Investigation on Certification and Evaluation Method of Harmful Substances Release from Furniture Products in China

Xiuxia Yuan^{1,*}, Haochun Yan², and Jia Liu³

¹China Building Material Test & Certification Group Co., Ltd., Beijing 100024, China

Abstract. Furniture products are the main sources of indoor air pollution due to the emission of formaldehyde and volatile organic compounds (VOCs). It is great significant to establish a scientific certification and evaluation system to promote furniture manufacturers to reduce the harmful substances release in furniture products and protect human health in China. This paper describes an investigation on release of formaldehyde, soluble heavy metals, benzene, toluene, xylene and other substances from 28 furniture products by dryer method and environmental chamber method. Studies on current development status of certification and evaluation of harmful substance release from furniture products in China were carried out. Case study of certification and evaluation method suitable for furniture production industry was made, and the existing problems and suggestions were provided for improvement of certification and evaluation method system based on the characteristics of furniture industry.

1 Introduction

Furniture is the main source of indoor air pollution because it emits formaldehyde and volatile organic compounds (VOCs). Establishing a scientific certification and evaluation system is significant to improve indoor air pollution, and to promote furniture manufacturing enterprises to reduce the release of harmful substances in furniture products and to protect human health. In order to reduce VOC emission in furniture products, many countries in the world have established VOC release identification system for furniture products. Third-party organizations issue VOC release labels for furniture products that meet specific requirements to promote manufacturing enterprises to reduce VOC emission in furniture products, such as Blue Angel and GUT in Germany, Green Seal, CRI Green Label Plus, LEED in the United States, and NF Environment in France., CESAT, AFSSET, Good Environmental Choice, TCO in Sweden, Swan of Nordic Europe, Umweltzeichen of Austria, EU Flower, Milieukeur of the Netherlands and others have established a identification system for VOC emissions from furniture products. Europe and the United States are two areas where the marking system is relatively concentrated. Some countries in Asia and Oceania have established marking systems, such as Australia Environmental Choice and Japan Eco Mark. Most of the foreign markings are voluntary ^[1]. At present, there is no VOC release identification system in China, and the evaluation of harmful substances release in furniture products can be carried out by product certification. Product certification, as a means of evaluation, refers to the activities of a fully trusted third party to verify that a

product conforms to specific standards or other technical specifications. It is a way to provide proof that the product meets the requirements of standards and other normative documents. Product certification can be divided into compulsory certification and voluntary certification. China's compulsory product certification is based on the Mandatory Product Certification Management Regulations to implement mandatory certification management for listed products. At present, the release of harmful substances in our country's furniture products is not listed in the catalogue. All of them are voluntary product certification, such as CEC's 10-ring certification, CQC's product environmental protection certification, etc. Voluntary product certification as a third-party evaluation method, used widely in China, promotes the furniture manufacturing enterprises to reduce the release of harmful substances in products to a certain extent.

2 Current Research on harmful Substances Release in Furniture Products in China

Based on GB 18584-2001 *Indoor decorating and refurbishing materials-limit of harmful substances of wood based furniture*, studies on soluble heavy metal content (lead, cadmium, chromium, mercury) and formaldehyde emission in 28 furniture products of solid wood furniture, panel furniture, steel-wood furniture and soft furniture were carried out in this paper. The statistical results of the test data were given in tables 2-1, 2-2 and figure 2-1.

*Xiuxia Yuan: xyxuan@ctc.ac.cn

Table 2-1 Test results of content of soluble heavy metals

Soluble heavy metal	Detection percentage (%)	Over limit percentage (%)	Undetected percentage (%)	Maximum value mg/l	Average mg/l
Lead	8	0	92	45.8	38.8
Cadmium	0	0	100	/	/
Chromium	4	0	96	5.2	5.2
Mercury	0	0	100	/	/

It can be seen from Table 2-1, the qualified rate of heavy metal content of the samples is 100%, and the detection percentage of lead, chromium, cadmium and mercury is

8%, 4%, 0% and 0% respectively. Soluble heavy metals (lead, cadmium, chromium, mercury) were not detected in most furniture.

