The biodegradation & characterisation of different polyurethane coatings

Topic introduction

There´s a worldwide focus on reducing our environmental footprint which can in part be realized by focusing more on biobased, biodegradable and recycled materials. As materials need to last as well to be both durable an economically favorable, coatings are employed.

Stahl produces polyurethane coatings for leather, for example for car seats. As they want to be more environmentally-friendly, the want their coatings to be more biodegradable. Stahl approached CoE BBE to help them with this goal.

Goal

Stahl produced different compositions of polyurethane coatings for CoE BBE to test. The goal was to research their biodegradability.

Method

To test the biodegradability of the samples, OxiTop respirometric systems were used (see figure 1). The amount biodegradation was calculated by measuring the amount of oxygen consumed by bacteria - from sludge – when degrading the coatings.

To gain extra information on the coatings, characterization was performed using:

- TGA, DSC (thermal properties and composition);
- FTIR (composition from functional groups);
- GPC (mass (distribution));
- SEM (surface structure and thickness).

Figure 1: OxiTop system

Results

Biodegradation

From the results in table 1 it can be concluded that MS-P1 (49.4 ± 1.05%) shows the best %Dt overall, surpassing the starch reference which should be readily biodegradable. MS-P10 showed to be the least biodegradable (3.2 ± 0.77%).

Table 1: %Dt with st.dev

Averaged %Dt (on day 21) ± standard deviation			
Sample	%Dt ± stdev.s		
<MS-P1>	49.4	±	1.05
<MS-P2>	4.8	±	2.26
<MS-P4>	35.7	±	8.14
<MS-P5>	30.9	±	4.10
<MS-P6>	24.9	±	7.09
<MS-P7>	28.8	±	6.63
<MS-P8>	33.6	±	7.30
<MS-P9>	5.5	±	5.50
<MS-P10>	3.2	±	0.77
<Reference>	34.8	±	6.57

The differences in biodegradability can be partially explained when looking at their molecular structure. From the OxiTop analysis, it can be concluded that:

- crosslinking has an influence on biodegradability, but that measure of this depends on the type of crosslinker;
- lower molecular weight and use of short isocyanates increase biodegradability;
- using cyclic isocyanates and decreasing isocyanate content decrease biodegradability.

Characterization (SEM)

Some of the results of the characterization with SEM are shown in figures 2, 3 and 4. For MS-P4 and MS-P10 the coating before degradation look similar but they show a different structure after degradation has taken place. The images do not give a clear indication of why one degraded better than the other, but the effect of the biodegradation is visible.

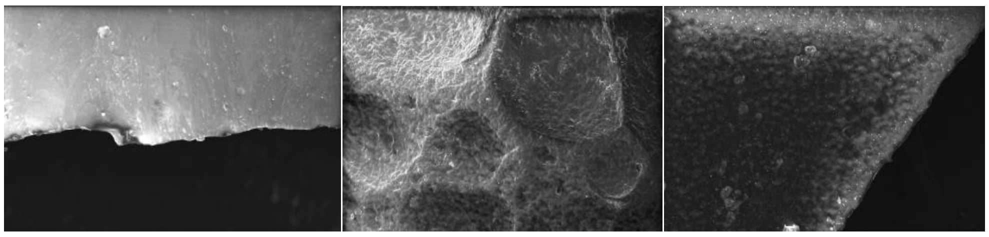

Figure 2: SEM analysis of MS-P4

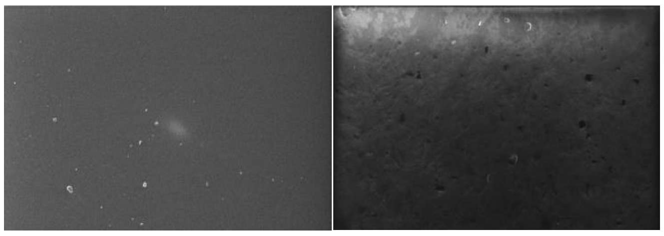

Figure 3: SEM analysis of MS-P10

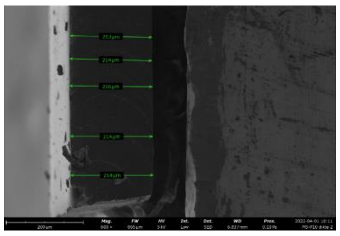

Figure 4: thickness measurement MS-P10

There is no clear correlation between the results from the characterization and the biodegradability of the coatings. Thus homogeneity, surface structure, coating thickness, thermal properties and mass distribution do not yet show an indication of how to improve the coatings.

Recommendations

Recommendations are to use a more representative reference; using a film starch reference and trying out another prepolymer composition based on MS-P6.

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