1 INTRODUCTION

Indoor air pollutants mean different harmful chemical, physical, and biological factors, which come from building materials, decoration materials, furniture and living discharges. These factors gathering in the room change some of the original interior elements and increase the content of certain toxic and hazardous substances then decrease indoor air quality and threat human health.

Infectious pathogens have been known for long, but less about other harmful factors. In fact, early humans who live in burrow use fire to grill food and to heat the house. There was smoke pollution but the impact was very small. People took outdoor activities very frequently, so there is no obvious evidence about indoor air pollution. Along with civilization, especially since the mid-20th century, the fuel was used increase, chemical products and electrical equipment makes indoor concentrations of pollutants up to several ten times higher than outdoor.

People used to spend about 80% their time in a day indoors. Today, work and entertainment are more available in room. People do not need do sports, shopping in the streets, so people spend more time for indoor activities. Therefore, indoor air quality on human health even more close and more important. Because the time of contact pollution is long, cumulative amount of contact is also high although the concentration of indoor pollutants is not so high. Indoor air quality is important for especially the old, young, sick, frail and disabled people and also for people who have fewer opportunities for outdoor activities.

In recent years, the industry has rapidly developed in China. The residential area increases 800-900 million square meters annually and about 90% of the area used decoration. China entered a new residential generation of housing. The new rate of residential renovation has reached more than 95%. In 2001, decoration industries in China have reached 600 billion Chinese yuan. At the same time, a large number of synthetic materials and finished products are widely used in furniture and interior decoration. These materials release toxic formaldehyde and other volatile compounds to the interior environment, which make serious environmental pollution on people's health. Now home health is a topic that people are mostly concerned. So what are the major indoor pollutions? What are the sources of them? What is the harmful on our body? These questions are very important for people who are live in new room.

There are seven chapters in my thesis. The thesis presents the sources of indoor air pollution, indoor air quality standard, major indoor pollutions, the indoor environmental testing and the reduction of indoor air pollution. Five major are indoor pollutions, the sources of pollution, harm of them and so on.

Just as was stated above, China entered a new residential generation of housing. More and more people want to have their own house. Before they move to the room most of them will have a decoration for their house. The harmful and toxic gases come from paint, plywood, wallpaper, wall paint, furniture, stone and other sources which are in the material of decoration. People may suffer from dizziness, throat pain and discomfort after they moved into the new flats. So the purpose of this thesis is to let people who will live into new room know how to test the pollution, how to improve the quality of indoor air. More attention should be paid to indoor air quality. Indoor air quality can have a great impact on people's health and the environment we live, so it is worth for research.

2 SOURCES OF INDOOR AIR POLLUTION

People always think that outdoor air pollution is more serious than pollution indoors. In fact indoor environments such as offices, bedrooms, hotels, theatres and dance halls have much greater health impact on human than out of doors environment. In fact, indoor air quality is far inferior to outdoor air. Indoor air pollution is 2 to 3 times more serious than pollution out of doors. In some cases, the serious level even up to 100 times. There are more than 300 kinds of contaminants that can be detected indoors. About 68% of human diseases are associated with indoor air pollution.

Indoor air pollution mainly comes from the following five sources: breathing and smoking; decoration materials and daily necessities; micro-organisms, viruses, and bacteria; cooking fumes; the effects of air-condition system. These pollutants enter the body by breathing, which can cause serious problems to people's health in long-term accumulation.

2.1. Breathing and smoking

Research findings show that the human metabolic process can produce about 500 kinds of chemical substances in which there are about 149 discharged through the respiratory tract. The Human respiratory system emits emanation pathogens and a variety of odour mixed with a variety of toxic elements, which cannot be neglected. The human body discharges 171 kinds of wastes from the skin sweat glands such as urea and ammonia. In addition, human skin cells fall-off accounts for approximately 90% of air dust. If the concentration is too high, it will form indoor biological pollution which can affect human health and even lead to various diseases. (Beijing monitoring centre)

Smoking is one of the major sources of indoor air pollution. Smoke components are complex and contain solid phase and gas phase. The National Cancer Institute expert group identified and proved by animal carcinogen experiments that there are 40 kinds of the "carcinogen" in the smoke. Smoking can increase the risk of cardiovascular diseases which is regarded as the number one killer for human's health.

2.2. Decoration materials and daily necessities

As people's living standards improve, both individual housing and public places have interior decoration and renovation. Building materials, paint, plywood, adhesives, artificial board, marble flooring and newly purchased furniture and other decoration materials will continue to emit more than 500 species of toxic and harmful compounds, especially in the newly renovated rooms. Many decorative materials can emit for instance ammonia, formaldehyde and benzene, radioactive radon, which can let people feel headaches, insomnia, dermatitis, and allergic reactions. The International Institute for Cancer Research identifies them as suspect carcinogens. The main ingredient of adhesives used in interior decoration is formaldehyde. It is in board residues and not involved in the reaction will be gradually released to the environment. This is the main reason for the formation of formaldehyde in indoor air. (Beijing monitoring centre)

Admixtures and concrete antifreeze in the construction contain large amounts of ammonia additive material. If these additives are applied in the wall when the temperature changes in the environmental, the additives will return to ammonia and slowly release from the wall, causing the indoor air concentration of ammonia increased significantly. In addition, radon released from building materials can also make high content of radioactive material indoor air. (Beijing monitoring center)

