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Study on chemical pollution in building decoration materials

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Abstract: *With the development of economy, technology and materials science, many building decoration materials with different functions have been invented and created. However, many building decoration materials will emit chemical pollutants harmful to human health, such as formaldehyde, benzene, ammonia, radon and total volatile organic compounds (TVOC). These toxic substances will cause harm to people's vision, skin, internal organs and other different parts, and even cause cancer and immediate death. This paper studies and summarizes the types and sources of common pollutants in indoor building decoration materials, as well as their impact on the environment and harm to human health, which is of great practical significance to avoid chemical pollution of building decoration materials.*

Keywords: *Building decoration materials; Chemical pollution; Harm; Prevention and control measures*

1. Introduction

In 2022, the national output of architectural coatings reached 16.4 million tons, an increase of 121.32% compared with 2018 (data source: China Coatings Network). China has basically formed an industrial system that has begun to take shape and has a relatively complete range of products in the field of building decoration materials. However, indoor air pollution caused by building decoration materials has become the third biggest air pollution problem after photochemical smog pollution and soot pollution[1]. In 2021, China Consumers Association released an interesting survey result, which focused on the indoor air quality of 100 finely decorated houses in Beijing and Shanghai. The results show that formaldehyde, a harmful gas, is extremely common, with 74% of households in Beijing and as high as 79% in Shanghai. After sampling inspection, indoor formaldehyde content is found to exceed the specified standard content. In addition, the pollution of total volatile organic compounds (TVOCs) can not be ignored, with 21% households in Beijing and 43% households in Shanghai affected by TVOCs. This survey has aroused widespread social concern, because many residents have reported symptoms of eye and nose discomfort after moving into newly renovated houses, and some residents have reported health problems such as headache, fatigue and listlessness. These symptoms are likely to be directly related to the excessive formaldehyde and volatile compounds in indoor air. This discovery once again emphasizes the importance of indoor air quality to residents' health, and the urgency of strengthening the supervision of decoration materials and upgrading indoor air purification technology. It is of great practical significance for people to avoid the chemical problems of building decoration materials by understanding and analyzing the types and sources of common pollutants in common indoor building decoration materials, as well as their impact on the environment and harm to human health.

2. Types of building decoration materials

Most building decoration materials belong to chemical products, such as adhesives, coatings, plastics, etc. According to their functions, they can be divided into the following common categories:

2.1 Architectural coatings

Painting is one of the most widely used decorative materials, which usually consists of three parts: main film-forming substances, secondary film-forming substances and replication film-forming substances. Toxic organic chemicals such as benzene, toluene and xylene are the main components involved in the production and manufacture of architectural coatings.

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2.2 Adhesive

Adhesives are used to connect objects and are widely used for architectural decoration such as wood[2]. Adhesives are divided into main agents and auxiliaries. Natural polymer materials and synthetic resins are common main agent materials, while curing agents, plasticizers and fillers are common auxiliary materials.

2.3 Wood boards and plastic products

Such as fiberboard, plywood and multilayer are commonly used for wood decoration. Plastics, synthetic resins and natural resins, which are widely used in decorative fields such as pipes and insulating materials, are the main raw materials for manufacturing their products.

2.4 Stones and pottery products

Granite and marble are the most common stones, which are often used for laying and decorating exterior walls and floors, and artificial stones are gradually appearing in the market. Ceramic products are mainly used in some household utensils or tiles.

3. Main chemical pollutants in indoor building decoration materials

3.1 Formaldehyde

The physical properties of formaldehyde are colorless, tasteless, soluble in water, pungent, and gaseous at normal temperature and pressure. It has good bactericidal ability and corrosion resistance, and is widely used in plastics, fibers, leather, medicine, dyes, agriculture and other industries.

3.1.1 Harm of formaldehyde to human body

The World Health Organization has long identified formaldehyde as a suspected carcinogen and teratogenic substance, and it is also a harmful substance that strongly causes gene mutation. According to relevant research results, formaldehyde can lead to abnormal sense of smell, abnormal liver and lung function and decreased immune function.