Table 2-2 Test results of formaldehyde emission (dryer method)

	Detection percentage (%)	Over limit percentage (%)	Undetected percentage (%)	Maximum value (mg/l)	Average (mg/l)
Formaldehyde	85.7	3.6	14.3	1.6	0.32

Fig. 2-1 Distribution Diagram of Formaldehyde Release (Dryer Method)

As can be seen from Table 2-2 and Figure 2-1, the detection percentage of formaldehyde emission (dryer method) of the samples was 85.7%, the exceeding standard ratio was 3.6%, the highest value was 1.6 mg/l, the lowest value was 0.1 mg/l, and the average value was 0.32 mg/l. Using the dryer method, most furniture

contains formaldehyde, and a few furniture contains excessive formaldehyde. Hence, formaldehyde is a harmful substance that needs to be controlled in furniture products.

At the same time, the release of formaldehyde, benzene, toluene, xylene, ammonia and TVOC from 28 furniture products were tested by the environmental chamber method. The results were given in tables 2-3, 2-4, figure 2-2 and 2-7. The simulated indoor area (the area of the environmental cabin is 30 m³, the size of the annular cabin is 3.4 m × 3.5 m × 2.5 m, the temperature is (23 ± 2) °C, the humidity is (50 ± 10) %, and the carrying capacity of the environmental cabin is less than 1.0 m²/m³). In this way, the samples were put into the environment chamber and sealed for 12 hours, then the gas samples were collected for testing.

Table 2-3 Detection of harmful substances in furniture products by environmental chamber method

	Detection ratio %	Undetected proportion %	Maximum mg/ m ³	Minimum detected mg/ m ³	Average mmg/ m ³
Formaldehyde	100	0	0.06	0.01	0.023
Benzene	81.1	17.9	0.05	0.01	0.018
Toluene	81.1	17.9	0.06	0.01	0.015
Xylene	81.1	17.9	0.04	0.01	0.014
Ammonia	50	50	0.06	0.01	0.015
TVOC	100	0	0.40	0.03	0.177

Fig. 2-2 Distribution Diagram of Formaldehyde Release (Dryer Method)

Fig. 2-3 Distribution Diagram of benzene Release

Fig. 2-4 Distribution Diagram of Benzene Release

Fig. 2-5 Distribution Diagram of Toluene Release

Fig. 2-6 Distribution Diagram of Toluene Release

Fig. 2-7 TVOC Release Distribution Diagram

From table 2-3 and figs. 2-2 to 2-6, it showed that the detection ratio of formaldehyde emission in 28 furniture samples detected by environmental chamber method was 100%, the highest, the lowest and the average value were 0.06, 0.01 and 0.27 mg/l respectively. The detection rates of benzene, toluene and xylene in 28 furniture samples were 81.1% and that of ammonia was 50%. It can be seen from the above data that besides formaldehyde and soluble heavy metals, volatile organic compounds such as benzene, toluene and xylene in furniture products are also important targets to be considered in certification evaluation.

3 Research on Certification and Evaluation Method of Harmful Substances Release from Furniture Products

Furniture products have strong customization. At present, there are no standardized products in our country. The type and volume of harmful substances released from furniture products varies significantly from raw material to raw material. Based on the above characteristics and existing standard system of furniture sector in China, the certification and evaluation methods of harmful substance release from furniture products can be divided into three aspects: raw material evaluation method, furniture product evaluation method and comprehensive evaluation method.

3.1 Raw Material Evaluation Method

Raw material evaluation method mainly aims at evaluating various raw materials used in furniture products. At present, the main raw materials used in domestic furniture products are wood, various wood-based panel, adhesives, textiles, leather, metal parts, coatings, stone, and fillers, etc. The main control indicators are formaldehyde emission, radioactive, as well as soluble heavy metal content. Volatile organic compounds, azo dyes and other indicators, various raw material control indicators and relative standards are presented in table 3-1.