2.3. Micro-organisms, viruses and bacteria

Micro-organisms and dust exist in warm, humid and dirty environment together with dust drift in the air. In particular, dust mites are human bronchial asthma allergens. Dust mites like to live in the dust, which is in the room. Dust mites grown and reproduction in spring and autumn. (Beijing monitoring centre)

2.4. Kitchen smoke

Kitchen is a very import place in our life, but it is also a place exists worse indoor air pollution. In the past, the kitchen smoke of indoor air pollution was rarely being pay attention. According to the research, the number of urban women in lung cancer is increase. By the hospital diagnosed the majority of patients are adenocarcinoma. It is a lung cancer, which has a very small link with smoking. Further research found that the way lead to patients have this kind of cancer are mutation of kitchen smoke, high temperature oil oxidation and decomposition. Another major source of pollution, which exists in kitchen, is the fuel combustion. If the room has poor ventilation, gas appliance product carbon monoxide and nitrogen oxide concentrations exceed limits of prescribed air quality standards, this concentration will result in harmful to human body. (Beijing monitoring centre)

2.5. Air-conditioned syndrome

Long-term work in air-conditioned environment, people always feel depressed, fatigue, lethargy, muscle pain, and higher incidence of colds. Productivity and health is decreased, these symptoms collectively referred as “Air-conditioned syndrome." The main reason for these adverse reactions is to stay within a confined space for too long time. CO2, CO, particulate matter, Volatile organic

compounds and a number of pathogenic micro organism are gradual accumulated which make a serious pollution. All these cause indoor poor air quality, which lead to a lot of people disease and thereby affecting the work efficiency. (Beijing monitoring centre)

2.6. Other indoor air pollutions

Using of variety electronic products such as B-ultrasound, radiation, isotope radiation and the use of a variety of furniture, electrical equipment such as microwave, TV sets, computer sound, range hood, electric blanket, telephone and other process can produce electric radiation, noise, vibration which speeds up the electromagnetic field. The human body will be influenced by the electromagnetic field. People often use a variety of spray pesticides to kill indoor mosquitoes, cockroaches and other pests. (Beijing monitoring centre)

3 INDOOR AIR QUALITY STANDARDS

"Indoor air quality standard" GB/T18883-2002 is constituted by Inspection and Quarantine of the People's Republic of China (AQSIQ), ministry of environmental protection the people’s republic of china and Ministry of Health of the People's Republic of China. China's first "indoor air quality standards" was put in use on March 1, 2003. This standard introduces the concept of indoor air quality, clearly advance. "Indoor air should be non-toxic, harmless and without unusual smell". The standard prescript project needs to be control such as, including chemical, physical, biological and radioactive contamination. The standard provides control of chemical pollutants include not only familiar formaldehyde, benzene, ammonia, oxygen and other pollutants, as well as particulate matter, carbon dioxide, sulfur dioxide and other 13 chemical pollutants. (AQSIQ 2002)

Indoor Air Quality Standard

(Standard No.: GB / T 18883－2002)

(AQSIQ), ministry of environmental protection and Ministry of Health

Published time:218/12/2002 Implementation time:201/03/2003

Indoor air quality standard

NO.	Parameter type	Parameter	unit	Standard value	remark
1	Physical	temperature	℃	22—28	Summer air-conditioning
				16—24	Winter heating
2		moisture	%	40—80	Summer air-conditioning
				30—60	Winter heating
3		Air flow rate	m / s	0.3	Summer air-conditioning
				0.2	Winter heating
4		Air volume	m^3 / h.	300	
5	Chemical	SO2	mg / m^3	0.50	1 hour average
6		NO2	mg / m^3	0.24	1 hour average
7		CO	mg / m^3	10	1 hour average
8		CO2	%	0.10	1 day average
9		NH3	mg/ m^3	0.20	1 hour average
10		O3	mg / m^3	0.16	1 hour average
11		HCHO	mg / m^3	0.10	1 hour average
12		C6H6	mg / m^3	0.11	1 hour average
13		C7H8	mg / m^3	0.20	1 hour average
14		C8H10	mg / m^3	0.20	1 hour average
15		B(a)P	mg / m^3	1.0	1 day average
16		PMl0	mg / m^3	0.15	1 day average
17		TVOC	mg / m^3	0.60	8 hours average
18	Biologically	222Rn	cfu / m^3	2500	Determined based on equipment
19	Radioactivity	Bacteria	Bq / m^3	400	Annual average

(AQSIQ 2002)

4. MAJOR POLLUTANTS

In the process of decorate the new house, the most important five pollutants are: formaldehyde, benzene, ammonia, TVOC, radon. This chapter will describe their sources, uses, and harm. So that let people have a preliminary understanding of these pollutants.

