RECOMMENDATIONS

Recommendations to recycling industry

Different elements make particular the development of recycling processes for PBS:

- Very different degradation states can be obtained at the end of a PBS cycle, which can be associated to different optimal recycling routes.
- As it is already the case with PLA, the development of PBS will be associated to the development of **numerous types of formulations**, including the possible use of PBS homopolymer, copolymers, blends with other polyesters, compounds,… Only specific sources (homogeneous composition) will be possibly targeted to close loop material recycling
- PBS shows a high degree of interaction with organic compounds; it was shown to behave the same way as low density polyethylene towards aroma sorption. Consequently a post-consumer sourcing of PBS will be **possibly highly contaminated** and will be then difficultly reintroduced in the composition of a food packaging, except to consider a very effective decontamination method

As a consequence, the three following routes of PBS recycling should be chosen in specific cases:

- **1-The total depolymerisation** could be envisaged for any type of PBS material whatever the material degradation state, the contamination by undesired products during consumer uses, and the formulation complexity. The (green) enzymatic catalysed depolymerisation route studied in the project is at low TRL for this purpose; but more classical chemical routes are already possible convert soft polyesters into monomers. This route should be developed in common with the recycling of complex PLA materials. Its advantage is the possibility to purify perfectly the monomers; as a consequence it is the only realistic route for a close loop recycling in food contact, after post-consumer collection.
- 2- The **conversion into oligomers** of this complex source is technically much easier; both enzymatic and chemical routes can be chosen to convert the initial material into functional oligomers; after this step, oligomers can be flexibly re-converted to appropriate grades by SSP or classical melt condensation. As underlined by the work done in WP1, oligomers are interesting intermediate products which can be flexibly converted into specific grades. Considering the quite undefined composition of such a material, no food contact application should be recommended. At the contrary in the case of a well-defined polymer source (i.e. not post-consumer source, and constant composition), this procedure should be compatible with a close loop recycling. For a better control of material composition, a fraction of the oligomer used should be from the virgin (well defined) material.
- 3- The **direct conversion of the degraded polymer into a repaired grade** (M_w increase + restabilization) should be made in the same conditions as the previous route ; the only difference is the less flexibility of a process starting with an

heterogeneous batch (oligomers + polymers) compared to the treatment of an homogeneous population of oligomers

The three recycling routes should be chosen as a function of the quality of the material:

- Very heterogeneous compositions (various formulations) should be oriented to route 1
- Very heterogeneously degraded sources should be oriented to route 2
- Other materials could be recycled via route 3.

Concerning the qualification of the degradation state, a smart labelling technic has been developed during the project. When marked, the material becomes yellow when its M_w is below 100 KDa. Due to the actual price of the molecular rotor used, the smart method is only envisaged as a quality control test. But cheaper molecules with the same function should be developed as systematic markers.

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