Determination of the content and release of formaldehyde from a particle board sample

Fatima KHAMMOUR a*, Abdelkbir KENZA a, Ayoub AINANE a, M’hamed ELKOUALI a, Mohammed TALBI a, Tarik AINANE b

a Laboratory of Analytical Chemistry and Physical Chemistry of Materials, Faculty of Sciences Ben Msik, University of Hassan II, BP 7955 Casablanca 20660, Morocco
b Superior School of Technology - Khenfira (EST-Khenfira), University of Sultan Moulay Slimane, PB 170, Khenfira 54000 Morocco.

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ABSTRACT
Two analytical methods were used to measure the formaldehyde content (perforator extraction method and gas analysis method) on a particle board sample made from urea formaldehyde resin. The perforator extraction method has a higher formaldehyde content compared to the gas analysis method.

Keywords: urea formaldehyde, perforator extraction method, analysis method, particle board.

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1. Introduction
Wood is known to contain and emit volatile organic compounds including formaldehyde. Exposure to formaldehyde has non-carcinogenic effects, such as irritation of the eyes, nose and/or throat and carcinogenic effects on health. Amino resins such as urea-formaldehyde (UF), melamine-urea-formaldehyde resins (MUF), etc. are primarily responsible for the EF of composite wood products. More recently, MUF has shown that resins produce particle boards with much lower FE than UF control resins [1] with good moisture resistance. According to Dunky [2], the stability to hydrolysis that increased MUF may be due to stabilization of the CeN bond resulting from the almost aromatic cyclic structure of melamine and slower decrease in pH in the binding line and due to melamine buffering capacity. Test methods such as the desiccator method, chamber method or the gas analysis method provide different FE values and different measurements of the formaldehyde content by the perforator method for the same wood product [3]. The desiccator method has been widely used in countries of the Asia-Pacific region, such as Korea, Japan, Malaysia, Indonesia, Australia and New Zealand, while the perforator method (also called method of extraction) has been conventionally used in European countries. In contrast, the grand chamber method was the norm in North America.

The purpose of this paper is to compare two methods of analysis to determine the level of formaldehyde in a particle board sample made from urea formaldehyde resin. [4-7]

2. Material and methods
2.1 Formaldehyde release
The formaldehyde release was performed on two test pieces of 400 mm × 50 mm × panel thickness (the test pieces should be sealed with a self-adhesive aluminum strip. The test pieces were placed on a chamber conditioned on the following parameters: Temperature (60 °C), Air flow (60L/h), Pressure (between 1000 and 1200 Pa).

The formaldehyde released by the test piece is continuously derived from the test chamber in "wash-gas" bottles where it is absorbed and determined in quantity, after the duration of the test (4 hours), the contents of each pair of vials in the 250 ml volumetric flask.

The solution of formaldehyde is determined by the acetylacetone method, the determination of formaldehyde is based on the Hantzsch reaction in which formaldehyde solution reacts with ammonium ions and acetylacetone to give diacetylhydrolutidine (DDL), this DDL has maximum absorption at 412 nm.
The gas analysis value and calculate it according to the following equation:

\[ Gi(\text{mg} / \text{m}^2\text{h}) = \frac{As - Ab}{F} \times f \times V \]

Or:
- \( Gi \): the formaldehyde content of the solution for each hourly sampling in (mg / m\(^2\)h)
- \( i \): the first, second, third and fourth hours
- \( As \): the absorption of the solution of the vials
- \( Ab \): the absorption of distilled water
- \( f \): the slope of the calibration curve of the formaldehyde standard solution, in (mg / ml)
- \( F \): the total area of unsealed emission areas, in (m\(^2\))
- \( V \): volume of the volumetric flask in (ml).

Therefore the mean gas analysis value \( Gm \) of a test piece is calculated according to the following equation:

\[ Gm = \frac{G1 + G2 + G3 + G4}{4} \]

If the maximum level is not reached during the first hour, use the sum of three times for the calculation

\[ Gm = \frac{G2 + G3 + G4}{4} \]

### 2.2 Influence of the Moisture content

The study of the influence of the panel moisture on the formaldehyde content was carried out by choosing samples in wood-based panels with a humidity ranging from 7 to 12%.

