the cylinder 1, so the sampling air is collected at the upper end of the cavity of the cylinder 1, and the electromagnet 7 is powered off, and the iron plate 9 is restored to its original position through the function of the spring 8, so that the gas will be injected into the gas sampling bag 6. Because the ammonia gas is lighter than the air, the ammonia gas will be well stored in the gas sampling bag 6, and the gas sampling bag 6 will be removed and sealed, and then it can be waiting to be connected The next experiment is to maintain the living environment of livestock in the farm.

In the work of the collection device, the intelligent adjustment function is designed, which can adapt to the constant change of the height of the livestock as they grow up, automatically adjust the height of the breathing, and better judge the living environment of the livestock. In practical work, the height adjusting device 11 includes a supporting cylinder 12, the outer wall of the supporting cylinder 12 is round, the inner cavity is square, the inner wall of the supporting cylinder 12 is slidably connected with a square block 14, the upper side wall of the square block 14 is fixedly installed with a threaded column 15, and the threaded column 15 is fixedly connected with the lower side wall of the cylinder 1, the upper end and the outer wall of the supporting cylinder 12 are rotationally connected with a rotating plate 16, and the upper side wall of the rotating plate 16 is opened with a rotating plate 16 The screw hole 17 and the inner wall of the screw hole 17 are connected with the screw stud 15. The height of the screw stud 15 can be adjusted only by turning the rotating plate 16. At the same time, the lower side wall of the support tube 12 is fixedly installed with a support plate 13, which makes the placement of the support tube 12 more stable.

In the intelligent ammonia collection and detection device of the farm, the lower end and the outer wall of the rotating plate 16 are integrally formed with a mounting protrusion 18, the outer wall of the mounting protrusion 18 is provided with a second threaded hole 19, and the inner wall of the second threaded hole 19 is connected with a screw 20. When the rotating plate 16 needs to be rotated, the screw 20 can be held, which is very convenient to rotate. When the rotating plate 16 and the

supporting cylinder 12 need to be fixed, only the screw 20 needs to be held Rotate the screw 20 to make it close to the outer wall of the support cylinder 12. At the same time, the outer wall of the left round hole 2 is fixedly installed with a dust screen 21 to prevent dust from entering.

3.2 Control Module Design of Ammonia Collection and Detection Device

The control module of ammonia collection and detection device is the key device of the collector. Its core is a stm32f030c8t6 microprocessor. STM32 microprocessor has strong processing ability and can implement some simple fusion processing algorithms. The hardware block diagram is shown in Figure 3.

The control module of ammonia collection and detection device controls several external modules through microprocessor. Among them, 4G communication module and ammonia collection sensor constitute the external structure of ammonia data collection in the farm. The 4G communication module adopts mature communication technology, which can be realized by general smart phones. The Bluetooth module adopts risym hc-05 master-slave integrated Bluetooth module, which can accept the short-range control of mobile phones. Compared with local button operation, it is more convenient. The 4G channel uses simcom sim7600ce 4G all network communication module, which can connect to the Internet. It is the communication channel between the collector and the data server, as well as the remote control and detection channel of the mobile phone. It can realize the ammonia detection sensor to send the collection information and receive the remote control information.

The sensor of ammonia collection and detection device is connected with microprocessor through RS485 interface module. Each external sensor has its own microprocessor to control and manage the specific sensor, and communicates with the collector control module through RS485. There are open standards of agreement between them. The advantage of this design is that the ammonia collection and detection device designed in this study can meet the needs of more air environment monitoring in aquaculture.
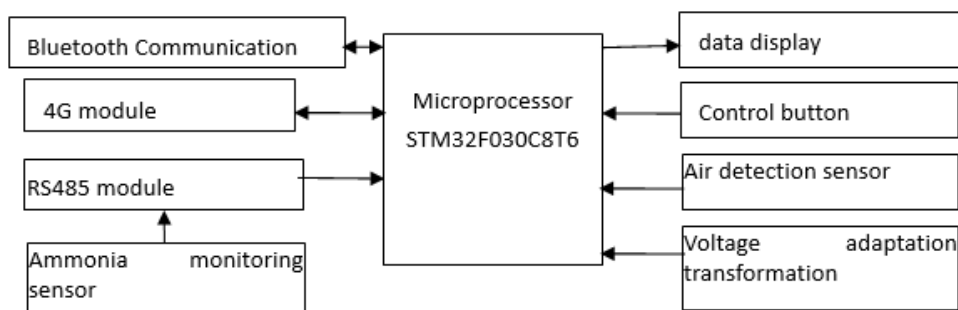

Fig 3. Control module design block diagram

4. Software Design

4.1 Control Procedure of Ammonia Gas Collector

The data acquisition and transmission control program of ammonia acquisition and detection device runs on the developed control module. The software system is responsible for data acquisition and transmission control of ammonia sensor, and control and management of relevant circuits of ammonia collector. The software structure design of ammonia collection and detection device is shown in Figure 4.

