

From application to CO2 in 180 days – biodegradable PSA tapes

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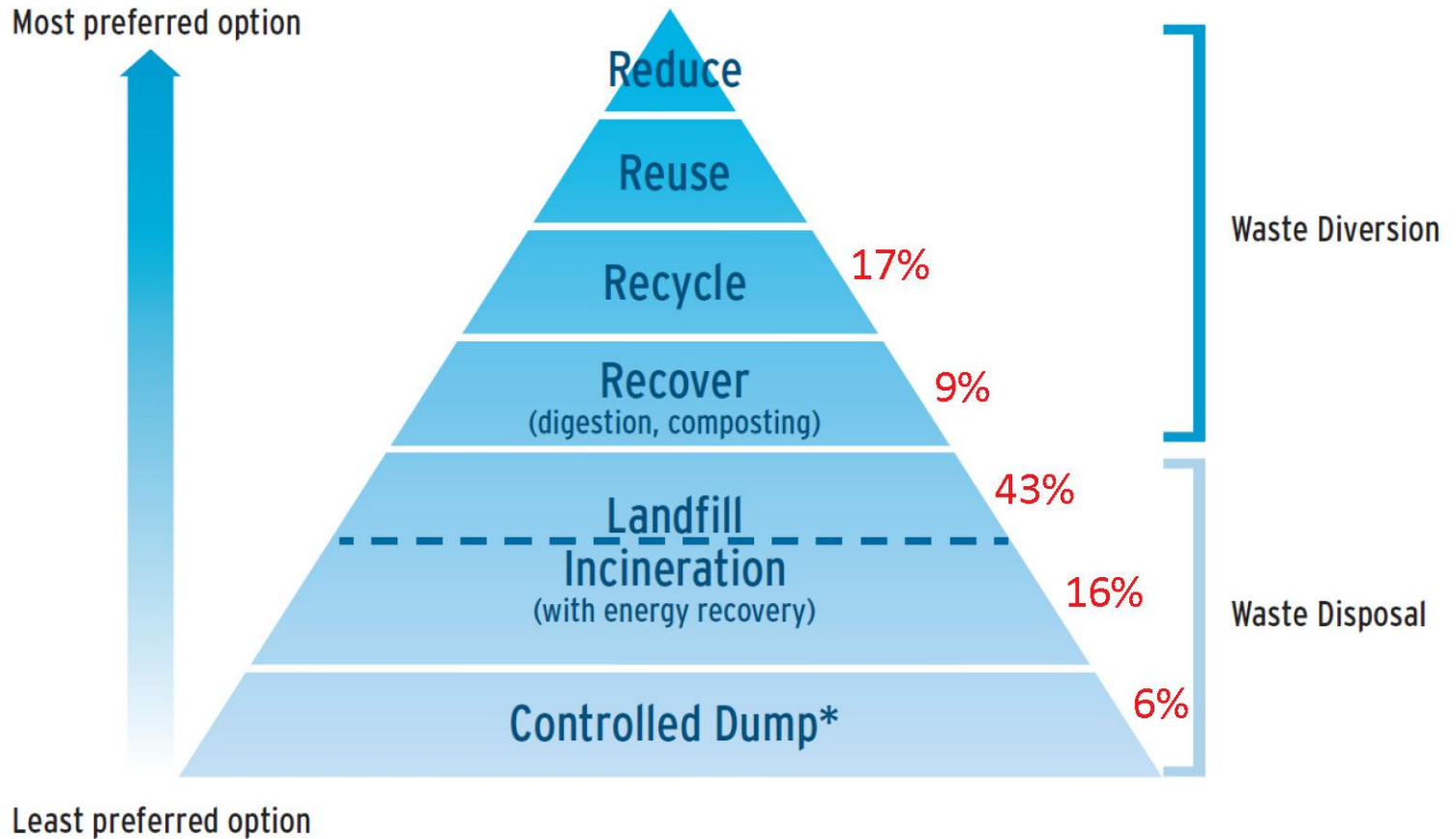
1. Motivation and Introduction
2. Principles of Biodegradability
3. Adhesive Design
4. Backing Selection
5. Design Example 1 (Surface Protection Tape)
6. Design Example 2 (Packaging Tape)
7. Summary

General Trends in Packaging Industry

- the good news
 - the packaging industry is continuously growing
 - packaging design is getting more and more important
 - packaging is supposed to offer further functionalities
- the bad news
 - the more packaging the more waste....

