The effects of low formaldehyde emission on the mechanical characteristics of wood-based panels: an experimental study

Catas and University of Udine collaboration (thesis student: Piero Cozzi)

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It is only in more recent years that the accumulation of information and experience on the health damage caused by poor air quality has led to a need for more in-depth knowledge on the sources of indoor pollution. Studies have shown that furniture is a potential source of indoor pollution, and the causes are linked to emissions of hazardous substances from wood-based panels, paints and coatings.

Since 2006, with the classification of formaldehyde as a carcinogenic substance, the international legislative and regulatory situation has gone through profound changes, requiring compulsory and no longer voluntary product certification.
In Europe, the harmonised standard EN 13986 has been defined, which regulates the requirements for the use of wood-based materials in building sector and the emission class E1; the formaldehyde emission class E1 defines a limit value for formaldehyde emissions of 0.1 ppm.
In the United States, on the other hand, CARB/EPA product certifications, being more restrictive than in Europe, were initially (2009) introduced only in the state of California and later (2017) in all federal states for some types of semi-finished products.
Other countries impose different limits to those in Europe and America.
For several years now, formaldehyde emissions have been affecting the entire world market for panels and products made from them, such as furniture and other furnishing components, because of the associated health implications.
While there is a growing interest in ensuring the sale of products that are considered 'healthy', i.e. not harmful to human health, the market also demands products that guarantee a certain standard of performance.
This gave rise to the idea of carrying out an experimental study on the effects of low formaldehyde emission on the mechanical characteristics of wood-based panels. The study was conducted as part of a **three-year thesis for the Mechanical Engineering course at the University of Udine** and was carried out in the Chemical and Mechanical departments of CATAS, which daily deal with analyses relating to the physical-mechanical characterization of wood-based materials and semi-finished products and formaldehyde emission.

The aim of the activity was to evaluate the possible variation in the physical-mechanical performance of wood-based panels (specifically CARB panels) as products characterized by lower formaldehyde emissions compared to those commonly commercialized on the European market (E1 panels).
The test methods selected for the study were:

- bending tests (EN 310),
- surface soundness (or adhesion, EN 311),
- tensile strength perpendicular to the plane (or cohesion, EN 319),
- resistance to axial withdrawal of screws from the surface (EN 320),
- determination of density (EN 323).

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The experimental tests were carried out on a large number of sample panels (39 samples), both particleboards and MDF, of the emission classes CARB and E1, from different manufacturers and characterized by different thicknesses. Such a selection of samples made it possible to collect a large amount of data and thus to get as general a picture as possible of the current situation.

First of all, it was verified that the tested samples complied with the minimum voluntary requirements for particleboards and MDF, as defined by the reference standards EN 312 and EN 622 respectively.

In order to identify possible trends in terms of mechanical performance for the two classes of panels, a general analysis of the graphs obtained was carried out by reporting the values of the mechanical characteristics (determined with the experimental tests) in relation to the thickness of the sample panels.
The general analysis of the test results did not allow to establish a certain correlation between the variation of the mechanical characteristics and the reduction of the formaldehyde emission; the graphs obtained for CARB and E1 panels, both chipboard and MDF, show in fact a good overlapping of the results (point clouds), such as not to allow to highlight noteworthy deviations.

Since the general analysis of the data did not show any significant trend, later it was decided to study the test results by classifying the samples into three thickness ranges in order to highlight any "local" trends, which could not be appreciated in general terms. In particular, more attention was paid to intermediate thickness panels (13÷22 mm) as they are widely used in the wood furniture sector.
This analysis showed, especially for low to medium thicknesses, a tendency for CARB in MDF panels to determine slightly higher values of mechanical properties than for E1 panels. For particleboards, on the other hand, no significant trends could be identified. Since an analysis of this kind is particularly sensitive to data variability and the size of the sample population, it was not possible to quantify exactly these trends based on the available data.
These observations therefore lead to the conclusion that, to date, CARB and E1 panels are characterized by completely comparable performances and therefore that the introduction of measures to reduce formaldehyde emissions has not led, actually, to the presumed decay of the mechanical performances of wood-based panels or, in any case, that the possible gap has already been overcome.
The results obtained from the experimental tests also confirm the statements made by some panel manufacturers. They claim that the need to reduce formaldehyde emission in order to comply with CARB emission limits has, over the years, stimulated the search for alternative production solutions to the simple reduction of adhesive (and therefore of formaldehyde) in order to guarantee the production of panels fully equivalent, in terms of mechanical performance, to those belonging to class E1.
The result obtained therefore confirms what the manufacturers had already anticipated.

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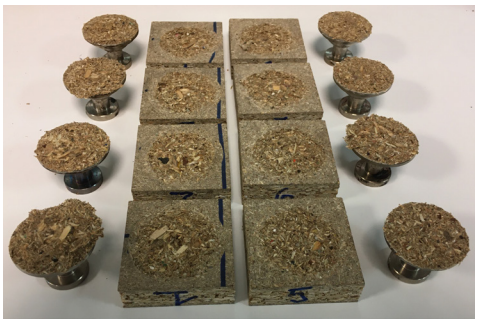

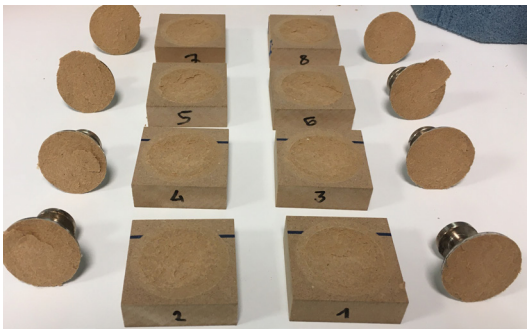

It should be pointed out that the observations to which the test results led, cannot disregard the fact that it was not possible to take into proper account all the variables that may have an influence on the final performance of the products analyzed (sampling method, year of production of the panels, raw materials and production techniques used, etc.), as well as the fact that the study took into consideration panels of the CARB and E1 emission classes only.
An interesting development of this work could concern the study of a limited number of sample panels having the same characteristics (type of panel, thickness, etc.) and from the same producer in order to minimize the variables involved and therefore make a comparison "all other things being equal" to precisely quantify the influence of formaldehyde emission on the mechanical characteristics of the panels.

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