The software structure of the ammonia collection and detection device is a three-tier architecture, and the lowest functional module is the interface driver layer of the software system, which realizes the control and drive of the hardware, the interrupt processing program and control driver of the ammonia collection and detection device. The middle layer of the software system is the communication transmission layer. The software structure of the ammonia collection and detection device designed in this paper mainly transmits the collected sensor data through Bluetooth and 4G communication interface. The system analyzes and processes the data in the form of byte stream. At the same time,

the software system encapsulates the information sent by the ammonia collection and detection device according to the set protocol.
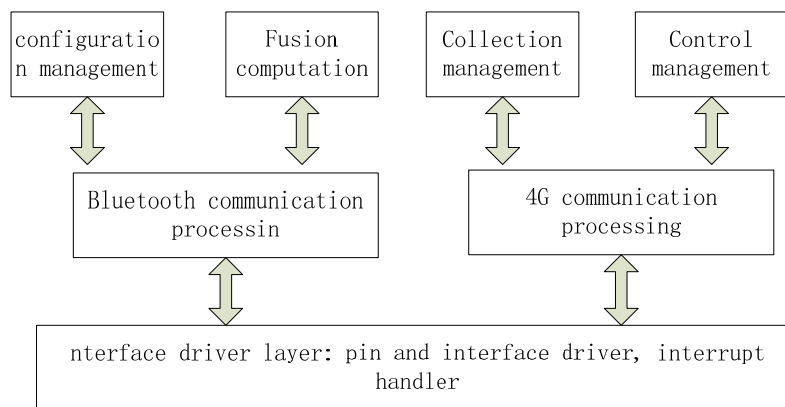

Fig 4. Control program structure of ammonia gas collector

The top layer of the software structure of the ammonia collection and detection device is the logic layer, including the logic function modules of the software system, such as system configuration management, fusion calculation, control management, data collection management, power supply adaptation management, etc. Among them, configuration management configures the program parameters of ammonia gas acquisition and detection system, realizes the setting of acquisition interval time and data server address of the device. The system control management function module mainly responds to the user's command and controls the system. The collection management function module of the system determines the information collection source according to the configuration requirements, and processes the collection information according to the sensor type, and then sends it to the server for fusion calculation. The power supply adaptation management obtains the power quantity of the power supply and the power consumption speed of the calculation system in time, and charges or changes the battery in time according to the warning of the power supply working state.

4.2 Client Management Program Design

Running the ammonia collection and detection management software system on the mobile smartphone or tablet computer can realize the management configuration, control and data monitoring of the ammonia collection device. Ammonia collection and detection software system is an app software system, which supports Bluetooth and network communication. When Bluetooth is turned on in the intelligent terminal and the Bluetooth signal of the ammonia gas collection sensor is associated, the software system will communicate with the ammonia gas collector control program through Bluetooth, or realize the network transmission based on 4G communication through settings, and use the Internet to transmit the collected data to the server, and then download it to the mobile terminal mobile phone or tablet computer.

The ammonia collection and detection device and software system designed in this paper have the function of setting and control. The structure of this program and hardware driver matching management program is relatively simple. It is not necessary to do analysis and calculation in the mobile terminal, which is convenient for users.

4.3 Data Server Management Program Design

Data server management program is a typical database management program, which mainly realizes the function of data receiving, receiving and analyzing the data information from ammonia collection and detection device. At the same time, realize the remote control of the ammonia collector through the app software system of the intelligent mobile terminal, and transmit the data information in the data server to the user of the intelligent mobile terminal through the data server program. The user can view the real-time data information and data comparative analysis results of the ammonia

collection device at any time through the app system. The data server program structure design is shown in Figure 5.
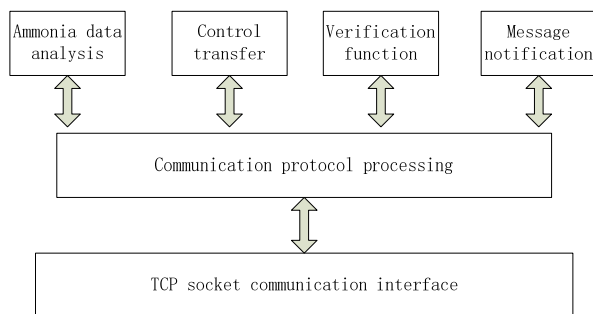

Fig 5. Program structure design of data server

In the data server program structure, the bottom layer realizes the network communication, realizes the TCP socket communication interface, decomposes the user data from the mobile intelligent terminal app and the data information sent by the ammonia collector, and encapsulates the sent data. In the four logic processing modules of the data server program, ammonia data analysis stores and analyzes the collected data, controls the transfer module to complete the remote control of the collection device, and the message notification mainly realizes the system customized message sent to the mobile management app at any time. The authentication management function module realizes the user's identity authentication and management authority assignment, and ensures the security of the user's login and the safe use of the data server.

