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Alkaline and enzymatic hydrolysis of poly-(ethylene terephthalate) plastics: kinetics and mechanistic insights obtained through Neutron Reflectometry

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With more than 82 million tons produced worldwide every year, poly-(ethylene terephthalate), PET, is one of the largest source of plastic waste. Among the various remedies sought to reduce the amount of PET into the environment, enzymatic hydrolysis holds great promise for upscaling. However, one of the challenges to overcome is the rapid loss of catalytic activity leading to incomplete polymer hydrolysis.
Many studies have been conducted to shed light on this issue, although methods that can provide direct measurement of polymer hydrolysis are lacking, making it difficult to obtain information from which to deduce mechanistic details. With the aim to fill this gap, we have used time-resolved Neutron Reflectometry (NR) as a technique to follow the PET degradation and providing a direct assessment of the hydrolysis rate of the polymer, and obtaining at the same time structural information on the enzyme /polymer/water system. We have seen that the enzymatic hydrolysis follows the Michaelis-Menten rate law, whereas the alkaline degradation is a pseudo first order kinetics, as expected. At the concentrations used in the experiments, the areal density of enzymes at the polymer surface is very low, ruling out surface passivation or overcrowding as inhibition mechanisms.

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