3.1.2 Main sources of indoor formaldehyde

(1) Furniture made from wood-based panels is often used as the preferred raw material for wood products such as plywood and particleboard in interior decoration because of its strong viscosity, good resistance to pests, good corrosion resistance, low economic cost and high profit. After the newly purchased furniture, the formaldehyde content in the room increases significantly, and the concentration can reach 0.1mg/kg[3] when the furniture is piled up.

(2) Various artificial boards derived from industrial formaldehyde use a large number of adhesives, and the main components of these adhesives are formaldehyde derivatives, such as urea-formaldehyde resin, melamine formaldehyde resin, phenolic resin, etc. Modern furniture production and wall and floor decoration all use adhesives, which may release formaldehyde.

(3) Indoor decorations such as carpets and bedding. Manufacturers often use formaldehyde resin finishing agent to pretreat carpets and bedding products, so as to improve their performance. These finished chemical fiber fabrics will release free formaldehyde after use. It is estimated that 750 mg of formaldehyde may be emitted per kilogram of synthetic textiles.

3.1.3 Solutions to formaldehyde hazards

(1) Physical adsorption. Physical adsorption is to make full use of adsorbable substances (such as activated carbon) to adsorb formaldehyde gas in the air. Activated carbon can remove formaldehyde economically and effectively, with strong adsorption and no risk of secondary pollution. For mild to moderate pollution, it can be used alone or in combination with other chemical methods, and the effect is better.

(2) Plant deodorization method. It is found that plants such as chlorophytum, green radish and aloe can absorb formaldehyde well, and the effect of economic and aesthetic superposition can be achieved by plant absorption method.

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(3) The photocatalytic decomposition technology for removing formaldehyde by chemical method is an advanced technology adopted by many indoor pollution control companies. Under illumination, the toxic waste gas in the air can be effectively decomposed by using the powerful catalytic degradation effect of photocatalyst.

(4) Spray decomposition of pure Chinese herbal medicine. This is an excellent and effective in addition to formaldehyde method with bright development prospects, which combines the advantages of plant and chemical removal methods and avoids their disadvantages. Compared with the chemical in addition to formaldehyde method, this method is safe and has no secondary pollution. Compared with the method of plant removal, the effect is better because it is herbal liquid extracted from plants.

3.2 Benzene

Under normal temperature and pressure, benzene is a colorless transparent liquid which is insoluble in water, fragrant and sweet. It is a commonly used organic solvent and toxic, and is listed as the first carcinogen by the International Agency for Research on Cancer.

3.2.1 Indoor air and benzene pollution

Mainly benzene series, taking styrene as an example, releasing benzene odor in a closed environment can cause dizziness, chest tightness, nausea and other uncomfortable symptoms in a short time, and long-term exposure can even lead to life-threatening. In addition, benzene is a carcinogen, which may cause health problems such as blood diseases. Benzene is a highly volatile substance, which is easy to diffuse in the air. After benzene metabolites enter cells, when DNA binds to them, it can lead to chromosome changes, including some chromosome breaks and some binding phenomena, which will promote cell carcinogenesis. In other words, mutation has occurred, because chromosomes are genetic materials, which control cell structure and life activities. If this state is maintained for a long time, it will cause cancer.

3.2.2 Symptoms of benzene poisoning

Short-term contact Short-term contact can cause acute poisoning. A small amount of benzene intake will lead to fatigue, dizziness, rapid heartbeat, headache, trembling, confusion, trance and other discomfort. Patients may suffer from headache, nausea, vomiting, confusion, loss of consciousness, coma, convulsions, etc. and highly poisoned people may die from central nervous system damage.

Long-term and continuous exposure to a small amount of benzene may cause chronic benzene poisoning, lead to cytopenia, chromosome abnormality, and then lead to leukemia, and may induce aplastic anemia. Phenol can cause severe bleeding, interfere with immune system function and lead to many diseases. Studies have pointed out that phenol lurks in the body for 12-15 years.

3.2.3 Emergency treatment of benzene poisoning

For inhalation poisoning, the patient should be immediately transferred to a well-ventilated area, contaminated clothes should be removed, clothes should be loosened for him and he should stay in bed, and dirt on his mouth and nose should be removed in time to ensure normal breathing and keep his body temperature. Patients with oral poisoning can use 0.005% activated carbon suspension or 0.02% sodium bicarbonate solution to gastric lavage and induce vomiting, and then take laxatives and diuretics to promote poison discharge and reduce toxin absorption. Patients with skin poisoning and poisoning should take off their contaminated clothes, shoes and socks, and thoroughly wash their skin and hair with soapy water and clear water.

