Open-BIO
Opening bio-based markets via standards, labelling and procurement

Work package 4
Functionality Testing

Deliverable N° D4.5:
Standardization report on bio-based product testing
Mechanical, chemical, thermal and additional functionality testing

Public summary

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1 Public summary

This report demonstrates the functionality of selected commercial Bio-based products through testing. Deliverable D4.1 describes the selection of 7 product categories from the key categories for bio-based products defined in the EU FP7 project KBBPPS. These product categories are:

1. Packaging Films
2. Disposable cups & plates
3. WPC decking
4. Pre manufactured components/insulation
5. Mulch films
6. Adhesives and binders
7. Bio-solvents

Based on the above product categories, commercially available bio-based products have been selected for functionality testing. Key mechanical properties, key chemical/thermal parameters and additional functionalities as defined in the combined deliverable D4.2, D4.3 and D4.4 were evaluated.

For each of the selected product categories the key mechanical properties were defined in a way that they ensure the functionality of the product in the specific application and during the entire lifetime. Additionally, specific characteristics of the bio-based products that differ from existing petrochemical products have been addressed. Examples of these specific characteristics are moisture sensitivity and/or uptake.

Chemical resistance of the bio-based product was also identified to be of major importance related to the cleaning/ washing of products and the resistance to (organic) solvents used for example in glues and inks. Heat resistance was identified to be of importance based on the specific application, related to hot filling, sterilizing, microwave heating but also the exposure to direct sun light..

For each of the selected product categories the functionality of the bio-based products properties that are not directly related to mechanical, chemical and thermal testing was addressed (additional functionalities). Tests considered include isolation properties, migration barriers to gasses, weather ability, transparency, adhesion to other materials/surfaces.

AUA organised and performed, with the contribution of Novamont and OWS, a series of tests on commercial bio-based plastic films applicable to the agro-food sector (packaging films and

mulching films). WFBR organised, and performed the mechanical, chemical and thermal tests for the categories: disposable cups & plates, WPC decking, adhesives and binders and solvents with help of ISA. It was decided to limit the work on premanufactured component/insulation materials to a desk study because of the complexity of testing and the lack of testing expertise in this field within the consortium.

All generated data can be used as input for CEN/TC 411, ISO, and ASTM and for WP8. NEN will be instrumental in this.

Since the product categories chosen for testing differ largely from each other, the results are be reported per product category instead of per key parameter tested. A summary of the results obtained is presented in the following sub-sections.

1.1 Packaging films

Food packaging films tested include typical examples of bio-based compostable food packaging films that have a commercial significance: starch-based and PLA-, PLA blends-based food packaging films. A BOPP film was also tested as conventional fossil-oil based reference packaging film product. Standard testing methods were used for testing the most important mechanical properties (tensile properties, tear propagation, penetration resistance, seal strength) and additional physical properties (radiometric properties, gas transport properties and wetting tension) of the plastic food packaging films. Important findings are:

The tensile properties: of the packaging films under standard testing conditions are in agreement with the corresponding values given by the manufacturers (MDS). The elongation at break is reduced under frozen conditions for all PLA based and Mater-Bi films. The elongation at break of starch-based films is also reduced under water soaking conditions. It is therefore recommended to include these conditions in the specifications for packaging films.

Both the tear propagation resistance values measured following the Elmendorf method and the WVTR (water vapour transmittance) values obtained by the two laboratories show considerable differences. by the participating laboratories and the MDS value reported for a PLA blend based film show significant differences. To avoid major discrepancies among the reported WVTR values by various laboratories using the same standard (e.g. ASTM E96 / E96M – 14) it is recommended that the standard provides an approach to be used in achieving the targeted testing conditions.

No CO_2 transmission rate values are reported in MDS. It is highly recommended to report values CO_2 transmission rate in MDS as this is a critical property for Modified Atmosphere packaging of food products.

1.2 Disposables

The functionality of three different commercially available coated paperboard disposable cups was evaluated. Two cups with a (partially) bio-based coating and one cup with commonly used petro-based coating were selected for testing, this last one was used for comparison. There are no standards available to characterize paperboard based cups as a product. Therefore evaluation was done by using adaptations of standards developed either for paper and board or for plastics. Focusing only on the coating material was difficult due to the large influence of paperboard type in for example mechanical properties. Mechanical testing standards are usually designed for paper and board or for plastic. Within the paper and board standards, there are few standards that mention explicitly coated paper, for example NEN-ISO 5630-5, NEN-EN 13676 and NEN-ISO 16532-1. Due to the limited dimensions of the cups, mechanical testing had to be adapted to the dimensions of the available product, usually much smaller than the ones indicated in the standards.

Evaluated mechanical properties were tensile strength (ISO 527-1 for plastics) in machine and cross machine direction, before and after use/ageing; resistance to bending (ISO 5628 for paper and board) in machine and cross machine direction, before and after ageing; tear strength in machine and cross machine direction (ISO 1974 for paper) and puncture resistance (NEN-EN 14477 for packaging) before and after use.

The different testing conditions after use (coffee, and several times pouring hot water) show that cups can deal with high temperature liquids, the functionality of the coating in paperboard based cups is sufficient to reuse the cup up to three times. Longer storage of liquids in the disposable cups is not recommended due to possible leaking, de-attachment of the coating, etc., here the extreme case of one week was evaluated.

Water vapour permeability is the higher for the cups coated with bio-based polymers. Howwever higher water vapour transmission does not affect the functionality of the cups to hold hot liquids.

