SUSBIND

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

Deliverable 5.5

Guideline for carbon footprint reduction at TRL 9

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Publishable summary

Background

The SUSBIND consortium partners have developed a partly bio-based, formaldehyde-free adhesive system for P2 PB and MDF boards. The 'SUSBIND resin' is based on fructose, hydroxymethylfurfural (HMF) from fructose and fossil bis(hexamethylene)triamine (BHT). The SUSBIND resin has shown promising technical performance in boards produced at small scale and in a prototype final product (TRL 5).

The first environmental goal of the SUSBIND project is to achieve a 5% carbon footprint reduction with an adhesive system based on SUSBIND resin when compared to state-of-the-art UF-based adhesive system. The LCAs conducted within SUSBIND (Deliverable 5.4) show that adhesive systems based on SUSBIND resin do not yet meet the 5% carbon footprint reduction target compared to UF. This is primarily due to the use of the fossil crosslinker, BHT. BHT contributes between 43% and 65% of the total carbon footprint of SUSBIND adhesive systems (with the values depending on the resin content and whether MDF or P2 PB is considered).

While not the focus of this analysis, it should be noted that the SUSBIND project achieved its second environmental aim, namely to develop a resin which reduces emissions that are toxic to humans during the use phase of wood-based boards (e.g. in a piece of furniture). A first assessment based on measured emissions from boards shows that the overall human health impact of SUSBIND boards is expected to be about 40 to 55% lower than that of UF/MUF boards (based on the ReCiPe 2016 human health indicator). The main contributor to the human health indicator are formaldehyde emissions. These are already very low in the MUF/UF reference boards (well below the E1 emission standard and thus considered safe).

Goal and approach

In this report, various options to reduce the carbon footprint when further developing SUSBIND resin from TRL 5 to TRL 9 are evaluated. They are derived from the contribution analysis of the LCA results from Deliverable 5.4 and have been discussed with the SUSBIND consortium. The analysis covers effects of upscaling, ingredient sourcing, resin formulation and board formulation. It focuses especially on BHT because of its large contribution to the carbon footprint. The analysis discusses six carbon footprint improvement options in detail and covers other developments relevant to the carbon footprint.

The aim is to assess whether such improvements can substantially reduce the carbon footprint of using a SUSBIND adhesive system in wood-based boards. The cradle-to-grave carbon footprint of the SUSBIND adhesive system should be reduced by 9% (MDF, 8% resin) or by 22% (P2 PB, 10% resin) to have the same carbon footprint as UF adhesive systems. However, as SUSBIND's formulated goal for TRL5 is to offer a 5% carbon footprint reduction compared to UF adhesive systems, this means that larger reductions are required.

Some key remarks on the current assessment are in order:

- The UF carbon footprint benchmark is relatively ambitious, as it is based on state-of-the-art production in Europe. In addition, urea and formaldehyde are relatively simple chemicals that have been produced in bulk for decades, meaning that producers have been able to optimise their processes extensively. Nevertheless, it is the most relevant benchmark for SUSBIND given its aim to reduce the carbon footprint compared to incumbent solutions.
- Due to uncertainties related to the early stage of development, the assessment of the six improvement options is partly based on assumptions and sometimes uses a break-even approach (i.e. 'What is required to meet the carbon footprint target?'). For example, since a bio-based production route to BHT is hypothetical at this point, we do not know whether its cradle-to-gate carbon footprint would be comparable to fossil BHT. When interpreting the results, these limitations should be kept in mind.

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Carbon footprint reduction options

The assessment of the six carbon footprint reduction options is summarised in Table 1 below. This shows that all options can result in carbon footprint reductions and are thus relevant directions for further research. However, they all have different shortcomings as well, since they:

- do not result in a sufficiently large carbon footprint reduction (alternative fossil crosslinkers, reducing energy consumption of SUSBIND resin production);
- have not yet been developed/are not commercially available (bio-based BHT);
- are unlikely to be technically feasible (substantially lower amount of BHT, substantially lower amount of resin); and/or
- can also be applied to UF adhesive systems (bio-based wax emulsion, lower amount of resin).