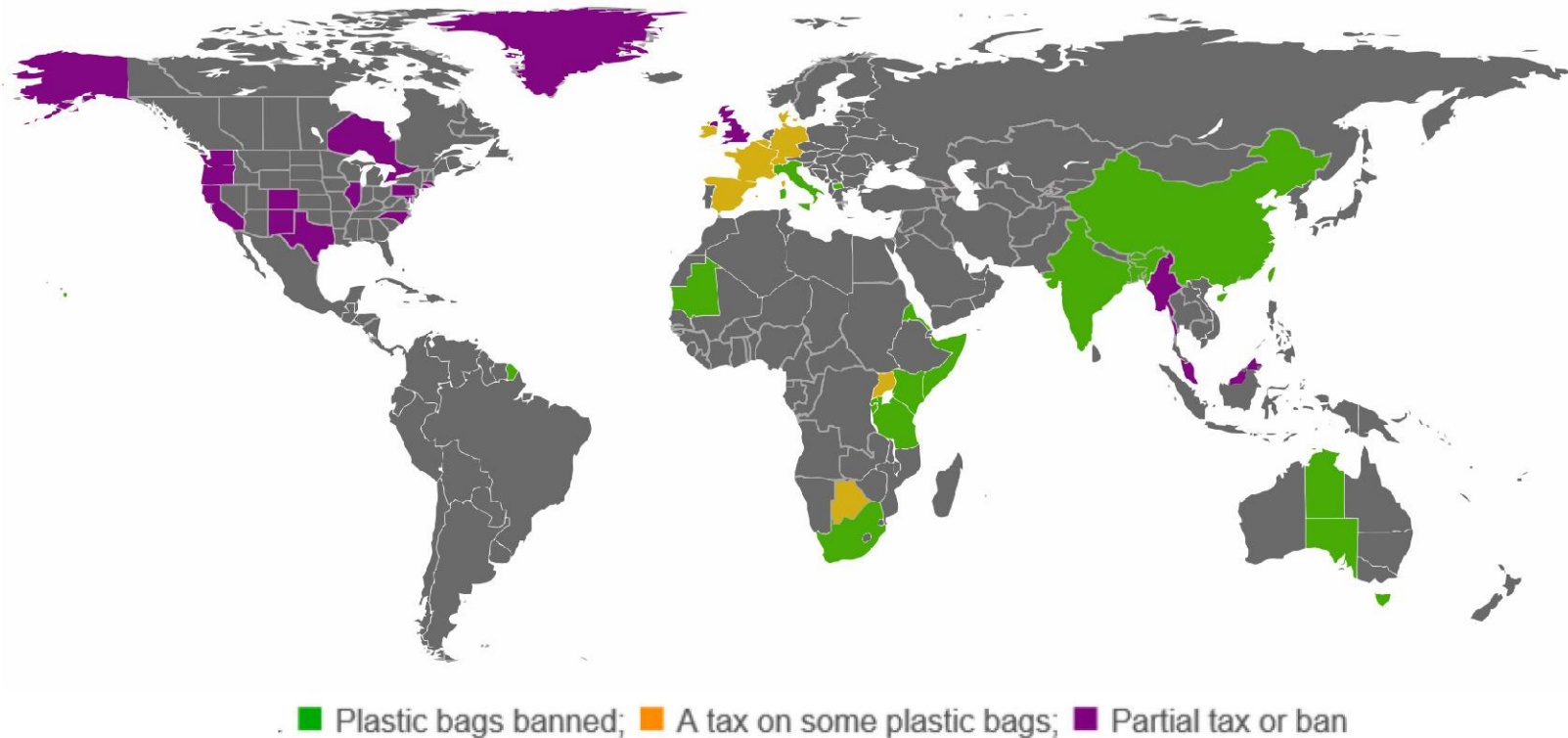
...we should at least use it right

Worldwide Waste Management



source: "What a waste – a global review of solid waste management (World Bank, 2012)"

Lightweight Plastic Bag Ban Regulations



- probably much more to come
- growing number of customer requests over the past years

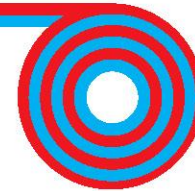
source: Wikipedia, seen on 2014-07-14; http://en.wikipedia.org/wiki/Phase-out_of_lightweight_plastic_bags#cite_note-worldbag_reduction-4

How Can We Contribute?

