(Bio)degradable polyurethanes with amino-acid phosphorodiamidates as breakage points

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Degradable polymers are of ever-growing interest to combat the global plastic waste crisis. Often the degradation of polymers should be fast and without toxic by-products while still maintaining mechanical properties. For this, cleavable linkers are necessary.

Amino-acid based phosphorodiamidates (APDA) present a promising option as cleavable linker[1]. They degrade at neutral or acidic pH, but remain stable under alkaline conditions. Upon hydrolytic cleavage, the phospohorodiamidate group yields ammonium cations and phosphates, which are biocompatible.

APDAs offer a high degree of chemical functionalisation. It is possible to synthesize small APDAs, which can be incoperated into the hard segment of thermoplastic polyurethanes, as well as high molecular APDAs for soft segments. Furthermore phosphorotriamidates (APTAs) can be used as crosslinkers, for example in degradable polyurethane foams. Of course, APDAs and APTAs are not limited to PUR applications, they can also be used in polysiloxane networks or acrylates [2].

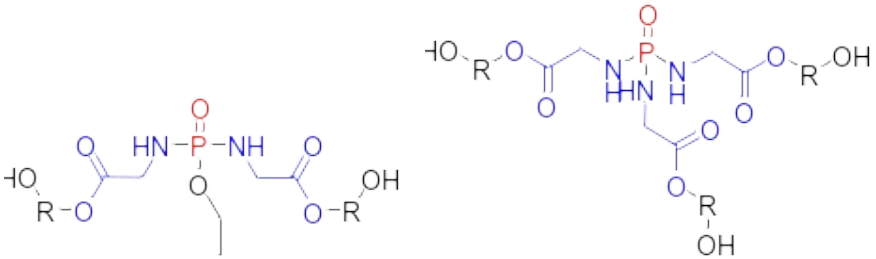

Figure 1: Structure of APDA (left) and APTA (right) as monomer; R = Alkyl, PEG, pTHF.

The degradation of APDAs and APTAs depends on the monomer structure, most of the monomers degrade completely within a few weeks up to a few months. Higher temperatures and lower pHs accelerate the degradation process.

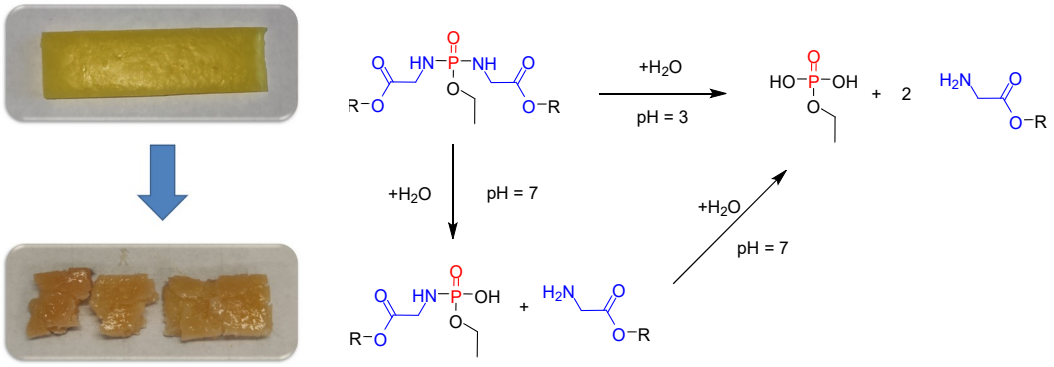

Figure 2: Degradation of TPU containing APDA (left) and degradation mechanism depending on pH (right).

Keywords: Polyurethanes, degradable polymers, phosphorous compounds

References

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[2] Haudum S.; Teasdale I.; Brüggemann O.; Vennemann N., Patent AT 526 968 B1, 2023