Classifying low formaldehyde emission from blockboard by gas analysis method and desiccator method

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Keywords: Blockboard; formaldehyde emission; desiccator method; gas analysis method; moisture content

Abstract. The paper studied formaldehyde emission (FE) of E_0 class blockboards by desiccator and gas analysis method. Results showed that for the same formaldehyde emission value got from desiccator method, the gas analysis (GA) values were quite different. It was suggested to use gas analysis method to evaluate formaldehyde emission at low formaldehyde content. The main reason for different gas analysis values was moisture content (MC), the lower the board moisture content the smaller the formaldehyde emission value. Gas analysis value was very sensitive to specimen's moisture content, it was suggested to keep low moisture content could be a solution to decrease formaldehyde emission for blockboards.

Introduction

Blockboards, a kind of plywood with the solid-wood strip core inside, are widely used in interior decoration application in China [1]. However formaldehyde-based resin adhesives especially urea-formaldehyde (UF) resin were widely used as bonding material which caused formaldehyde emission during long term utilization [2]. The International Agency for Research on Cancer (IARC) reclassified formaldehyde as"carcinogenic to human (Group 1)" from "probable carcinogenic to human (Group 2A)"in 2004 [3]. Test methods were invented to quantify FE such as desiccator method, chamber method, perforator method, gas analysis etc [4-7]. Desiccator method, originally came from Japan[8] was commonly used to test FE from blockboard and plywood [9,10]. Desiccator test should pre-treatment the sample for 7 days plus 24 hours sampling period [10]. Gas analysis method, originated from Europe [11] shorts test period from 8 days to 4 hours by high temperature (60˚C) and air flow rate, the method were adopted by China [12] and ISO [13]. Emission classes of E_0 (≤0.5mg/L), E_1 (≤1.5mg/L), and E_2 (≤5mg/L) were established by China national standard for blockboard [9]. The values measured by EN 717-2 were under the E_1 emission class (E_1≤3.5 mg/m^{2}h) and E_2 emission class (E_2≤8 mg/m^{2}h) for plywood according to BS EN 13986 since 2004 [14].

The paper studied FE of E_0 class blockboards by desiccator and gas analysis method, compared FE values of the two methods and analyzed the influence factors. The objectives of this study were to investigate the possibility of using gas analysis method to evaluate formaldehyde released from blockboards, differentiate low formaldehyde emission and short test period.

Materials and methods

Blockboard specimens Ten pieces of E_0 class blockboards from different brand manufactures by size of 2440×1220×12 mm (length by width by thickness) were brought from building material market. Then cut into 150×50 mm (10 pieces) and 400×50 mm (3 pieces) (length by width) for desiccator and gas analysis test, respectively. The four edges of 400×50 mm specimens were sealed with aluminium-foil paper.

FE test method For desiccator method, test pieces were placed in a 20 ˚C desiccator (10L) containing a vessel with 300mL distilled water (Fig. 1) for 24h. The formaldehyde release was expressed by the formaldehyde concentration of 300mL distilled water (mg/L) [10]. Gas analysis test was carried out in a closed chamber with 60˚C temperature and less than 3% RH for 4h. Formaldehyde released from the test piece mixes with the air in the chamber. This air was continually drawn from the chamber with 1L/min rate and passed through 4 groups of gas wash bottles, containing approximately 20mL water, which absorb the released formaldehyde (Fig. 2). The formaldehyde release was calculated from this concentration, the sampling time and the exposed area of the test piece and was expressed in milligrams per square meter and per hour (mg/m^2h) [11-13].