4.4 Data Fusion Algorithm Design of Ammonia Sensor

The ammonia collection and detection device realizes the monitoring of the air environment of the farm. Most of the time, it needs to collect the ammonia concentration data information of multiple points. Because the air environment data information of each point is different, it is often unable to estimate the air quality of the whole area in time. Therefore, this paper designs a fast ammonia sensor data adaptive fusion algorithm In order to achieve multiple collection devices while collecting, at the same time, data fusion analysis, give the current real-time air detection status of the farm.

At present, the adaptive weighted fusion algorithm is widely used in various occasions where information fusion is needed [10]. It relies on each node to collect data and uses adaptive method to calculate the data fusion weight of each node, so that the fusion result is the best. The calculation formula of the fusion algorithm is shown in Formula 1:

$$X = \sum_{i=1}^{n} W_i X_i \qquad \sum_{i=1}^{n} W_i = 1 \tag{1}$$

In Formula 1, X represents the result after fusion, Xi represents the data collected for the i-th time, wi represents the weight during information fusion for the i-th time, where n represents the number of current collection. In order to obtain the best wi, according to the reasoning in [10], the best weight can be obtained, as shown in formula 2.

$$W_i = \frac{1}{e_i^2 \sum_{i=1}^{n} \frac{1}{e_i^2}} \tag{2}$$

In formula (2), e_i represents the sensor accuracy value corresponding to the ith data. In the case of portable mobile acquisition, all the collected data come from the same sensor, so the accuracy of all sensors is the same, so $W_i = 1/n$. This shows that when using portable mobile to collect soil information,

complex data calculation can be avoided and the best fusion results can be obtained. Therefore, formula (1) can also be simplified as formula (3), and the best fusion result is the average value of the collected information of each point.

$$X = \frac{1}{n}\sum_{i=1}^{n}X_i \tag{3}$$

5. System Test Analysis

In order to verify the effectiveness of the design of the ammonia collection and detection device system, an area of about 200 square meters was selected for trial operation test. Firstly, the stability of the ammonia collection and detection device system is tested, and then the data fusion processing ability of the ammonia collection and detection device is tested by collecting the ammonia concentration data information of different points.

5.1 System Data Acquisition Stability Test

The communication module selected in this paper is the 4G DTU network module with RS485 interface, the RS485 / 232 g780v communication module with bidirectional data transmission equipment interface, and the ya-d10000 model ammonia detection sensor. Test ambient temperature 15 °C. The test time was at 10 a.m., and 5 ammonia collection points were set up in total. The test results are shown in Table 1.

Table 1. Data measurement comparison of ammonia collection device

Location number	Measuring temperature °C	Measure ammonia concentration ppm	Actual ammonia concentration ppm	Ammonia concentration error ppm	Error rate%
1	12.5	1.33	1.31	-0.02	0.015
2	15.2	1.21	1.2	-0.01	0.008
3	15.0	1.2	1.21	0.01	0.008
4	13.7	1.28	1.3	0.02	0.015
5	16.3	1.19	1.18	-0.01	0.008

It can be seen from table 1 that the difference between the measured value and the actual value is not big, and the error rate is controlled below 2%, which shows that the data of ammonia gas acquisition and measurement device designed in this paper is stable and reliable.

5.2 Test Experiment of Data Fusion Algorithm

Table 2. Data fusion comparison

Position number	measurement temperature°C	measurement ammonia concentration ppm	best weight	definition weight
1	12.5	1.33	0.2	0.2
2	15.2	1.21	0.2	0.25
3	15.0	1.2	0.2	0.2
4	13.7	1.28	0.2	0.22
5	16.3	1.19	0.2	0.13
Fusion mean	14.51	1.242		
Fusion variance	2.153	0.00367		

For the five points in the previous test, replace the fusion result with the mean value, and compare the fusion result with the user-defined weight. The result is shown in Table 2.

The experimental analysis shows that the ammonia collection and detection device system is suitable for the algorithm in this paper. It can automatically detect the ammonia concentration. The system design is reliable and the algorithm is stable.

6. Conclusion

The front end of the intelligent ammonia collection and detection device collects ammonia concentration with the help of data sensors, and then transmits the collected data to the network server through the wireless transmission equipment based on RS485 protocol. The background analyzes the ammonia concentration of the farm in real time through the special software, and carries out pre alarm and detection. The system adopts the ammonia sensor based on RS485 communication protocol to collect and real-time detect the ambient air of animals in the farm, and through the setting of the height adjustment device, the air collection point can be adjusted high and low, so as to collect air samples of different heights, so that the ammonia of different heights in the farm can be collected and detected. The system can detect the concentration of ammonia in real time and protect the health and safety of livestock. The experiment shows that the intelligent ammonia collection and detection device can detect the concentration of ammonia effectively and automatically, which is easy to realize and apply.

Acknowledgments

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