3.2.4 Ways to avoid benzene hazards

From the source of control, decoration materials strictly adopt building decoration materials that meet national standards. Choose water-based materials with no pollution or less pollution. Wear masks and goggles when painting interior decoration to avoid direct contact with benzene for a long time. We should choose a formal and reputable decoration company that has passed the quality system certification, especially for families with old people, children or allergies. Nowadays, some environmental protection decoration companies use paint-free technology to effectively reduce the indoor harmful gas content. In addition, timely operation of indoor air purifiers and ventilation equipment helps to maintain indoor air cleanliness. When the outdoor air quality is good, it is helpful for the release and discharge of harmful gases. Newly renovated rooms should not be moved in immediately, but should be well ventilated until benzene and organic compounds are released.

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3.3 Ammonia gas

Ammonia, or "ammonia gas", is a colorless gas with a strong irritating smell. Human olfactory threshold for ammonia is 0.5 ~ 1 mg/m.

3.3.1 Harm of ammonia

Ammonia reacts with water to produce ammonia water, which is alkaline, highly permeable and corrosive, which will denature and inactivate tissue proteins in the body and destroy the metabolic function of the body. Ammonia has a strong irritating smell, and high concentration of ammonia will stimulate the central nervous system, causing convulsions, convulsions and even cardiac arrest and respiratory arrest[4]. Ammonia will penetrate mucosa and alveolar epithelium and invade submucosa, interstitial lung and capillaries, thus affecting the ventilation function of bronchi, causing pulmonary edema and systemic hypoxia[5].

3.3.2 Clinical manifestations of ammonia poisoning

Mild poisoning is characterized by pungent sensation in eyes, nose and pharynx. Clinical examination shows congestion of conjunctiva, nose and pharynx mucosa, and audible and dry rales in lungs. Severe poisoning is manifested as pulmonary edema, cerebral edema, laryngeal edema, laryngeal spasm and suffocation. Failure to rescue in time may be life-threatening.

3.3.3 Prevention and control measures of ammonia poisoning

Choose building decoration materials that meet the relevant national regulations, prevent the decoration project from running, dripping and leaking, and select materials and materials in strict accordance with the relevant national regulations to avoid air pollution. Eating, drinking, smoking, naked flames and sparks are prohibited in the renovated workplace. After the decoration is completed, try to ventilate the room to make the air circulate, and then move into the room after the toxic gas in the room is exhausted. Plants that can absorb toxic gases and purify the air are placed indoors.

3.4 Radon gas

Radon gas is usually transparent, odorless and radioactive. The decay of radioactive elements such as uranium and thorium may produce radon, which is widely distributed in the earth's crust. The World Health Organization has listed 19 major harmful carcinogens, and radon is one of them. Radon is the second leading cause of lung cancer after cigarettes[6].

3.4.1 Harm of radon

The influence of radon on human life and health mainly depends on the depth of radon in a limited space and the length of its contact with people[7]. Radon generally exists in indoor air or outdoor. Governments and relevant organizations all over the world have formulated the upper limit value (70 ~ 150 bq * m) and action value (150 ~ 400 bq * m) of indoor radon concentration according to the influence of radon concentration on human health.

According to American estimates, about 7000-10000 cases of lung cancer are caused by indoor radon every year, which is the second largest cause of lung cancer after smoking. According to the Netherlands, cases of lung cancer caused by radon have reached two-thirds of the number of traffic accidents. In Sweden, radon ranks fifth among all cancer causes. In addition, radon and its daughters will have a toxic effect when combined with benzene, that is, the toxic effect on the body is greater than the sum of the effects of the two alone.

3.4.2 Sources of radon

The volatilization of stone, concrete, brick and other materials and the release of natural gas are the main sources of indoor radon. Usually, the lower the floor, the higher the radon concentration. Uranium is a permanent source of radon: uranium decay produces radium, and radium decay produces radon.

