Study on the Rheological Mechanism of Formaldehyde Emission from MDF

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Abstract: The behavior of formaldehyde emission from medium density fiberboard (MDF) is a function of time elapsed. However, the correlation between formaldehyde emission and the time elapsed is still not clear yet. Here the behavior of the formaldehyde emission from MDF was modeled using the rheological theory. Formaldehyde Emission from MDF was divided into three components of instantaneous, time delayed and permanent when the driving force of formaldehyde emission from MDF is set to be fixed. The Maxwell model, Kelvin model, and Burger model were used to curve-fit the three different time-related components, individually. The results show that the effects of the time on the three different time-related components of formaldehyde emission from MDF can be well modeled by the Maxwell, Kelvin, and Burger formulae.

Key words: MDF; formaldehyde emission; rheological mechanism
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1 Introduction

The factors, which affect the formaldehyde emission from MDF, are formaldehyde resource and its propagation. The air pressure difference between the MDF and the atmosphere and the propagating path are the two necessary conditions for the formaldehyde emission from MDF. There are two interfaces of air-material surface and material surface-inner part for the VOC (volatility organic compounds) emission from a wood composite to exterior air[1].

The rheological theory was applied to model the formaldehyde emission from MDF. The related rheological characteristics of the formaldehyde emission from MDF were built.

2 Experiments

Two series of experiments were conducted to study the correlation between the formaldehyde emission from MDF and the time elapsed using the desiccator method. In series 1, the sample was enclosed a container for 24 hours to evaluate the formaldehyde emission. Then the same sample was kept in a clean container to evaluate the second 24-hour formaldehyde emission. The total of twelve 24-hour formaldehyde emission was evaluated on the same sample. In series 2, a total of twelve samples cut from the board were kept in twelve different containers. A sample was taken out to evaluate the formaldehyde emission every two hours.

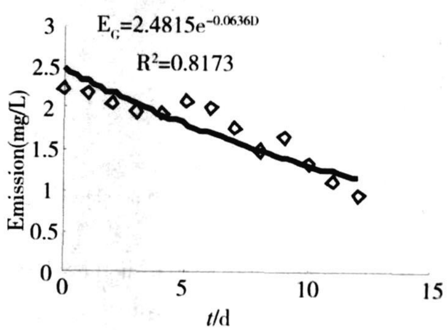

Fig. 1 Formaldehyde emission vs time elapsed (2h)

3 Results and analysis

The formaldehyde emission quickly decreases with the time elapsed because the formaldehyde continuously released from the outside part of the MDF board toward the environment. It is safe to say that the time elapsed remarkably influences the testing values of the standard desiccator method.

Considering Maxwell Model and Kelvin Model, the following equation can be obtained.

$$C_M = C_0 e^{-0.0636t} \quad (1)$$

$$F_k = \frac{P_0}{K}(1 - e^{-0.0636t}) \quad (2)$$

Formaldehyde emission can be modeled using Maxwell model. The reason is thought to be that the formaldehyde emission is mainly from the dissolved

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formaldehyde in the UF at the initial stage so that the releasing velocity of dissolved formaldehyde is faster[2].

The Kelvin Model describes the rheological phenomenon of the formaldehyde emission from MDF, which imitates the flexibility and viscidity characteristics of formaldehyde emission. The formaldehyde emission is caused by the dissolved formaldehyde, the reversible reaction between formaldehyde and urea in the UF, and rupture of the chemical bonds[3]. The total velocity of formaldehyde emission is determined by the decreasing trend in Maxwell Model and the increasing trend in Kelvin Model. The formula of Burger Model is combined together with Kelvin Model and Maxwell Model and its curve is a gradually decreasing curve.

The results of the second series experiments were shown in Fig. 2.

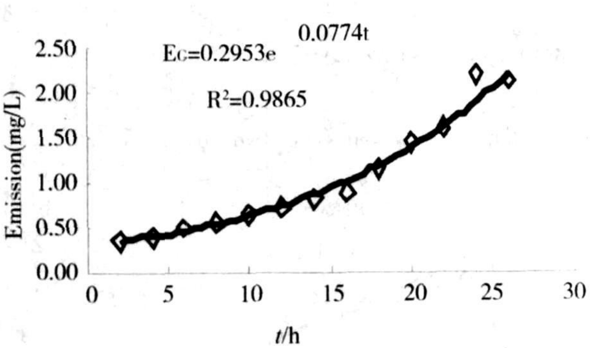

Fig. 2 Formaldehyde emission vs time elapsed (24 h)

The tested values increased with the time elapsed because the amount of formaldehyde absorbed in the distilled water in desiccator increased.

Considering Maxwell Model and Kelvin Model, the following equation can be obtained.

$$E_{GM} = E_{G0}\, e^{0.0774\,t} \tag{3}$$

$$E_{GK} = \frac{P_0}{K}\left(1 - e^{0.0774\,t}\right) \tag{4}$$

The fact showed the combination of Equations (3) and (4) can well describe the influence of the desiccator testing time on the formaldehyde emission from MDF.

4 Conclusions

(1) Maxwell Model could well simulate the rheological characteristics of the formaldehyde emission from MDF when the driving force was invariable.

(2) Kelvin Model could well simulate the postpone characteristics of the formaldehyde emission from MDF.

(3) Burger Model could well simulate the creeping characteristics of the formaldehyde emission from MDF.

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MDF甲醛释放流变性的研究

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摘 要：在MDF甲醛释放蠕变过程中，MDF甲醛释放驱动力保持不变时，MDF甲醛释放量随时间延长而变化。马克斯韦模型可在甲醛释放驱动力为恒定条件下，较好地模拟MDF的甲醛释放流变性的规律；凯尔文模型较好地模拟了MDF甲醛延时释放特征；勃格模型是描述MDF甲醛释放蠕变的重要公式，它较好地模拟了MDF甲醛常规释放蠕变特征，换算得到的公式可较好地描述锯切后试件放置时间对MDF甲醛释放量的影响规律，是描述和预测MDF甲醛释放松弛特性的有价值模型；也可较好地描述干燥器测试时间对MDF甲醛释放量的影响规律，是描述和预测MDF甲醛释放蠕变特性的有价值模型。

关键词：MDF；甲醛释放；流变性

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