4.1. Formaldehyde

4.1.1 Properties of formaldehyde

Formaldehyde is a colourless gas with strong pungent odour. It dissolves in water, alcohol and ether. Formaldehyde is gas at room temperature but usually it is in the form of aqueous solution. The 37% of aqueous solution known as formalin, which is a solution of soak samples. The solution boiling point is 19.5 ^{O}C. It is highly volatile at room temperature. Evaporation speed increases with temperature increase. Formaldehyde is the toxic chemical, which stands in the second place of the list of priority control toxic chemicals in China. Formaldehyde has been defined by WHO as substance which can lead to Carcinogenic and mutagenic deformity. (Beijing QQJH environmental monitoring centre)

4.1.2 Sources

Formaldehyde is a source of widespread air pollutants. Furniture and decoration materials: all kinds of artificial board, solvents, paints, adhesives, paint, UF foam, synthetic, fibre. Human activities: smoking, cooking. Burning 1,000 gallons of oil can produce formaldehyde 0.908kg.Automobile off-gas containing 70mg per kg of

formaldehyde. Burning a ton of coal can produce 2.3g of formaldehyde. Coal flue gas per kg of formaldehyde containing 6mg.(Beijing QQJH environmental monitoring centre)

4.1.3 The use of formaldehyde

Formaldehyde is widely used in industrial production because it's strong and low cost. Formaldehyde is a strong fungicide, which is widely used to preserve sample in scientific research and hospitals. Some low-grade paint and white latex make use of formaldehyde as preservative. Some unscrupulous traders using formaldehyde to keep food (such as seafood, rice, etc.) fresh. Formaldehyde is widely used in industrial production. It is a material for making synthetic resin, paint, plastic and synthetic fibre. It is also an important material for make adhesives. Formaldehyde is use in plywood manufacturing. Currently, produce wood-based panel main use of urea formaldehyde resin (UF) for the adhesive. The materials of urea formaldehyde resin are urea formaldehyde and Formaldehyde. (Beijing QQJH environmental monitoring centre)

4.1.4 Release period and way

The release period of formaldehyde is 3 to 15 years. Temperature and humidity can affect the wood release very little of formaldehyde. When the urea-formaldehyde resin makes process, it cannot avert remain some formaldehyde that is release. Panel in the consolidation process is a part of linearity resin which cannot come into net-like structure so it break down into free form of formaldehyde to release. Part of the resin is not solidifying completely so it can break down into free form of formaldehyde to release under the heat and water. Interior decorative materials in use, with certain temperature, humidity and time change, can

continuous make formaldehyde release. (Beijing QQJH environmental monitoring centre)

4.1.5 Harm of formaldehyde

Formaldehyde on the human skin and mucous mucosa has a strong stimulate. It can make the protein in cell to solidification and control some cell function. Long-term contact to low doses of formaldehyde can cause chronic respiratory disease, nasopharyngeal cancer, colon cancer and brain tumour. It can make Pregnancy syndrome, newborns chromosome abnormalities, leukemia, memory and mental of young people descend. In all contacts people, children and pregnant women are particularly sensitive to formaldehyde, and more harmful. (Beijing QQJH environmental centre)

Formaldehyde in the body builds to Methanol that has strong damage effect on optic's thalamus and retina. Effects of formaldehyde on human health mainly comport in the sense of smell unusual, stimulating, allergy, pulmonary function abnormalities, and immune dysfunction and so on. (Beijing QQJH environmental monitoring centre)

Formaldehyde has high toxicity. Formaldehyde has been defined by WHO as carcinogenic and deformity substances which is recognized as source of allergy. It is potentially one of the strong mutagens. (Beijing QQJH environmental monitoring centre)

4.1.6 Limits of Indoor air formaldehyde concentration

With economic development and improvement of living standards, people began to use various raw materials for building and furnishing. In indoor air pollution formaldehyde is recognized as a representative of chemical substances. Pollutions caused by formaldehyde: Decorative materials and furniture are major sources that make formaldehyde pollution. The formaldehyde will be released when the decoration materials and plywood in furniture and particleboard binder heat and deliquescence. It is the most important indoor source of formaldehyde release. UF foam is used on housing for heat and cold insulation. Foam will age when it under the light and heat then the formaldehyde will release. Formaldehyde is used for preservative coatings, chemical fibre carpets, cosmetics and other products. Each cigarette contains formaldehyde about 20-88ug, which have carcinogenic synergistic reaction.

4.2. Benzene

4.2.1 Properties of benzene

Benzene (C6H6) is a colourless, transparent liquid with sweet and strong fragrance at room temperature. Benzene is combustible, toxic and carcinogenic. Benzene is the simplest arene. It is insoluble in water but soluble in organic solvents. It can be used as organic solvents. When Benzene meets heat, fire, it can burning and blast. Benzene is not only a basic raw material of petrochemical, but also an important material to make different kinds of resin, which is wildly used as solvent in decoration.(Beijing indoor air quality testing center 2009)

4.2.2 Source of benzene

Benzene inside homes and office mainly come from chemical decoration materials. This is a large number materials used in decoration, such as coatings, fillers and various solvent. They all contain a large number of organic compounds. The following Decorative materials have higher content of benzene:1)Paint: benzene compounds mainly volatilize from the paint;2)Various adhesives: sofa releases a lot of benzene mainly because in the sofa production process used adhesive which contain high benzene.3)Some low-grade and fake paint

4.2.3The use of benzene

In 1920s, benzene has already used as a commonly solvent in industrial, which is mainly used for metal degreasing. Because of its toxic character, human body can direct contact with solvent production process.