Table 3-1 Control Index and Standard of Main Raw Materials Used in Furniture Products

No.	Raw material types	Control index	Standards
1	Solid wood	Pentachlorophenol in Contactable Solid Wood Parts (PCP)	GB/T35607-2017
2	Wood-based panel	Formaldehyde emission	GB 18580-2017
3	Textiles (sofas, mattresses)	Formaldehyde emission, azo dyes decomposed into carcinogenic aromatic amines, carcinogenic dyes, extractable heavy metals containing lead, cadmium, hexavalent chromium, etc.	GB 19601-2013
4	Leatherwear	Free formaldehyde, volatile organic compounds, banned azo dyes, extractable heavy metals (lead, cadmium), etc.	GB/T 16799-2018
5	Stone material	Radioactivity	GB 6566-2010
6	Filler	Use chlorophenols preservatives, formaldehyde, halogenated flame retardants, organochlorine bleaching agents, etc.	/
7	Coating	Benzene, toluene, xylene, VOC, etc.	GB 18581-2009
8	Adhesive agent	Free formaldehyde, benzene, toluene, xylene, etc.	GB 18583-2008

Raw material evaluation method can provide corresponding requirements for all kinds of raw materials used in furniture, and can also propose

specifications for main materials. Raw material evaluation method has strong pertinence, detailed and comprehensive, relatively complete and controllable criteria, which can ensure that the key raw materials used in furniture manufacturing process can meet the requirements. The standard or requirement that should be met. For furniture products, this is an indirect way of evaluation, because furniture products are not standard products of fixed style. Because of different structures, the types and quantities of raw materials used in different furniture products will be quite different. Because of the superposition effect, the release amount of harmful substances from individual raw materials meets the corresponding standards or requirements, which does not mean that the release amount of harmful substances from finished furniture products meet the requirements.

3.2 Furniture Product Evaluation Method

Furniture product evaluation method is an evaluation index for finished furniture products. At present, the relevant standards for evaluating the release of harmful substances in furniture products are GB 18584-2001 *Indoor decorating and refurbishing materials-limit of harmful substances of wood-based furniture*, GB/T35607-2017 *Green Product Assessment-Furniture*. Specific technical indicators are shown in Table 3-2.

Table 3-3 Comparison of advantages and disadvantages of three authentication evaluation methods

Evaluation method	Advantage	Disadvantage
Raw material evaluation	Detailed, comprehensive, targeted, multi-evaluation indicators, many standards to be based on	Long test period and high cost, can not evaluate products directly.
Furniture product evaluation method	Direct evaluation of finished products, concise and efficient	VOCs control index is relatively small
The comprehensive evaluation method	Detailed, comprehensive and multi-angle	Long test period and high cost

Table 3-4 Examples of Wood Furniture Certification and Evaluation Projects

Object of evaluation		Controllable Indicators	Standards
Raw material	Solid wood	Pentachlorophenol (PCP) in Contactable Solid Wood Parts	GB/T35607-2017
	Artificial plate	Formaldehyde emission	GB 18580-2017
	Adhesive agent	Free formaldehyde, benzene, toluene, xylene, etc.	GB 18583-2008
	Coating	Benzene, toluene, xylene, VOC, etc.	GB 18581-2009
Furniture product	Furniture	Formaldehyde	GB 18584-2001
		Soluble heavy metals (lead, cadmium, chromium,	GB 18584-2001

Table 3-2 Control Index and Standard of Furniture Products

No.	Controllable Indicators	Standard
1	Formaldehyde	GB 18584-2001
2	Soluble heavy metals (lead, cadmium, chromium, mercury, arsenic, selenium, antimony, barium)	GB 18584-2001 GB/T35607-2017
3	Benzene, toluene, xylene	GB/T35607-2017
4	TVOC	GB/T35607-2017