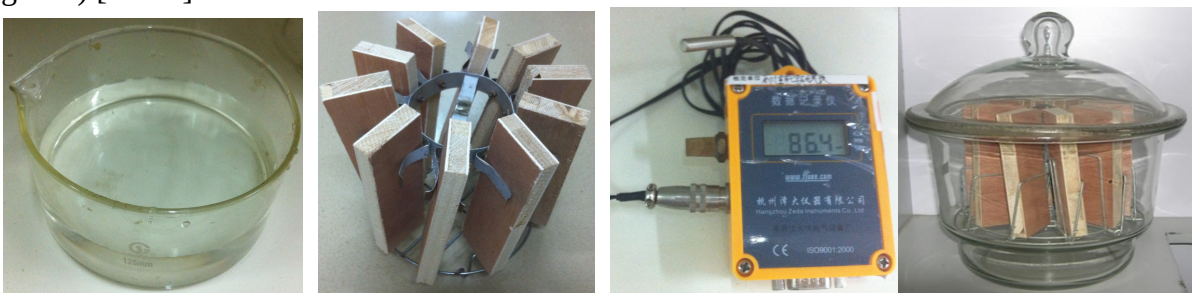
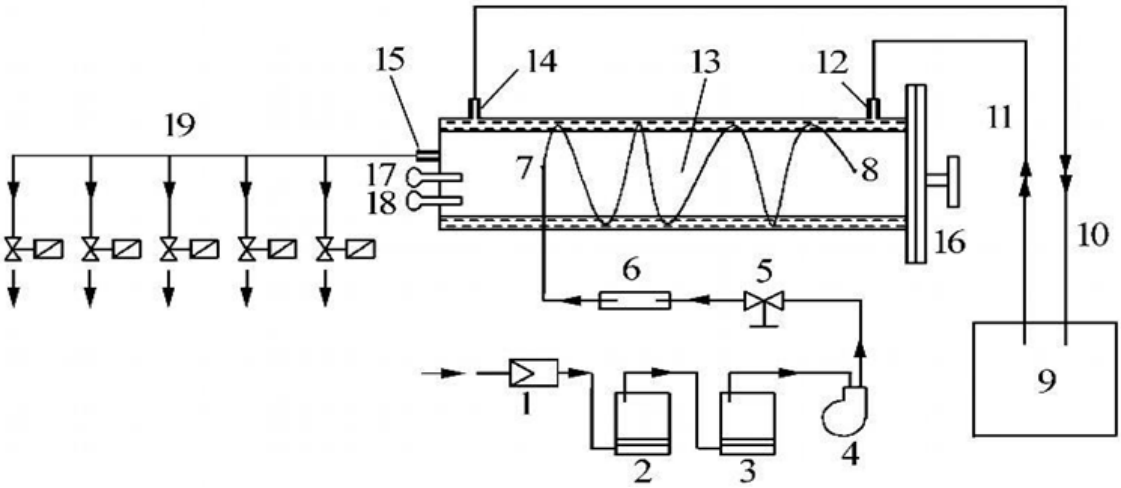


Fig.1 Desiccator test for formaldehyde emission (from left to right were beaker with 300mL distilled water; blockboard specimens; temperature and humidity recorder; 10L desiccator with samples, respectively)



1. Air filter, 2. Wash bottle, 3. Desiccator, 4. Air pump, 5. Needle valve, 6. Equipment for measurement of air flow, 7. Inlet of air (test chamber), 8. Outlet of test air, 9. Heat medium, 10. Come back water tube, 11. Inlet of water tube, 12. Water inlet, 13. Test chamber, 14. Water outlet, 15. Outlet of mixed air, 16. Door, 17. Temperature monitor, 18. Pressure monitor, 19. Magnetic valves.

Fig.2 Formaldehyde emission test apparatus using the gas analysis method

Results and discussion

Formaldehyde emission values tested by gas analysis and desiccator method The GA values for 0.3, 0.4 and 0.5 mg/L from desiccator method ranged from 0.6-1.2, 1.5-2.2, and 1.5-3.2 mg/m^2h, respectively. However, most of the values were lower than the corresponding level of gas analysis method got from linear regression from E_1 and E_2 class described by two methods ($y=1.2857x+1.5714$). Test result (table 1) showed that gas analysis values were below the standard limit lower than expected. Table 1 also showed that for same FE value got from desiccator method,

the gas analysis value were varied, so it can classify the FE further on at very low formaldehyde emission level.

