A Mechanistic Understanding of Polyethylene Biodegradation by the Marine Bacterium Alcanivorax

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Polyethylene (PE) is one of the most recalcitrant carbon-based synthetic materials produced and, currently, the most ubiquitous plastic pollutant found in nature. Over time, combined abiotic and biotic processes are thought to eventually breakdown PE. Despite limited evidence of biological PE degradation and speculation that hydrocarbon-degrading bacteria found within the plastisphere is an indication of biodegradation, there is no clear mechanistic understanding of the process. Here, using high-throughput proteomics, we investigated the molecular processes that take place in the hydrocarbon-degrading marine bacterium Alcanivorax sp. 24 when grown in the presence of low density PE (LDPE). As well as efficiently utilising and assimilating the leachate of weathered LDPE, the bacterium was able to reduce the molecular weight distribution (Mw from 122 to 83 kg/ mol) and overall mass of pristine LDPE films (0.9 % after 34 days of incubation). Most interestingly, Alcanivorax acquired the isotopic signature of the pristine plastic and induced an extensive array of metabolic pathways for aliphatic compound degradation. Presumably, the primary biodegradation of LDPE by Alcanivorax sp. 24 is possible via the production of extracellular reactive oxygen species as observed both by the material's surface oxidation and the measurement of superoxide in the culture with LDPE. Our findings confirm that hydrocarbon- biodegrading bacteria within the plastisphere may in fact have a role in degrading PE.
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