3.4.3 Prevention and control of radon

Grasp the pollution source, and strictly control the site selection of buildings and the use of building decoration materials; In terms of domestic water, it is absolutely necessary not to use geothermal water. Stoves and water heaters that use natural gas must be used in a ventilated environment, develop good living habits at ordinary times, and frequently open windows for ventilation to maintain the cleanliness of indoor air.

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3.5 Total Volatile Organic Compounds (TVOC)

Total volatile organic compounds (TVOC) are complex mixtures, and the main components are benzene, aldehydes, ketones and unsaturated hydrocarbons. TVOC has odor, irritation and potential genotoxicity of some components. TVOC requires high detection technology, and gas chromatography is usually used, but FT-IR spectrum, fluorescence spectrum, ion chromatography and reflection interference spectrum can also be considered.

3.5.1 TVOC's harm to human body

According to relevant research results, TVOC exceeding the threshold will lead to immune dysfunction, central nervous system dysfunction, headache, chest tightness, digestive system dysfunction and other symptoms, and even allergic reactions in severe cases. After long-term research, it is found that pregnant women, children, office white-collar workers, the elderly, and people with respiratory or heart problems are the most vulnerable to TVOC.

(1) Due to the different physiological structures of pregnant women, the harmful gas pollution produced by indoor decoration materials has a great influence on women's health. After being absorbed, benzene will be stored in fat, which will have adverse effects on the normal growth of embryos and fetuses, and in extreme cases, it will lead to fetal malformation and death.

(2) Children's immune system is not yet mature, and their respiratory capacity is higher than that of adults, so they are more vulnerable to indoor air pollution. Indoor air pollution may cause blood diseases in children, increase the prevalence of asthma, and affect the healthy growth of height and intelligence.

(3) Office workers In the office, poor air quality in the office may lead to breathing difficulties, inattention and decreased work efficiency. Professor Zhaolin Xia from Fudan University School of Public Health pointed out that people who have been sitting in the office for a long time are more likely to suffer from "white-collar syndrome".

(4) Older people are more susceptible to environmental factors and cause various diseases because of their weakened physical function. Living in an environment with serious air pollution for a long time may lead to respiratory diseases, such as tracheitis, pharyngitis, pneumonia, etc. and may also induce hypertension, cardiovascular diseases, cerebral hemorrhage and other diseases, and potentially endanger the lives of the weak.

(5) TVOC in patients with respiratory diseases will cause respiratory function decline, lead to chronic bronchitis, chronic obstructive pulmonary disease and other problems, and increase the probability of lung cancer and nasopharyngeal carcinoma. According to the data, about 4 million children around the world die of acute respiratory infection caused by air pollution every year.

3.5.2 TVOC source

Fuel combustion and vehicle emissions have caused outdoor air pollution, while indoor environment is mainly affected by smoke released from coal burning, natural gas, smoking, heating and cooking, building materials, furniture, household appliances, cleaning supplies and human body emissions. TVOC mainly comes from interior decoration materials, including paints, coatings and adhesives. Indoor TVOC concentration is usually between 0.2 mg/m^3 and 2 mg/m^3, but it may increase greatly during the decoration process. Although TVOC has strong volatility and rapid release rate, TVOC in solvent only releases 25% of the total amount during paint drying, and a large amount remains indoors[8].

3.5.3 Prevention of TVOC damage

Starting from the source, using building decoration materials in line with relevant national regulations to develop green building materials; Keep the room ventilated to aggravate TVOC volatilization; Do not move in immediately after renovation, and check whether TVOC exceeds the standard after testing, and keep indoor ventilation for two to three months before moving in; Use Maya blue to absorb some indoor harmful gases; Some green plants, such as Chinese rose and lily, can also effectively absorb appropriate TVOC.

4. Conclusion

According to the statistical analysis of relevant departments, it is estimated that by 2025, China will become a country with an annual number of lung cancer patients exceeding one million. Air pollution seriously threatens people's lives and health. It is urgent to control indoor air pollution. In order to avoid

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the harm of building decoration materials to human health, we should strengthen the control of construction links and ensure the overall quality of materials in the decoration process. Ventilation can promote air flow, discharge harmful substances and effectively slow down air pollution; Most plants can absorb building pollutants, so they can make full use of the regulating function of plants when dealing with environmental pollution of building materials. Vigorously advocate the popularization of green decorative materials, and fundamentally solve the environmental protection problem.

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