Table 1 FE value test by GA method and desiccator method and corresponding FE limitations

Test method	Unit	Emission level				
Desiccator method	[mg/L]	0.3	0.4	0.5 (E_0)	1.5(E_1)	5(E_2)
GA method	[mg/m^{2}h]	2	2.1	2.2	3.5	8
AG average(range)	[mg/m^{2}h]	0.9(0.6-1.2)	1.6(1.5-2.2)	2.1(1.5-3.2)	-	-

Effect of relative humidity on FE values by GA and desiccator method It was very important to determine the effect of humidity on formaldehyde emission rates. As a result, it has been reported that any change in water content of the product (bonded with UF) may alter formaldehyde release over the short term [15-17]. For desiccator method, with 300mL distill water inside, the 9-11L small closed container will reached almost 100% relative humidity in short time for empty desiccator, and reached to about 90 %RH within 2h with specimen inside(Fig. 3).

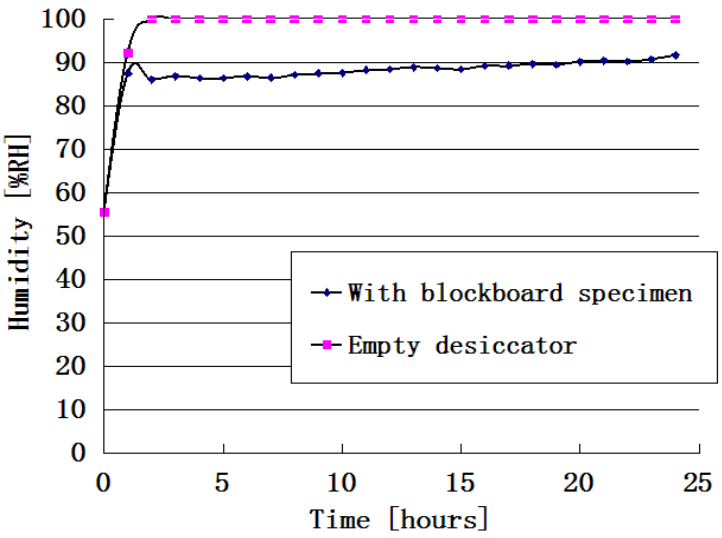


Fig. 3 Relative humidity changes in desiccator during 24h test

During test period, MC in blockboard changed and tried to reach a steady state, when its equilibrium MC below or above atmosphere relative humidity, it will absorb or desorb moisture from air, in the meanwhile, specimen will release or absorb formaldehyde and also reach a steady state in the long term [18] and the initial MC of the sample will play an important role on both of these balance. As reported [19], UF will hydrolyzed when water exist and will speed up with temperature rising.

Effect of moisture content on FE values by gas analysis method Due to high temperature and low humidity, free water in the specimen was easy to evaporate.

Table 2 Moisture content changes during GA and desiccator test

No.	Specimen MC[%]	MC decrease rate for GA method[%]	MC increase rate for desiccator method[%]
1	14.9	4.1	0.5
2	14.9	3.9	0.5
3	13.8	3.7	0.7
4	12.6	3.1	0.6
5	12.5	3.1	0.6
6	11.7	2.1	0.5
7	11.7	2.0	0.5
8	10.7	2.0	0.6
9	10.6	1.8	0.4
10	10.4	1.9	0.6

Table 2 showed the higher the MC the greater the decrease values. The decease rate ranged from 1.8 to 4.1% after 4h 60˚C test, the evaporation will carry out a few amount formaldehyde consequently accelerate the FE rate. Moisture content closely related with formaldehyde release for GA test. In contrast, moisture content increased a little (0.4 to 0.7%) for desiccator test which may explain the less influence by MC.

