DEVELOPMENT AND PILOT PRODUCTION OF SUSTAINABLE BIO-BINDER SYSTEMS FOR WOOD-BASED PANELS

Deliverable 5.1 - Summary

LCA current state-of-the-art resins

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Publishable summary

The SUSBIND project

The SUSBIND consortium develops, produces and tests bio-based adhesive systems as an alternative to adhesive systems based on a formaldehyde resin as currently used for wood-based panel boards in furniture mass production. SUSBIND aims at producing these bio-based adhesive systems with leading wood board manufacturers for two product types: P2 particleboard (PB) and medium density fibreboard (MDF). The resulting bio-based adhesive system aims to outperform current conventional adhesive systems by means of a significantly lower carbon footprint, while also reducing emissions toxic to humans.

This study

The goal of this Life Cycle Assessment (LCA) is to determine the environmental performance of conventional adhesive systems currently used in PB and MDF. This sets the benchmark/reference for the bio-based adhesive system that will be developed within the SUSBIND project. In line with the project's goals, two environmental indicators are used to assess whether the bio-based board is an interesting alternative: the carbon footprint (contribution to climate change) and the human toxicity potential. For the bio-based adhesive systems, LCAs will be carried out as well. In these LCAs the carbon footprint and the toxicity potential will be addressed, as well as other impact categories such as land use and eutrophication. These impact categories will be included in the assessment, to make sure the most sustainable choices are made for the bio-based product.

Function and functional unit

The SUSBIND consortium aims to develop an adhesive system for two types of board products, particle board (PB) of Type P2 and medium density fibreboard (MDF). For each of these boards a functional unit is defined:

- Functional unit for PB: An adhesive system for P2 PB measuring 450 by 550 by 14 mm, meeting the performance requirements.
- Functional unit for MDF: An adhesive system for MDF measuring 450 by 550 by 12 mm, meeting the performance requirements.

'Adhesive system' is defined in this assessment as all components of the board which are not wood. This includes the resin and any additives which contribute to attaining the functional requirements. The assumption behind this definition is that the wood use (type and quantity) will not change when switching from conventional to a bio-based adhesive. The energy use required to produce the board (to press resin and wood chips together etc.), as well as wood production and (pre)treatment is outside the scope of this first analysis, with the assumption that switching from conventional to bio-based adhesive will not influence this energy use. For end-of-life, incineration without energy recover is assumed. These assumptions will be checked later in the SUSBIND project.

Carbon footprint

The default carbon footprint of PB adhesive is about 540 g CO_2 eq./piece of board for a UF-based adhesive, and 600 g CO_2 eq./piece of board for a MUF-based adhesive. These results are illustrated in Figure 1. For MDF, the carbon footprint of a UF-based adhesive is about 720 g CO_2 eq./piece of board and about 970 g CO_2 eq./piece of board for a MUF-based adhesive (not shown since results for PB are lower).

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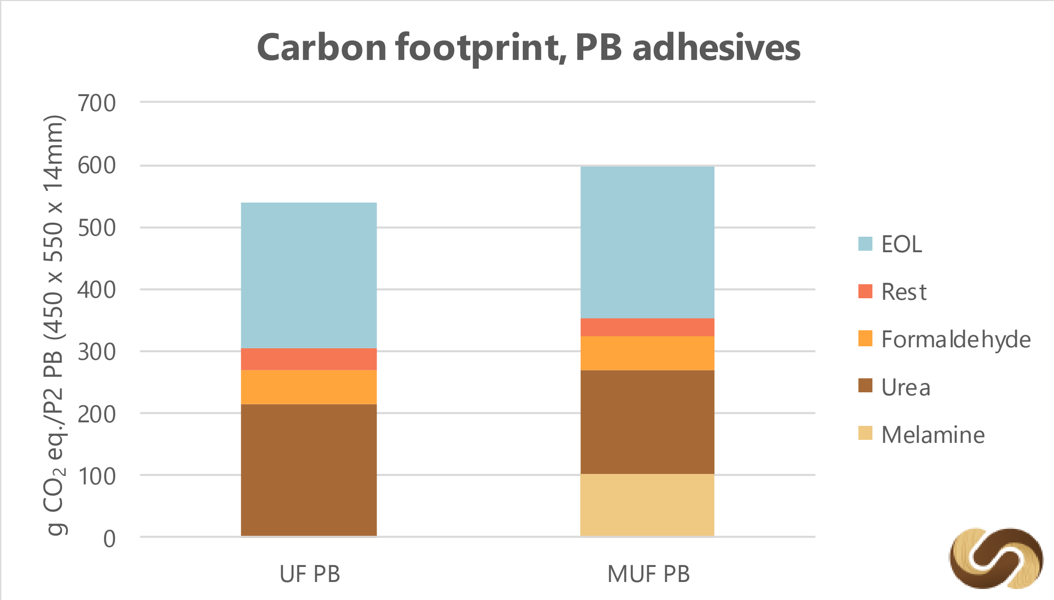
Figure 1 Carbon footprint of adhesive systems in PB, expressed per piece of board (functional unit).