Table 1 – Results for various carbon footprint reduction options for SUSBIND resin

Improvement option	**Most important assumption(s)**	**Effect on overall carbon footprint**
Reduce amount of BHT	Rest of board formulation/production stays the same Technical requirements can still be met with reduced BHT content	P2 PB (10% resin): if BHT reduction of 35% can be achieved, carbon footprint is equal to UF-based P2 PB MDF (8% resin): if BHT reduction of 20% can be achieved, carbon footprint is equal to UF-based MDF
Switch to alternative crosslinker	Rest of resin formulation stays the same	P2 PB (10% resin): if alternative crosslinker has a cradle-to-grave carbon footprint of max. 5.2 kg CO_2 eq./kg, carbon footprint is equal to UF-based P2 PB MDF (8% resin): if alternative crosslinker has a cradle-to-grave carbon footprint of max. 6.4 kg CO_2 eq./kg, carbon footprint is equal to UF-based MDF
Change BHT production: bio-based	Rest of resin formulation stays the same Impact of production of bio-based BHT is the same as of fossil BHT No EOL emissions for bio-based BHT	P2 PB (10% resin): if bio-based BHT with set assumptions can be used, overall carbon footprint is still higher than UF-based P2 PB MDF (8% resin): if bio-based BHT with set assumptions can be used, overall carbon footprint is lower than UF-based MDF
Reduce energy consumption of resin production	-	Even if the impact of energy use would be reduced to 0, the total carbon footprints of the SUSBIND adhesive systems would still be higher than that of UF adhesive systems
Change additives: bio-based hydrophobic wax	Rest of board formulation stays the same Impact of production of bio-based wax is the same as of fossil wax No EOL emissions for bio-based wax	P2 PB (10% resin): the overall carbon footprint can be reduced by 3% using bio-based wax with set assumptions. However, as the same amount of wax is used in UF-based PB, the effect on the carbon footprint would be bigger and as such the difference between the two would increase. MDF (8% resin): the overall carbon footprint can be reduced by 25% using bio-based wax with set assumptions. However, as the same amount of wax is used in UF-based MDF, the effect on the carbon footprint would be bigger and as such the difference between the two would increase.

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Improvement option	Most important assumption(s)	Effect on overall carbon footprint
Reduce amount of resin used	Technical requirements can still be met with reduced resin content	P2 PB (10% resin): the break-even point to achieve the same carbon footprint as UF-based P2 PB is a resin content of 7%. It is unknown whether a lower resin content can be used for UF-based P2 PB as well. MDF (8% resin): the break-even point to achieve the same carbon footprint as UF-based MDF is a resin content of slightly below 7%. It is unknown whether a lower resin content can be used for UF-based MDF as well.

Conclusions and recommendations

This report explores various carbon footprint reduction options for the SUSBIND resin for wood-based boards. It can be noted that the carbon footprint reduction options considered are for the most part not mutually exclusive and that combinations might be possible. Given the uncertain nature of the individual assessments conducted here, it is complex to evaluate the overall carbon footprint effect of a combined approach. While challenging, it is not unlikely that a combination of options would enable SUSBIND resin at TRL5 to achieve its goal of a 5% carbon footprint reduction compared to UF resin.

However, larger carbon footprint reductions are required in order to meet the European and worldwide climate change goals. Furthermore, the carbon footprint of UF resin can also be reduced by improving its key production steps (ammonia production and methanol production). Nevertheless, such improvements would not change the composition of UF resins and as such, boards based on these resins would still emit the same level of formaldehyde and have the same potential human health impact. This is an area where SUSBIND resin is advantageous due to its lower formaldehyde emissions during the use phase.

Overall, we consider it unlikely that a truly substantial (e.g. >50% compared to UF) carbon footprint reduction would be achieved when the SUSBIND adhesive system is based around fossil BHT, or other fossil amine crosslinkers. In addition, next to its carbon footprint effect, the availability and price of BHT are also challenging (see the SUSBIND market uptake analysis, Deliverable 5.6).

In conclusion, the SUSBIND project shows that a carbohydrate-based adhesive for wood-based boards is technologically feasible. Moving forward, a promising direction is therefore to consider whether alternatives for the fossil crosslinker BHT would be able to offer a lower carbon footprint, e.g. when based on bio-based or recycled feedstocks. If, from a technical performance point of view, it is required to use amine groups in the crosslinker, the source of the nitrogen used should be considered as well.

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