Benzene can be used as additive of gasoline because it has the ability to reduce the affect of detonation. In the 1950s before the using of Tetraethyl lead, almost all the uprising agent is benzene. Benzene has harm affect on the human body and it can contaminate underground water’s quality. European and American countries have a limit level of benzene using in gasoline. The percentage should be below 1%. Benzene is the most important chemical material used in industry.

4.2.4 The ways of benzene release

Benzene mainly comes from the large number of chemical materials, which is used in architectural decoration, such as paint, wallpaper, adhesives, and detergents and so on. Formaldehyde, benzene and other volatile components in

paint will release when the paint become membrane and solidifies which can cause pollution. Temperature and humidity are the factors, which affect benzene's release.(Beijing qingqing jiu huan environmental monitoring centre)

4.2.5 Harm

Benzene has characters of volatile, flammable, vapour and explosiveness. If people breathe in high concentration of toluene and xylene in a short time, the central nervous system can be anaesthetic. Dizziness, headache, nausea, choking sensation in chest, fatigue will happen in light case while in serious case, respiratory and circulatory can be damaged. If people contact toluene and xylene in long term, it can cause chronic poisoning. Headache, insomnia, listlessness, memory loss and other symptoms of neurasthenia may occur. Benzene compounds have been defined by WHO as carcinogenic chemical. Benzene inhibits human's hematopoietic function, which can reduce white blood cells, red blood cells, platelets and result in many diseases. It also has a stimulating effect on people's skin and mucous membranes. It can cause poisoning by inhaled or skin. (Beijing qingqing jiu huan environmental monitoring center)

4.3 TVOC

4.3.1 Properties of TVOC

Indoor air quality researchers always call all the indoor organic gaseous substances sampling as VOC with the full name Volatile Organic Compound. All of the VOC, which are being measured, is regard as total volatile organic compounds TVOC.

TVOC has more serious impact of indoor air quality in the three types of pollution (Physical pollution such as dust; chemical pollution such as voc; and biological contamination such as mildew). TVOC is the organic matter with saturated vapour pressure over 133.32pa at room temperature. Its boiling point between 50 ^{O}C to 250 ^{O}C. TVOC can evaporate in air at room temperature. It has toxicity, irritation, carcinogenicity, and special smell, which will affect the skin and mucous membranes and damage to the human body. World Health Organization (WHO), U.S. National Academy of Sciences / National Research Council (NAS / NRC) and other organization have stressed the TVOC is an important class of air pollutants. U.S. Environmental Protection Agency (EPA) of the defined TVOC as: TVOX are carbon compounds which can participate in atmospheric photochemical reactions such as carbon dioxide, carbonic acid, metallic carbides, carbonates and ammonium carbonate and so on. (Suzhou Indoor Environmental Network 2006)

4.3.2 Sources of TVOC

TVOC mainly come from coal and natural gas combustion products. Such as smoking, heating and cooking smoke; construction and decoration materials; furniture, domestic appliances; depurative and the human body's own emissions. There are nearly a thousand kinds of TVOC. VOC mainly release from paints and adhesives in the process of interior decoration. It is reported that the concentration of indoor TVOC usually between 0.2mg/m3 to 2mg/m3, but in the improper decoration the concentration can become tens of times higher. Indoor variety of aromatics hydrocarbons and alkanes mainly release from tail gas of cars. (76% - 92%). Because TVOC has strong volatile ability, under normal condition, it can volatile 90% after decoration 10 hours, while the TVOC which is in the solvent release only 25% of the total in the paint drying process.(Suzhou Indoor Environmental Network 2006)

4.3.3 The main ingredients and classification of TVOC

Main ingredients：Hydrocarbons, halogenated hydrocarbons, oxide hydrocarbons and nitrogen hydrocarbons, which include: benzene, organic chloride, freon, organic ketones, amines, alcohols, ethers, esters, and acids etc.

Classification: Alkanes, aromatic hydrocarbons, terpenes, halocarbons, esters, aldehydes, ketones and others.

4.3.4 The harm of TVOC

TVOC are compounds with odour and irritant properties. Some compounds have gene toxicity. TVOC can lead to immune disorders; affect central nervous system function; dizziness; headache; drowsiness; weakness; choking sensation in chest and other symptoms. TVOC also may affect the digestive system which appears to be in appetence and nausea. In serious, it can damage liver and hematopoietic system etc. (Suzhou Indoor Environmental Network 2006)

Generally, in non-industrial indoor environment, the TVOC concentration level would not lead to human tumors and cancer. When the concentration of TVOC is 3.0-25 mg/m3, it will generate stimulation and discomfort, which combined with other factors, maybe has a headache. When the concentration of VOC greater than 25 mg/m3, other effect of neurotoxicity may appears.(Suzhou Indoor Environmental Network 2006)

4.4. Ammonia

4.4.1 Properties of Ammonia

Ammonia with the formula NH3 is a colourless gas with strong pungent odour. It can easily dissolve in water. In normal temperature and pressure, 700 volumes of ammonia can dissolve in one volume of water. Ammonia is important for life form, which is live on Earth. It is an important component of all food and fertilizer.

4.4.2 The use of Ammonia

Ammonia has a wide range of application and it has corrosive nature. Because ammonia has a wide range of usage, it is one of the most inorganic compounds in the world. More than eight percent ammonia was used to make fertilizer. NH3 used for making ammonia, liquid ammonia, nitrogen fertilizer, HNO3, ammonium salt and soda ash which are widely used in chemical industry, light industry, chemical fertilizer, pharmaceuticals, synthetic fibers, plastic, dyes and so on.