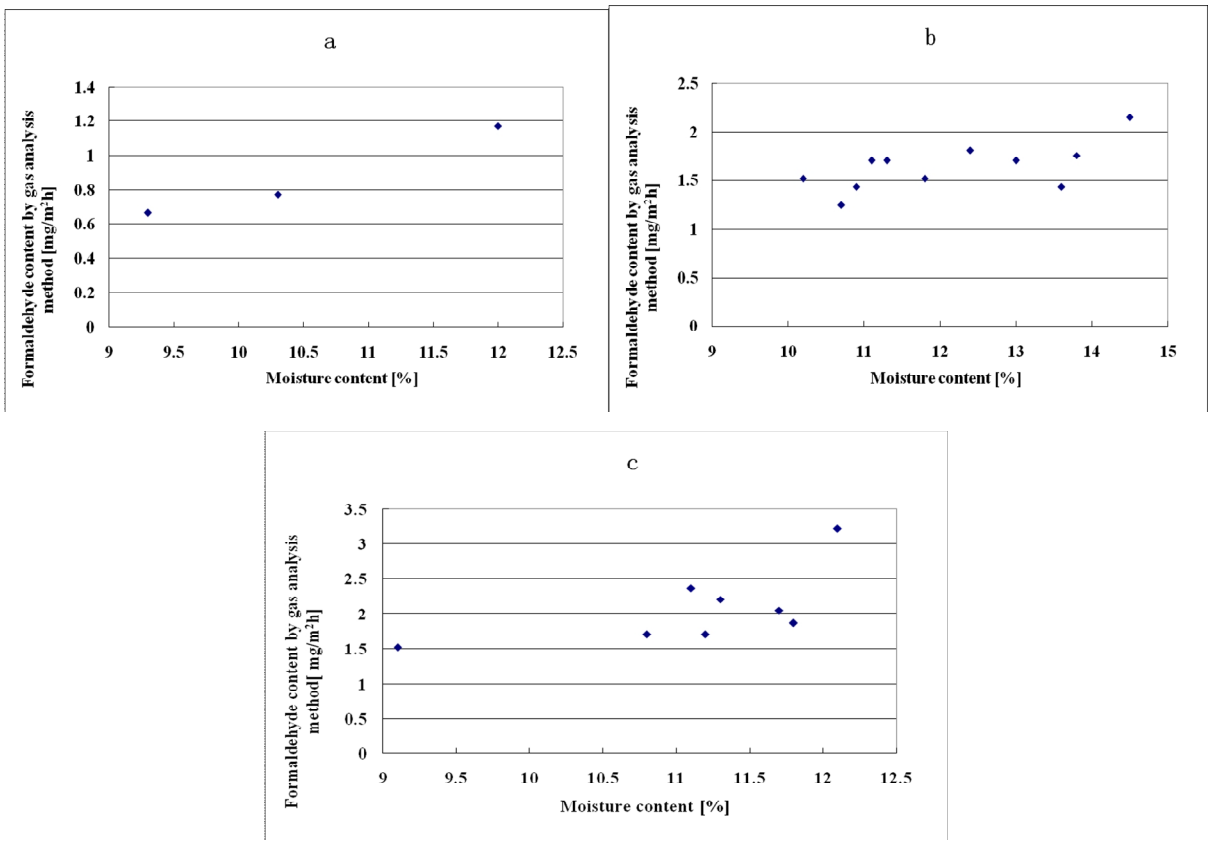


Fig. 4 Influence of MC on FE tested by GA method (Desiccator method value: a. 0.3mg/L, b. 0.4mg/L, and c. 0.5mg/L)

Fig. 4 showed that FE were closely related to MC, the lower the board moisture content the smaller the formaldehyde emission value. This was in agree with previous study by Long[20]. Gas analysis value were very sensitive to specimen's moisture content, to keep low moisture content could be a solution to decrease formaldehyde emission for blockboards.

Conclusions

Formaldehyde emission values of E_0 class blockboard got from desiccator method were quite different from GA values, the corresponding averages of FE values of GA method for 0.3, 0.4, and 0.5 mg/L by desiccator method were 0.9, 1.6 and 2.1 mg/m^2h, respectively. GA method can further classify FE value low FE products. It was suggested to use GA method to evaluate FE properties at low formaldehyde emission. The main reasons for the differences were originating from MC, the lower the MC the smaller the FE value. GA value were very sensitive to MC, to keep low MC could be a solution to decrease FE value for blockboard.

Acknowledgment

The authors appreciate financial support from Cooperation projects between Zhejiang province and Chinese Academy of Forestry (NO. 2014SY11).

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