- enable more sustainable end-of-life scenarios
- enable completely biodegradable packaging

biodegradable backing

biodegradable adhesive

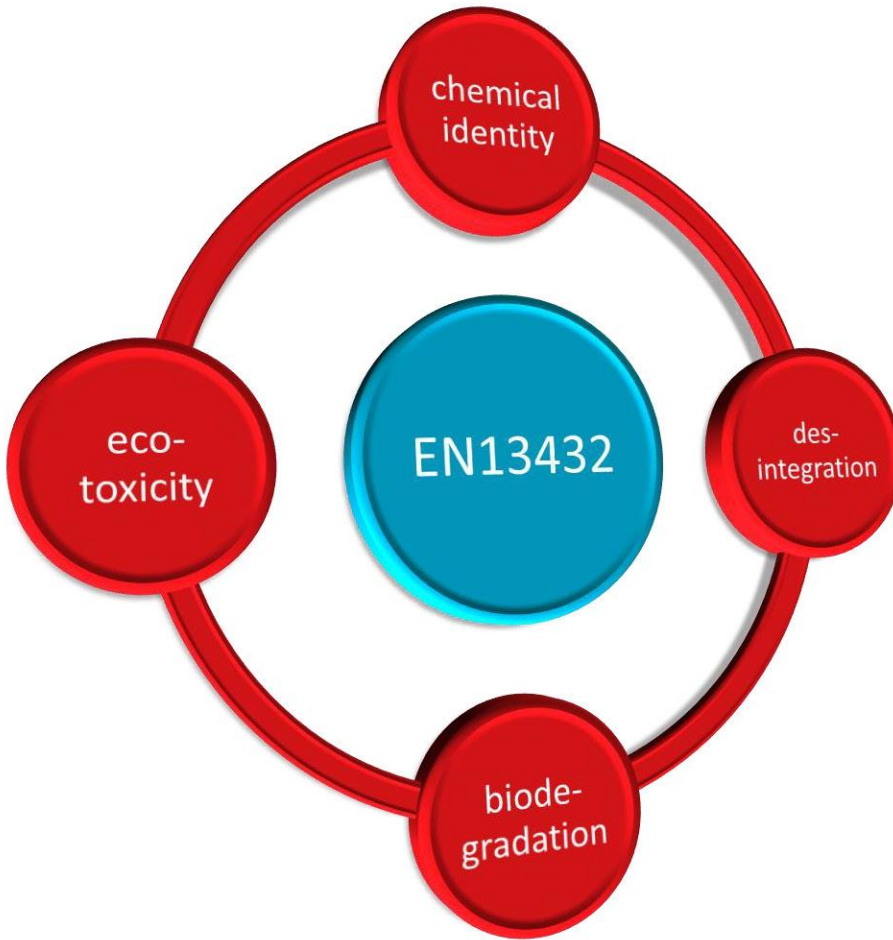


biodegradable
tape

Lead products: biodegradable films for surface protection and packaging

- biodegradability according to DIN EN 13432 (90% of material converted into CO₂, H₂O and biomass within 180 in industrial composting facilities)
- adhesion according to application
- high shear strength
- ageing stability
- clean removability
- nice-to-have: high biobased content

What Does Biodegradability Mean?