4.4.3 Sources of ammonia

In North part of China, when people build the residential houses, offices, hotels, restaurants and other buildings, high-alkali and concrete antifreeze which contain urea in concrete and other additives are added to prevent the broken of construction in the winter time by freeze. These additives, which contain large of ammonia in the walls under the humidity, temperature and environmental factors changes ammonia will finally deoxidize to ammonia gas and then release from the

wall slowly, which caused the indoor ammonia concentration significantly increased.

At the same time the indoor ammonia can also from the interior decoration materials, such as additives and brighteners, which are used in decoration furniture. They are mostly ammonia. Ammonia as a neutralizer is large in use of hair shops and salons.

As people know that the CFC Ang can breach ozonosphere, so the forbidden uses of CFC Ang as cryogen was started word widely. Ammonia was re-used as refrigerant since it has been used about half-century in dominant position. This is also a potential pollution source.

4.4.4 Harm of ammonia

Ammonia belongs to low toxic compounds. When the ammonia concentration in ambient air reaches a certain level, it has a strong irrigative odour. People's olfaction range for ammonia is 0.5 ~ 1.0mg/m3. Ammonia is an alkaline substance. When ammonia enters into human’s body, it can absorb the organization's water solubility. It has irritate and corrosive function for body's upper respiratory tract and it can weaken the body's resistance to disease. After the entrance into the alveolus, ammonia combines with haemoglobin, which can breach oxygen transport function. Short-term inbreathe of ammonia, tears, sore throat, hoarseness, cough, dizziness, nausea may occurs. If in severe case, people can appear pulmonary edema, respiratory distress syndrome or concurrent peogaster irritation symptom. According to Manufacturing Chemists Association of USA, staffs are allowed to work 8 hours below 100ppm concentration of ammonia.

4.5. Radon

4.5.1 Properties of Radon

Radon is a colourless odourless gas. The melting point is -71 °C, boiling point is -61.8 °C, gas density is 9.73 g / liter; Water solu bility is 4.933 g / kg of water. Radon is soluble in organic solvents such as kerosene, carbon disulfide etc. Radon is easily adsorbed in the rubber, activated carbon, silica gel and other sorbent. Radon is a natural radioactive element. The chemical nature of radon is a very torpescence and unstable nuclides. Radon has dangerous radioactivity, which can breach the formation of any compounds. Radon is more easily compressed into a colourless phosphorescent liquid. Solid radon has blue diamond luster. Radon compound only exists radon fluoride because its chemical properity. Compounds of radon are similar as the compounds of xenon, but more stable and less volatile. Radon is mainly used for radioactive materials research. It is also used as neutron source in experiments and gas tracers for research pipeline leakage and gas sports.

4.5.2 Source of radon

Radon comes from decay of radioactive elements radium, which is from decay of radioactive elements-uranium. Uranium is a permanent source of radon. Radon also comes from soil, sand, stone, cement, and ceramics etc.

4.5.3 Use of radon

Because radon has radioactivity, it will become radioactive polonium and alpha particle after decay. It is available for medical use. Radiation can use for cure cancer. The golden needle full of radon into the ailing tissue can kill cancer cells.

4.5.4 Harm of radon

Radon can damage the blood circulatory system, such as neutropenia and thrombocytopenia, which can lead to leukemia. Radon also can affect the nerve system, blood-forming organs, reproductive system and digestive system.

The United States estimated that there are 7000-10000 cases of lung cancer caused by indoor radon annually. Radon is the second largest factor, which can cause lung cancer. The first factor is smoking. In 1987, radon was included indoor important carcinogen by IARC. But now people do not have enough awareness of the pollutions, which are caused by radon.

5. INDOOR ENVIRONMENTAL TESTING

Indoor air testing should be specified in national standard test conditions. For indoor air quality testing, consumers need to find a qualified testing organization but the most important details is to test the direct impact of the detection results. In fact, any test has stringent test conditions, especially when consumers want to use the testing results as the evidence for resolution of disputes, or legal proceedings. If the testing result report does not indicate the conditions, that result cannot be effect. Therefore, it is necessary to understand some test condition standard in order to get more objective and reliable results. (Beijing indoor air quality testing centre 2009.)

Testing should be started after the decoration has finished 7 days. Many consumers think that the best time to test is when the decoration is just finished. In fact, the maintenance period of paint is about 7 days. The highest pollution concentration in volatilizes is in 7days while after 7 days it can be reduced to stability state. (Beijing indoor air quality testing centre 2009)

The concentration of indoor air pollution is closely related with the closing time of door and window. The more time for the doors and windows closed the higher concentration of the indoor pollution we suffered. Radon testing should be carried out after doors and windows have been closed 24 hours. The other four pollutants should be tested adequately ventilated and after the door closed 1 hour. This is for considering the process of accumulation of pollutants and the body's normal working life. (Beijing indoor air quality testing centre 2009)

5.1 Formaldehyde detection

According to expert analysis, the most important source of indoor air pollution is caused by decoration. Now most people have recognized this. People take comprehensive test for indoor air quality after decoration.