The determination of this property is based on the difference between the wet mass and the anhydrous mass of 12 samples of dimensions (25 × 25 × panel thickness) mm after drying to a constant mass at (103 ° C ± 2), by the standard NF EN 322.

The moisture content was calculated as a percentage to within 0.1% using the following formula:

\[ H(\%) = \frac{M_h - M_0}{M_0} \times 100 \]

Or: \( M_h \) is the initial mass of the test piece in grams and \( M_0 \) is the mass of the test piece after drying in grams.

### 2.3 Formaldehyde extraction

The formaldehyde content was carried out according to the perforator method, this method consists in cutting test pieces of dimensions (25 × 25 × panel thickness) mm, then the test pieces were conditioned to a constant mass at temperature of (23 ± 1) ° C and at (45 ± 5)% relative humidity.

A mass of 110 g of panel was introduced into a flask, toluene is added to the flask, and then the mixture is bonded to the perforator.

After an extraction time of 2 hours, the formaldehyde content of the aqueous extract was determined photometrically by the acetylacetone method, the determination of formaldehyde is based on the Hantzsch reaction in which formaldehyde solution aqueous reacts with ammonium ions and acetylace tone to give diacetylhydrolutidine (DDL), this DDL has an absorption maximum at 412 nm.

The formaldehyde content is calculated according to the relationship below:

\[ FC = \frac{(As - Ab) \times f \times (100 + H) \times V}{mH} \]

Or:
- \( FC \): is the formaldehyde content (mg / 100 g anhydrous dry panel)
- \( As \): is the absorption of the extraction solution analyzed
- \( Ab \): is the absorption of a distilled or demineralized water
- \( f \): is the slope of the calibration curve (in mg/ml)
- \( H \): is the moisture content of the wood-based panel as a percentage
- \( mH \): is the mass of test pieces, in grams
- \( V \): is the volume of the volumetric flask (2000 ml)
3. Results and discussion
Mean values and standard deviations of the formaldehyde content and formaldehyde release of the particleboard sample are given in the following tables:

**Table 1. Extraction value perforator.**

<table>
<thead>
<tr>
<th>Humidity of the panel (%)</th>
<th>Value at the perforator</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>11.1</td>
</tr>
<tr>
<td>Value at the perforator</td>
<td></td>
</tr>
<tr>
<td>(mg / 100g dry anhydrous panel)</td>
<td>1st determination</td>
</tr>
<tr>
<td>Value at the perforator</td>
<td></td>
</tr>
<tr>
<td>(mg / 100g dry anhydrous panel)</td>
<td>2nd determination</td>
</tr>
</tbody>
</table>

**Table 2. Gas Analysis Values.**

<table>
<thead>
<tr>
<th>Gas analysis value (mg / m²h)</th>
<th>1st determination</th>
<th>2nd determination</th>
<th>Gas analysis value (mg / m³h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st hour</td>
<td>0.845</td>
<td>1st hour</td>
<td>0.813</td>
</tr>
<tr>
<td>2nd hour</td>
<td>0.780</td>
<td>2nd hour</td>
<td>0.683</td>
</tr>
<tr>
<td>3rd hour</td>
<td>0.618</td>
<td>3rd hour</td>
<td>0.553</td>
</tr>
<tr>
<td>4th hour</td>
<td>0.520</td>
<td>4th hour</td>
<td>0.488</td>
</tr>
<tr>
<td>Average</td>
<td>0.7</td>
<td>Average</td>
<td>0.6</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>0.1</td>
<td>Standard deviation</td>
<td>0.1</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>0.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

It can be seen that the formaldehyde content by the so-called perforator extraction method is very high compared to the formaldehyde release value, which makes it possible to say that the extraction method makes it possible to determine the total formaldehyde content of the formaldehyde sample of the panel tested, against the method of gas analysis can determine that the amount of formaldehyde released by the faces of the panel tested.

**References**