In PB, the production of melamine, urea and formaldehyde account for 50-55% of the carbon footprint, and EOL for about 40%. The contribution of other processes and auxiliary materials is minor. In MDF, the production of melamine, urea and formaldehyde account for 35-55% of the carbon footprint, while EOL accounts for 50-55%. The contribution of other processes and auxiliary materials is minor.

Uncertainty analyses show that the carbon footprint can vary; in practice board densities vary depending on for instance the type, quality and moisture content of the wood used. This can influence the amount of adhesive necessary to meet the functional requirements. Assuming a low density (based on low amount of adhesive use), the carbon footprint could be 490 g CO_2 eq. for PB (based on UF-adhesive) and 650 g CO_2 eq. for MDF (also based on UF-adhesive).

Human toxicity potential

The production phase and the use phase are relevant when assessing the toxicity potential of boards. The goal of the assessment of the toxicity potential is not to assess total toxicity, but to provide a benchmark against which the bio-based board can be assessed. We use the ReCiPe endpoint indicator *Human Health*[1] as an indicator for the toxicity potential, which we will call 'toxicity score' here.

Our assessment show that for conventional boards, emissions other than formaldehyde contribute relatively little to the total (weighted) toxicity score.

For the production phase, the toxicity score is based on the range of the total emission of formaldehyde in the production phase.

For the use phase, we look at the steady state emissions, which are reached after a certain period after production. Quantifying a toxicity potential for the whole use phase is both impractical and unnecessary. Using steady state emissions values is preferable over trying to develop such a toxicity indicator which covers all emissions during the use phase over the whole lifespan of a product, for two main reasons. First of all, we assume that the conventional board and the bio-based board will be used in the same way. And secondly, in practice (in people's homes) emissions and the impact of those for substances can vary substantially, related to for example humidity, temperature and ventilation, as well as number of inhabitants. Steady state emission

[1] ReCiPe is a life cycle impact assessment methodology. For more information see https://www.rivm.nl/en/Topics/L/Life_Cycle_Assessment_LCA/ReCiPe

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values imply a steady state over time. Assessing the toxicity impact for a time period (lifespan of 10 years) means a linear extrapolation of the impact at a point in time (the steady state).

Recommendations

For further carbon footprint assessments in SUSBIND we recommend comparing the bio-based to conventional adhesives using the lowest carbon footprints presented. These are 490 g CO_2 eq. for PB (based on UF-adhesive) and 650 g CO_2 eq. for MDF (also based on UF-adhesive). These values correspond to the analysis of boards at the lower end of the density range. They represent a comparatively ambitious benchmark for the SUSBIND project. At a later stage in the project, the assumptions underlying this benchmark should be double checked, to see whether an even more detailed assessment on density is necessary.

Furthermore when the bio-based adhesive has been developed, it is important to check whether the amounts of wood and energy used in the board production processes will change substantially. If so, they should be included in the analysis and we recommend revisiting the analysis presented here.

For the toxicity evaluation in the SUSBIND project we recommend that formaldehyde emissions from conventional boards, converted to a value in DALY (Disability-Adjusted Life Years)[2] on the ReCiPe endpoint indicator Human Health, should be used as a benchmark. For the production process this can be the total emission and for the use phase these should be the steady state emissions.

Bio-based boards should be tested according to the same test method as used for the conventional board to assess whether standards are met. If characterisation factors are not available for substances emitted from the bio-based boards, a representative proxy should be sought. The method proposed here should be regarded as a first order screening method and shall be evaluated in a later phase of the project, to assess the suitability for comparison with the bio-based boards produced. This method should be used to provide a go/no go decision; to provide an answer to the question whether it is reasonable to assume that the bio-based board has a lower impact on human toxicity (according to the goal set in the Grant Agreement). New insights may lead to changes or additions to the toxicity evaluation to make sure the most appropriate and suitable method is used.

Based on the conclusions and recommendations above, Table 1 presents the state-of-the-art carbon footprint and toxicity score for conventional adhesive systems. These can be used as benchmark values for environmental impact comparisons with the bio-based adhesive system that will be developed in SUSBIND.

Table 1 Benchmark values for carbon footprint and human toxicity impacts for conventional adhesive systems for use in the SUSBIND project

Indicator		PB	MDF	Unit
Carbon footprint		490	650	g CO_2 eq. / piece of board
Human toxicity	Production	< 1.5E-07	< 1.5E-07	DALY / piece of board, based on total emissions
	Use phase	< 1.5E-11	< 1.9E-11	DALY / piece of board, based on mg / m^3; steady state emission (EN 717-1)

[2] DALY is a unit that described the years of life lost due to impact on human health as well as years of life lived with a disability.

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