biodegradable polymers

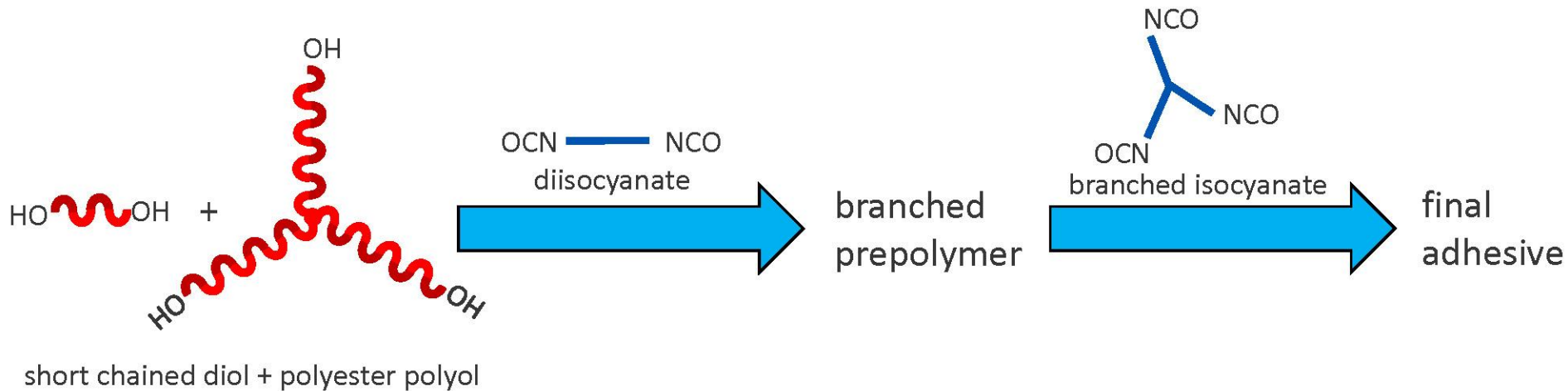
- polyesters
- polyurethanes
- carbohydrates
- amino acid-based polymers
- ...

→ heteroatoms in the polymer backbone

biodegradability tests performed at



Basic Architecture of PU-Based PSA



Variations that might influence adhesive properties AND the biodegradability

- polyester composition
- diol/polyester ratio
- OH/NCO ratio
- degree of prepolymer branching
- final degree of branching

Polymer Design vs. Adhesive Properties and Speed of Disintegration

| | | A | B | C | D |
|--|--------|------|------|------|------|
| diol/polyester | | 0.43 | 0.43 | 0.43 | 0.43 |
| isocyanate/diol (prepolymer) | | 0.7 | 0.7 | 0.9 | 0.9 |
| isocyanate/diol (final) | | 0.9 | 1.05 | 0.9 | 1.05 |
| peel (180°, steel) | [N/cm] | 2.64 | 0.1 | 0.43 | 3.33 |
| peel (180°, ABS) | [N/cm] | 2.82 | 0.64 | 0.36 | 3.77 |
| disintegration | [d] | 49 | 107 | 14 | 84 |
| micro shear test (40 °C, 3 N, 15 min) | [µm] | 120 | 19 | 2000 | 61 |