In all test items, the most necessary test for dangerous indoor pollution is the test for formaldehyde, because a formaldehyde hazard is the most obvious one.

At present, spectrophotometry detection, electrochemical detection, gas chromatography detection, liquid chromatography detection and sensor method are the main testing methods for formaldehyde.

5.1.1 Spectrophotometry

Spectrophotometric method is based on the different molecular structure of substances have selective absorption of electromagnetic radiation to establish a qualitative and quantitative analysis method. This is the most common method to test formaldehyde in room, textiles and food. Currently there are acetyl acetone, phenol reagent, AHMT, chromotropic acid method, phloroglucinol and catalytic spectrophotometry, etc. Different methods applied in different areas with advantages and limitations. (Beijing Huada Hing-Tech Indoor Reserarch Institut 2009)

5.1.1.1 Acetyl acetone

Acetylacetone method means formaldehyde and acetylacetone react at 45 ~ 60 ^{O}C water bath 30min or react at 25 ^{O}C room temperature in 2.5 h to produce a

yellow compound and then colorimetric formaldehyde content ration. Formaldehyde and acetylacetone have specific good reaction with less interference factors. The coexistence of phenols and other aldehydes do not interfere with each other. The reagent is stable. It is good use for detection high levels of formaldehyde in room and water-fat foods. But during the testing of formaldehyde in water-fat foods, it is necessary to extract formaldehyde sample in phosphoric acid by heat distillation, absorption by the solution and then fixed before used the testing. The operation process is complicated, cumbersome, and time-consuming. (Beijing Huada Hing-Tech Indoor Reserarch Institut 2009)

5.1.1.2 Phenol reagent

Phenol reagent is MBTH method, that is, the reaction of formaldehyde with MBTH to get a substance, which is oxidized in acidic solution, and then change to blue colour after 15 min at room temperature and then conduct colorimetric quantification. Phenol reagent method is simple, high sensitivity method. Detection limit is 0.02mg / L which is more suitable for the determination of micro-formaldehyde. Phenol reagent does not have a good stability. The colour agent can save only 3 days in 4 ^{O}C refrigerators. The stability of the absorbency is not good as acetylacetone method after coloration. Colour is affected by the time and temperature. This method is more used to test the formaldehyde in the room. (Beijing Huada Hing-Tech Indoor Reserarch Institut 2009)

5.1.1.3 AHMT method

AHMT method means that AHMT and formaldehyde condensate under alkaline conditions and oxidized by potassium periodate to amaranth compound. After this, use colorimetric method for detection of formaldehyde content. This method is

good in specificity and selectivity. In the condition of many acetaldehyde, propionaldehyde, butyraldehyde, benzene, acetaldehyde and other aldehydes co-exist, no interference appear in determination. The detection limit is 0.04 mg / L. However AHMT colour in operation gradually deepens with time. This method is often used to detect room formaldehyde. (Beijing Huada Hing-Tech Indoor Reserarch Institut 2009)

5.1.2 Electrochemical

Electrochemical analysis is based on the change of current (voltammetry), electricity (Coulomb law) and potential (potential method) in chemical reaction to estimate concentration in reaction system, and then use quantitative analysis method to detect. There are two methods for test the formaldehyde, which are polarographic method and potential method. (Beijing Huada Hing-Tech Indoor Reserarch Institut 2009)

5.1.3 Chromatography method

Chromatography method has strong separation ability, which is not easy interference by stroma and colour of sample reagents. It is sensitive and accurate for complex samples' detection which can be applied in bedroom, textiles and food samples' detection. Bedroom, textiles and food samples' formaldehyde detection are generally with complex components which have many interference and low level of formaldehyde content. By using conventional testing methods, it would cost a lot of time and energy for separation, inspissations etc. Chromatographic method is sensitive, accurate, and with strong anti-interference character, which can be used for detection of formaldehyde in room, textiles and food. However, this method has high demand for equipment. Long time derivatization, extraction

and other steps are not suitable for general laboratory and rapid home used detection. (Beijing Huada Hing-Tech Indoor Reserarch Institut 2009)

5.1.4 Sensor

The sensors used to detect formaldehyde are electrochemical sensors; optical sensors and optical biochemical sensors. The configuration of Electrochemical sensors is simple and the cost is low, but with too much interfering substances. The price of optical sensor is quite expensive, and with large volume. Although the optical biochemical sensors' selectivity has been improved, the activity of enzymes and other factors lead sensor instability and lack of practicality. It can not be popular in these disadvantages. (Beijing Huada Hing-Tech Indoor Reserarch Institut 2009)

5.2 Benzene detection

Detection of benzene in new houses is very important, because decoration materials and furniture all contain a certain amount of benzene.

Methods used in benzene detection can be divided into GC (gas chromatography) and HPLC (High Performance Liquid chromatography). Freezing point method is quite often used in determination of the benzene purity level.

Gas chromatography is a method of chromatography. There are two phases in chromatograph, one is the flow phase, and the other is the stationary phase. If use liquid as phase, it is called liquid chromatography; if use gas as the flow phase, it is called gas chromatography.

By chromatogram separation principle to points, gas chromatography can be divided into adsorption chromatogram and partition chromatogram. In gas-solid chromatography, the stationary phase is adsorbent and gas-solid chromatogram is adsorption chromatogram while liquid chromatogram is partition chromatogram.