3.3 The Comprehensive Evaluation Method

The comprehensive evaluation method combines the raw material evaluation method with the product evaluation method to compose the evaluation requirement of harmful substance release of furniture products. This method can select representative key raw materials for evaluation according to the characteristics of a certain furniture product, and then synthesize furniture product evaluation. This method is detailed and comprehensive. It can reflect furniture from various angles, and it is strongly recommended. The disadvantage is the high cost. Table 3-3 gives a comparison of the advantages and disadvantages of the three evaluation methods.

		mercury)	
		VOCs (formaldehyde, benzene, toluene, xylene, ethylbenzene, trimethylbenzene, dichlorobenzene, styrene, phenol, and acetaldehyde, etc.)	/
		TVOC	GB/T35607-2017

4 Problems and Suggestions on Certification and Evaluation Technology of Harmful Substances Release from Furniture Products in China

At present, the domestic product certification of furniture industry adopts the evaluation indexes and control requirements in the existing national or industry standards. The advantage of using the existing standards is that the research of certification technology is relatively simple, and evaluator can evaluate the products by adopting the items and indicators in the standards. The limitation of this certification mode is that the development of certification technology is limited by the development of relevant standards in this industry. For example, the existing standards for evaluating harmful substances in furniture products mainly adopt GB 18584-2001 *Limit of harmful substances in interior decoration materials and wood furniture* and GB/T35607-2017 *Green product assessment- furniture*. From the technical indicators, the attention of VOC on typical characteristics of different furniture products is insufficient. On the other hand, from the perspective of industry development, we hope to improve the control level of harmful substance release in products continuously through the development of certification technology. It will be more difficult only according to the requirements of existing standards. Mandatory clauses in mandatory standards should be meet before the furniture products enter into the market, such as formaldehyde and soluble heavy metals such as lead, cadmium, chromium and mercury in GB 18584-2001. The amount of harmful substances released from furniture products will directly affect human health [2]. Therefore, the development of certification technology related to harmful substances released from furniture products at this stage should not only be limited to the existing national or industrial standards. It should promote the development of technical specifications and propose stricter and more comprehensive indicators than the existing standards.

4.2 Indicator parameters for Certification Evaluation

Volatile organic compounds (VOC) released from furniture products are the one of the main sources of indoor air pollution. At present, the evaluation of VOCs is insufficient in domestic certification and evaluation system. Different furniture products are produced with

different process and different raw materials, so the types of VOCs will vary greatly. Therefore, regarding different types of furniture products, controlling typical VOCs and their limits are the key technology to study the release of harmful substances in furniture products.

4.3 Evaluation Items

There are many factors affecting the release of harmful substances from furniture products, such as the processing technology and storage time of furniture products. For example, as for solid wood products, due to the lack of edge sealing technology, formaldehyde and other releases will be higher when tested at the initial stage after production. The releases will be reduced to a certain extent after storage for a period of time. For panel furniture, due to the edge sealing technology, the release rate is small, and the initial release volume may be lower than that of solid wood furniture. In the long term, the total release amount will be higher than that of solid wood furniture. Therefore, the release amount and rate of harmful substances in a period should be evaluated, so as to evaluate the impact of the release amount of harmful substances from furniture products on indoor air quality more comprehensively and objectively.

5 Conclusions

(1) Furniture products have become the main sources of indoor air pollution due to the emission of harmful formaldehyde and VOCs. At present, China has not established a corresponding identification system. Therefore, the establishment of scientific certification and evaluation system is of great significance for improving indoor air pollution, promoting furniture manufacturing enterprises in China to reduce release of harmful substances in products and protecting human health.

(2) For different types of furniture products, a comprehensive certification and evaluation method for formaldehyde emission, soluble heavy metal content and typical volatile organic compounds (VOCs) should be established.

(3) The Certification Evaluation of harmful substance release from furniture products should not be limited to meet requirements of existing standards, but should satisfy more comprehensive and stricter requirements through encourage furniture producers to follow technical specifications.

(4) In addition to absolute release, the release amount and rate of harmful substances from furniture products in

a period should be evaluated during the certification and evaluation.

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