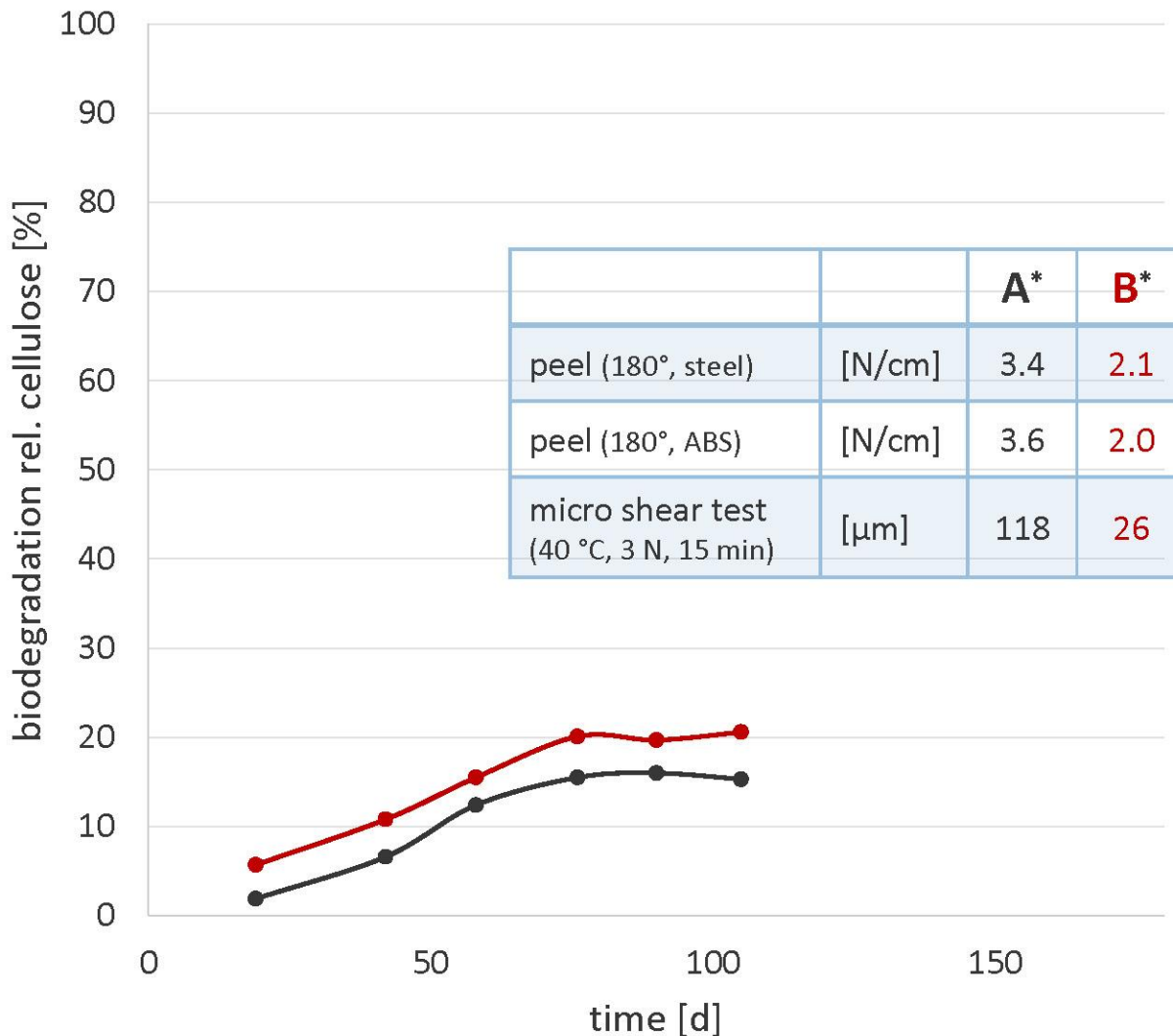
* 50 g/m², coated on 23 µm PET backing

Polymer Design vs. Adhesive Properties and Speed of Disintegration

| | | E | F | G | H |
|--|--------|----------|----------|----------|----------|
| diol/polyester | | 2.33 | 2.33 | 2.33 | 2.33 |
| isocyanate/diol (prepolymer) | | 0.7 | 0.7 | 0.9 | 0.9 |
| isocyanate/diol (final) | | 0.9 | 1.05 | 0.9 | 1.05 |
| peel (180°, steel) | [N/cm] | 2.1 | 0.23 | 3.65 | 1.37 |
| peel (180°, ABS) | [N/cm] | 2.43 | 0.11 | 2.54 | 1.44 |
| disintegration | [d] | 130 | X | 14 | X |
| micro shear test (40 °C, 3 N, 15 min) | [µm] | 22 | 4 | 2000 | 14 |

