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Tracking the fate of carbon during microbial biodegradation of plastics

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Assessing the biodegradation of polymers is essential to understand their fate and persistence in the environment and to better evaluate the risks of impact on ecosystems. Despite the identification of many microorganisms capable of degrading polymers, the metabolic pathways and the rates of biodegradation remain poorly understood. The combinations of methodologies commonly used to characterise the transformation of polymers and/or to evaluate microbial growth often provide information on bio-deterioration and bio-fragmentation but generally do not explain the fate of polymers after their assimilation. The use of stable isotopes is a powerful method for carrying out an in-depth study of the biodegradation processes of organic pollutants. The measurement of the isotopic enrichment (13C/12C) of CO2 by GC/MS or of biomarkers of metabolism and biomass by NMR CP-MAS and HR-MAS makes it possible to quantify the use of a substrate labeled with 13C by a living cell. We evaluated the biodegradation of a 13 C labelled polyethylene by a pure bacterial strain of Rhodococcus rhodochrous. Incubation with the strain was carried out for 60 days in a minimum mineral medium containing (1) the labeled polymer, (2) the unlabelled polymer as the sole carbon source or (3) no carbon source. A clear bacterial growth was recorded, with the production of CO2 and biomass enriched in 13C isotope in the presence of labeled polyethylene, confirming the mineralization of the polymer by the bacteria. Isotopic enrichment proves to be a valuable technique for carrying out a carbon balance and determining the rate and speed of biodegradation.