High performance liquid chromatography, also known as "high-pressure liquid chromatography"; "High-speed liquid chromatography"; "high separation liquid chromatography"; and "Modern column chromatography". HPLC is an important branch of chromatography, which takes liquid as the flow phase used in high-pressure transfusion system.

Air benzene testing can use volatile organic solvents-methyl silicone oil or use low molecular polymer to absorp and then analyzed by chromatography or colorimetric method. We can also deeply freeze air-contained benzene and then added ferric sulfate and peroxide solution. After that, brown or black precipitate formed. Next, we dissolved it use nitric acid and then analyzed by colorimetry method. The other way is absorp the benzene in air directly with nitric acid, formed into dinitrobenzene, and then titrated this with titanium dichloride, or use the solution of methyl ethyl ketene base which is be prepared with dinitrobenzene to colorimetric.

5.3 TVOC detection

TVOC detection in air use Tenax-TA tubes to take samples. After thermal desorption, it will be cold adsorpted to the Tenax-TA pipe, and then by thermal desorption again, finally use gas chromatography to analysis. This method applies to determination of VOCS with concentrations ranging from 0.5 μg / m ~ 100mg / m in air. (Beijing indoor air quality testing center 2009)

5.4 Ammonia detection

There are several ways to detect ammonia according to the "indoor environmental quality and testing standards".

1) Sodium reagent spectrophotometry method. This is the method is to determination of ammonia in industrial waste gases and air. This method is suitable for test pharmaceutical, chemical, coking and other industrial emissions of ammonia.

2) Potassium hypochlorite - salicylic acid Spectrophotometry. This is used for the determination of ammonia in ambient air. The Interference: when the amine concentration is higher than 1mg/m3 this can not be applied.

3) Ammonia gas electrodes: applied to the determination of air and industrial emissions of ammonia.

4) Indophenol blue spectrophotometry: This method applicable to determination of ammonia in public places and also applied to test concentration of ammonia in residential indoor air.

Instruments used for detection concentration of ammonia on the market can be divided into: spectrophotometry, electrochemical methods and rapid test tube:

1) Spectrophotometry: relatively high accuracy data detection but the operation is not convenient. There is no on site operate the equipment till now.

2) Electrochemical methods: Take the ammonia sensor as the main body of the detector in high cost but test data is relatively accurate and easy to handle.

Disadvantage is the sensor can be easily damaged , so it need to be replaced every year.

3) Rapid assay: Rapid test tube-based detection accuracy was not very good, but it can meet the requirement of ammonia detection. This method is generally applicable to the detection of indoor air. Rapid detection tube is the gas through the test with the indicator reaction, use colour change to determine the concentration of test gas. The operation very easy with relatively low cost.

5.5 Radon detection

There are so many methods to test radon used in indoor air. From the measure time points, it can be divided into: transient measurement, continuous measurement and cumulative measurement; from the sampling methods it can be divided into passive measurement and initiative measurement; from the measured object aspect it can be divided into radon measurement, radon daughter measurement or both radon and radon daughters measurements at the same time. Instantaneous measurement with characters of fast, convenient and timely acquire monitoring data, but in poor typical level. Passive measurement is a better way to measure concentration of radon. It reflects the annual average of radon's concentration. GB/T14582-1993 (measurement of radon in the air) declares four measurements of ambient radon and its progeny: tracks etch method, activated charcoal method, two-filter method and the balloon method. Charcoal and solid track methods are two of the most often used methods. (Detection of indoor radon 2008)

5.5.1Track etching

Track etch method is a cumulative radon measurement method. It is belongs to passive sampling method. Radon concentration in the environment can be a cumulative measured. Annual average data in the measured place can be obtained directly, which avoid influence factors such as the time, season and weather. It has the characters of high sensitive, good reproducibility, simple operation and easy to preserve the data. The sample taking time of is 3 months, at least not less than 30 days. The measurement limit is 2.1 * 10^3 (Bq h) / m^3. (Detection of indoor radon 2008)

5.5.2 Activated charcoal method

Activated charcoal method is a commonly used passive cumulative measurement method for indoor radon detection. The activated charcoal method has priorities of low cost, easy operation, measuring result accurate and small volume, etc. However it is not suitable used for outdoor and humidity place. Timely analysis is needed after sampling (<7 days) otherwise it radon will decay. The detection limit was 6 Bq/m^3.(Detection of indoor radon 2008)

5.5.3 Double-filter method

Two-filter method is the instantaneous measurement of radon which belongs to active sampling method. It can measure radon and radon daughters at same time. This is a mature method of measuring radon which can exclude interference of radon progeny and improve the measurement accuracy. This method is in high sensitive. The measurement time is short and with simple operation. Backward is

the device heavy and large noise when we sampling. The detection limit was 3.3Bq/m^3.(Detection of indoor radon 2008)

5.5.4 Balloon method

Balloon method is the most instantaneous measurement of radon with active sampling. It can also measure radon and radon daughters. The balloon method and two-filter method have same elements to work. One different is the balloon instead of a decay tube. Radon and its daughters in the detection limits were 2.2Bq/m^3, 5.7 * 10^{-7}J/m^3.(Detection of indoor radon 2008)

6. INDOOR AIR QUALITY MEASUREMENTS

6.1 Pollution sources control

Control sources of pollution include keeping the indoor area clean. People should use low pollution energy such as: using gas instead of coal; the use of electricity can reduce some gaseous and particulate pollutants; Reduce smoking is a very important method to reduce the emissions of carcinogenic and potential carcinogenic substances; install exhaust system; changing cooking habits and reduce harmful gas emissions in room; Use of green building and green decorative materials. All of these ways are useful to eliminate pollutant emissions in large extent.