* 50 g/m², coated on 23 µm PET backing

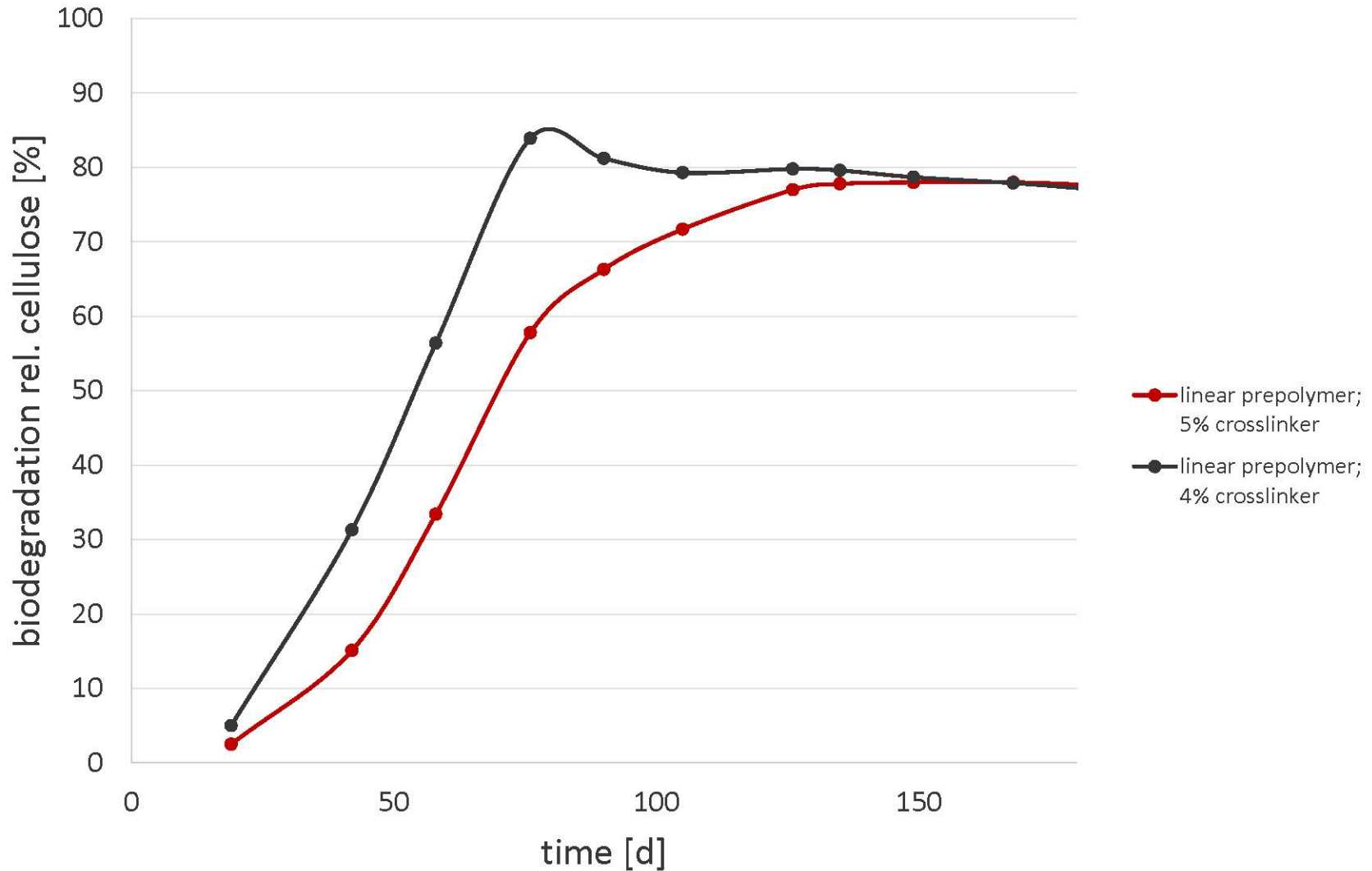
Biodegradability of Adhesives With Branched Prepolymers