1.3 WPC decking

Based on the research described in OpenBio Deliverable report 4.2-4.4, three key parameters have been identified which are currently a technical hurdle for widespread introduction of WPC decking profiles in the European market: creep behaviour at elevated temperature (e.g. 50°C), impact resistance at low temperature (e.g. -20°C) and cleanability. Furthermore, heat build up, though not a property directly related to customer satisfaction, is considered a key parameter as it is a simple test which relates to high temperature creep rate of WPC profiles.

These properties have been tested for three commercially available WPC decking materials, two hollow profiles and one solid profile.

Results show that creep deformation of all three profiles meet the requirements at both 20°C and 50°C as specified in EN 15534-4. Outdoor trials in the Netherlands indicate that more demanding conditions than presently specified in EN 15534-4 should be included in this standard. At more demanding conditions, one WPC profiles (one producer) breaks in 3 out of 4 creep trials..

All three WPC profiles meet the specifications set for dart impact resistance in EN 15534-4, both at +20°C as well as at -20°C. However, it is questionable whether the impact mass of 1 kg dropped from 70 cm height sufficiently cover accidents reasonably occurring throughout many years of anticipated WPC service life. Impact tests using an increased dropping height of 150 cm, not uncommon for everyday life, show that one of the WPC profile grades leaves residual indentation and crack lengths larger than specified maximum in EN 15534-4.

Initial staining and cleanability trials have been performed. Further contamination and cleanability tests on WPC materials have to be performed in order to develop a standard test method for cleanability which is reproducible and which has practical meaning. An approach to develop such a standard cleanability test method has been drafted.

1.4 Premanufactured components/insulation

The key technical properties of pre manufactured biofibre insulation materials which have been identified to be currently a technical hurdle for widespread introduction in the European market include: Thermal conductivity, relative to mineral wool based insulation, at relevant humidity ranges; heat storage capacity, which is claimed to be better (higher) for biofibres than for mineral wool competitors, however, which is not included in everyday practice and design; sound insulation, which is considered to be better for biofibre than for mineral fibre, however, a clear comparative study on sound absorption seems missing.

As testing these properties would be complex and none of the Open-Bio project partners has got facilities to test these properties, it was decided that no tests will be performed. Instead, the background of the issues has been mapped, and a proposal for dealing with the issues have been developed.

The advantages of biofibre based insulation mats cannot be marketed effectively due to standard test methods which are not based on practically most relevant testing conditions. It is proposed that the testing method specifies analysis of the thermal conductivity performance of insulation materials at typical winter conditions, and at typical summer conditions, e.g. at 60°C and 60 or 80% RH. using direct meausements (rather than calculations). Biofibres have a higher heat capacity than mineral wool, which allows for improved protection against summer heat by using biofibres. It is proposed that a relevant set of experimental data will be collected to form the basis for communication to consumers. Impact sound re-

duction tests have to be performed for the entire construction, so including the covering, which may be a wood fibre based panel on one side and roofing tiles on the other side. It is proposed that the testing of sound absorption at different frequencies according to EAD 040005-00-12.01 (section 2.2.8) by just the insulation material alone will give a good first indication of its performance.

1.5 Mulching films

Products selected for testing are two typical examples of bio-based biodegradable mulching films that have a commercial significance: starch based and PLA blend based mulching films A Linear Low Density Polyethylene (LLDPE) 3-layer mulching film was used as conventional fossil-oil based reference mulching film product. Standard testing methods were used for the mechanical properties (tensile properties, weathering effect on tensile properties, tear propagation, impact resistance) and additional physical properties (radiometric properties, water vapour transmittance) of the plastic mulching films.

Some highlights and recommendations are summarized below.:

Ageing: The biodegradable mulch films are susceptible for ageing resulting in a decrease of mechanical properties. It is recommended to include a section on the artificial weathering exposure of bio-based films also in the draft standard prEN 17033.

Radiometric properties: The relative light transmission is suggested by prEN 17033 draft and the EN13655 standard to be measured by a lux-meter over a portion of the visible radiation spectrum, 500-600 nm, and not over the whole visible spectrum (380-780 nm), or the most important for plants (and weeds) PAR spectrum (400-700 nm) as required by the ASTM D1003 standard. As the most important spectrum for the photosynthetic organisms, and so for the weeds development, is the whole PAR (or visible) radiation spectrum, it is recommended that the prEN 17033 draft also measures of the whole visible spectrum.

1.6 Adhesives and binders

Adhesives and binders are a very broad product category and specific target (bio-based) products have been identified based on importance for the industry, novelty and identified hurdles. Recently water-borne paints with novel bio-based binders have been introduced into the market. A bio-based paint and a traditional oil based paint with the same color and for the same application were tested for mechanical and physical properties.

In most of the tests the bio-based paint results are comparable to the oil-based paint. This indicates that the bio-based paint is competitive in the market in comparison to oil-based counterparts. Scrub tests show that bio-based paint has good adhesion to the glass plate and scrubs less than the oil-based paint. Effect of household chemicals was evaluated by using ASTM D1308. The bio-based paint is more water sensitive and it absorbs water. Still it is not clear if this hinders commercial use of the paint.

1.7 Solvents

Within the solvents community there is certainly a need for a set of technical parameters to characterize a pure solvent and identify its potential uses. Especially for bio-based solvents that aim to replace existent, well known petro-based solvents, a set of characteristics to determine its functionality can be crucial in its successful introduction in the market.

Hansen solubility parameters are crucial for the introduction of bio-based solvents in the market, its knowledge and widespread can be helpful to make them of common use.

There are several ways of characterizing thermal properties of solvents, here we have shown that ISO 4626:1980 is a suitable method to determine boiling points if the values are not too high such as for Galasolv NV300 (above 300°C). And that TGA curves give already a first impression on the volatility of the solvents and the temperatures of complete and 50% evaporation. This is certainly a valuable method.