6.2 improve indoor ventilation

Good ventilation is the most simple and effective way to solve indoor air pollution problem. Studies show that natural ventilation can reduce indoor particles significantly and concentrations of microorganisms.

6.3 using purification technique

Purification of indoor air pollution methods are listed below:

(1) Plant

Plants can be used as decoration, but some kinds of plant can also be used to purify the air. People did not took much research to certify that plants can purify

indoor air, however some emissions of plants are harmful to human. Therefore it is necessary to carefully select the indoor plants. (Environmental Governance 2009)

(2) Chemical removal method

Certain reagents can be used to remove pollutions indoor such as: pesticides, fungal agents, acaricides can be used for delete biological pollution; a variety of chemical sprays agent, such as: fumigation of peroxyacetic, lactic acid and formaldehyde are also can be used but this method is easy to add other toxic substances to indoor area, so this is the last method we want to use. (Environmental Governance 2009)

(3) Activated carbon filtration method

Activated carbon (including fibers Activated carbon) is a good adsorbent. As it has rich porous, so the adsorption capacity is great. This method is often used to adsorb low concentrations of industry organic exhaust gas. Activated carbon is also commonly used in the deodorization of indoor air purification. However, this method is not very good to removal of harmful gases. (Environmental Governance 2009)

(4) Catalytic Purification method

As most air pollutants (such as aldehydes, benzene, and NOx) are oxidisable and reduction, therefore heterogeneous catalytic oxidation can be used to remove pollutants from the air. Photocatalytic degradation can be used at room temperature by water vapour and oxygen in air to remove contaminants. Some researchers suggested that the photocatalytic air purification materials used in building wall surface can be realized integration with the function of building and air purification which has broad foreground application. There are many

photocatalytic materials, but titanium dioxide photocatalyst is mostly used for environment. (Environmental Governance 2009)

Nano-titanium dioxide photocatalytic degradation has the following advantages:

(1) Low energy consumption; mild reaction conditions; occurs at the UV light, natural light and even low light illumination (2) Fast reaction. Organic pollutants can be destroyed in a few minutes to several hours. This method avoids the formation of central Poly Products ;(3) Degradation has no selectivity. Almost any organics can degradation; (4) Elimination of secondary pollution.

7 CONCLUSIONS

This thesis deals mainly with the types of indoor air pollution and their sources. The thesis is meant to increase knowledge in this field. Five main factors include indoor air pollution, sources, release way, the harm impact for the human and also the methods to reduce these pollutants. By understanding the harm of this pollution on human, people can improve the awareness of detection and control the indoor air pollution. People should use scientific and environmental ways to reduce indoor air pollution.

This research also describes the detection method for the five sources of pollution, which let people has a preliminary understanding for the testing. People can have a basic understanding of testing and this is useful when we do our detection of our own houses in future.

In the measures of improve indoor air pollution, improve ventilation system in room and plants purification methods are worth emphasizing. This is because they are easy implemented in daily life. Not all plants can purify the air. Some plants would be harmful for our health. Studies show that aloe and orchids have super-capacity to absorb formaldehyde indoors. Chrysanthemum, kumquat, pomegranate and daisy can absorb harmful gases, which are emitted from electrical equipment and plastic products. However, the vegetation with glaring, special smell or thick flavor should not be placed in room. Such as: oleander, yellow oleander, datura flowers. These toxic plants will harm people’s health.

The indoor air quality problem should be paid more attention to by the governments, engineers, owners and the several public. People should not neglect this important problem. More research should be done in this field in the future.

REFERENCES

Indoor Environmental Testing 2010.Beijing indoor air quality testing centre. (In Chinese.)
Available:http://www.kongqi360.com.cn/html/jiancebiaozhun/20091223104.html.
Accessed on 16 April 2010.

Indoor Air Quality Standard 2010.Quarantine of the People's Republic of China. (In Chinese.)
Available: http://www.law110.com/lawserve/guihua/1800011.htm.
Accessed on 16 April 2010.

Beijing monitoring center 2010.Beijing qingqing jiu huan environmental monitoring center. (In Chinese.)
Available: http://www.9green.com/hjyjk1.htm.
Accessed on 18 April 2010.

Formaldehyde testing 2010.Beijing Huada Hing-Tech Indoor Reserarch Institut. (In Chinese.)
Available: http://www.ierm.net.cn/jcjc/2009/1111/158.html
Accessed on 14 April 2010.

TVOC Testing 2010.Beijing indoor air quality testing centre. (In Chinese.)
Available:http://www.kongqi360.com.cn/html/jiancejishu/2009121264.html
Accessed on 14 April 2010

Detection of indoor radon2010.Environmental Health 25, No.1. (In Chinese.)

Available: http://www.doc88.com/p-99839798969.html

Accessed on 14 April 2010