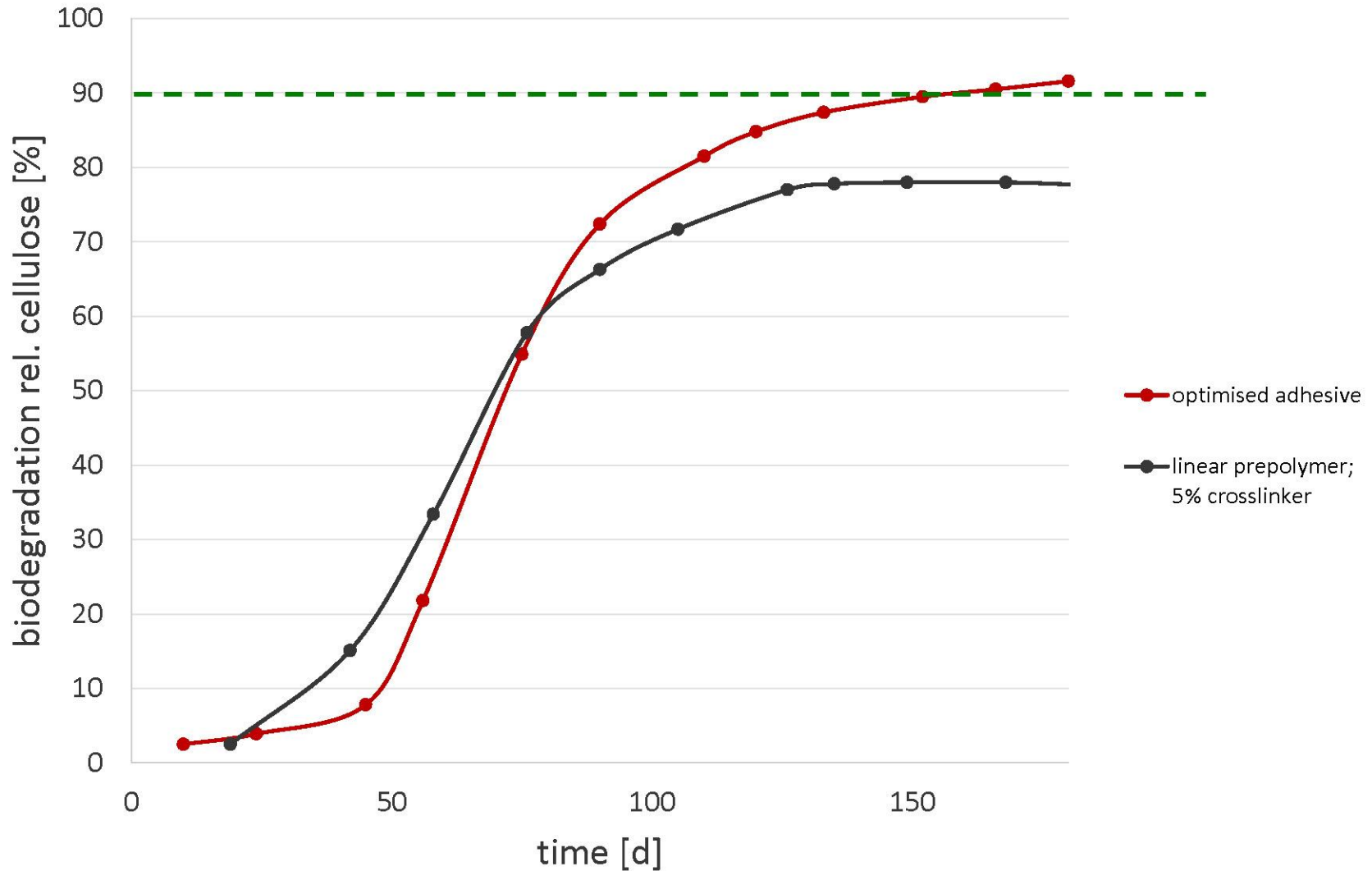
- branched prepolymer; 5% crosslinker
- branched prepolymer; 4% crosslinker

* 50 g/m², coated on 23 µm PET backing

Biodegradability of Adhesives With Linear Prepolymers



Biodegradability of Optimised Adhesive



Biodegradable Films Suitable as Tape Backing

- polybutyrates (e.g. ecoflex® by BASF)
 - PLA blends (e.g. ecovio® by BASF)
 - PBS
 - PLA
 - PHA
 - ...
- } soft, low modulus
- } rigid, high modulus

Evaluation criteria

- mechanical behaviour (depending on application)
- temperature resistance (during coating process and storage)
- solvent resistance (coating process)
- anchorage to adhesive

Adhesive Profile of a Biodegradable Surface Protection Tape

| | | |
|---|------------|---------|
| peel strength (steel) | [N/cm] | 0.4 |
| peel strength (ABS) | [N/cm] | 0.6 |
| peel strength (ABS) 21 d @ 60 °C | [N/cm] | 4.0 |
| micro shear test (max.) (15 min, 5 N, 40 °C) | [μ m] | 30 |
| static shear test (10 N, 23 °C) | [min] | >10 000 |

Results of Application Tests for Surface Protection Tape

| | | | 21d @ 60 °C | 7d @ 40°C, 100% rel. hum. |
|-------------|----------------|------------|---------------|---------------------------|
| ABS | discolouration | | slight shadow | none |
| | residues | 90 ° slow | ✓ | ✓ |
| | | 180° rapid | ✓ | ✓ |
| | adhesion | | good | good to high |
| glas | discolouration | | none | none |
| | residues | 90 ° slow | ✓ | ✓ |
| | | 180° rapid | ✓ | ✓ |
| | adhesion | | good | good |

Adhesive Profile of a Biodegradable Packaging Tape

| | | |
|--|--------|--------------------------|
| peel strength (box paper) | [N/cm] | 2.7 (paper splitting) |
| static shear test (steel, 10 N, 23 °C) | [min] | >5 000 |
| static shear test (cardboard, 30 N, 23°C) | [min] | >1 000 |

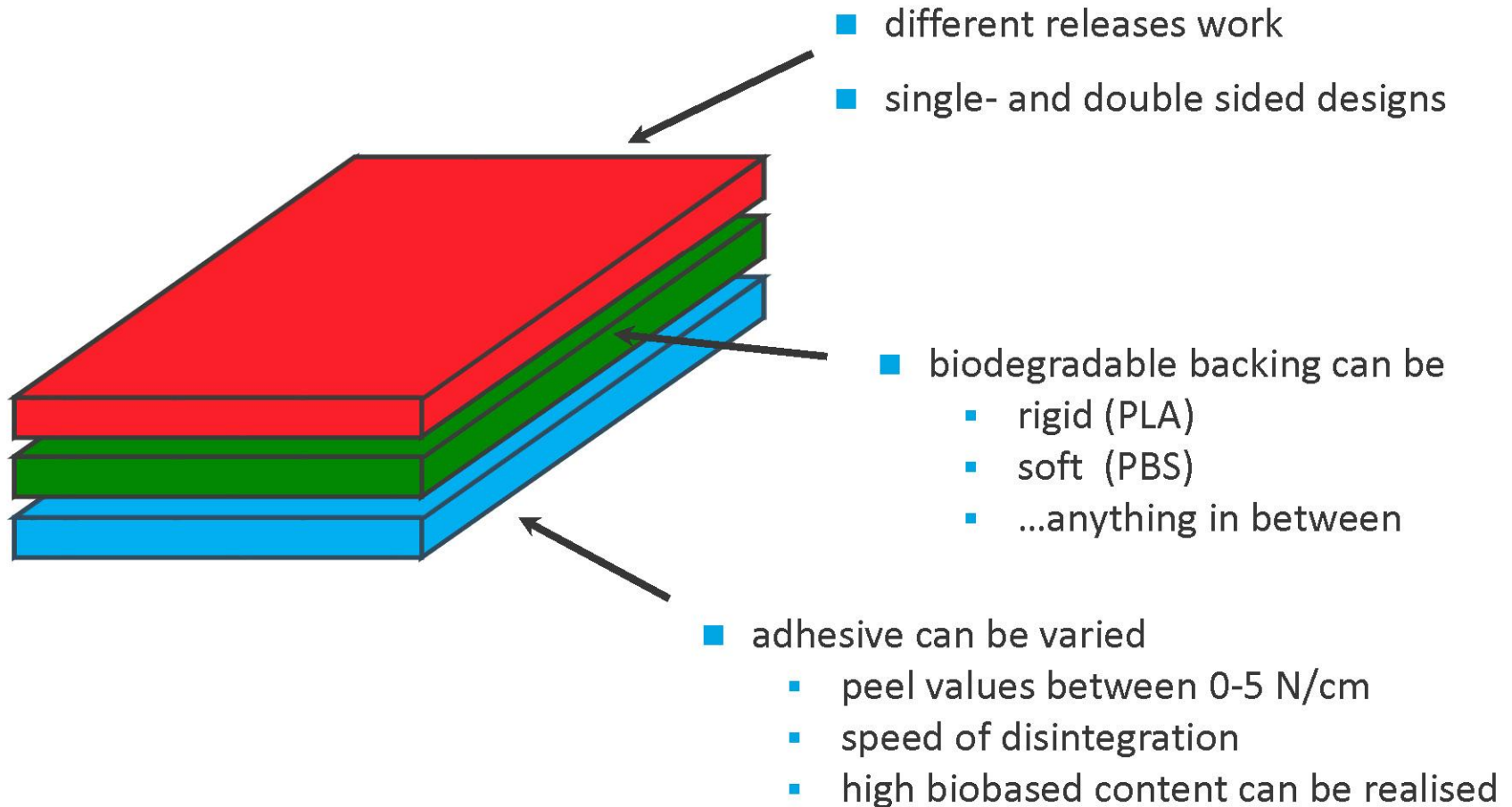


Results of Cardboard Sealing Test for a Biodegradable Packaging Tape

| number of lids | tension of lids | temp. | quality of lid | | | |
|----------------|-----------------|-------|----------------|------|------|---|
| | | | 1 | 2 | 3 | 4 |
| 4 | low | r.t. | ✓ | ✓ | ✓ | ✓ |
| 4 | | 40 °C | ✓ | ✓ | ✓ | ✓ |
| 4 | high | r.t. | ✓ | ✓ | 1 mm | ✓ |
| 4 | | 40°C | ✓ | 2 mm | 1 mm | ✓ |



Variants of Product Design



→ various product designs and fields of application possible

Thank you for your kind attention

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