Environmental Behavior and Fate of ^{14}C-Polylactic Acid in Soils

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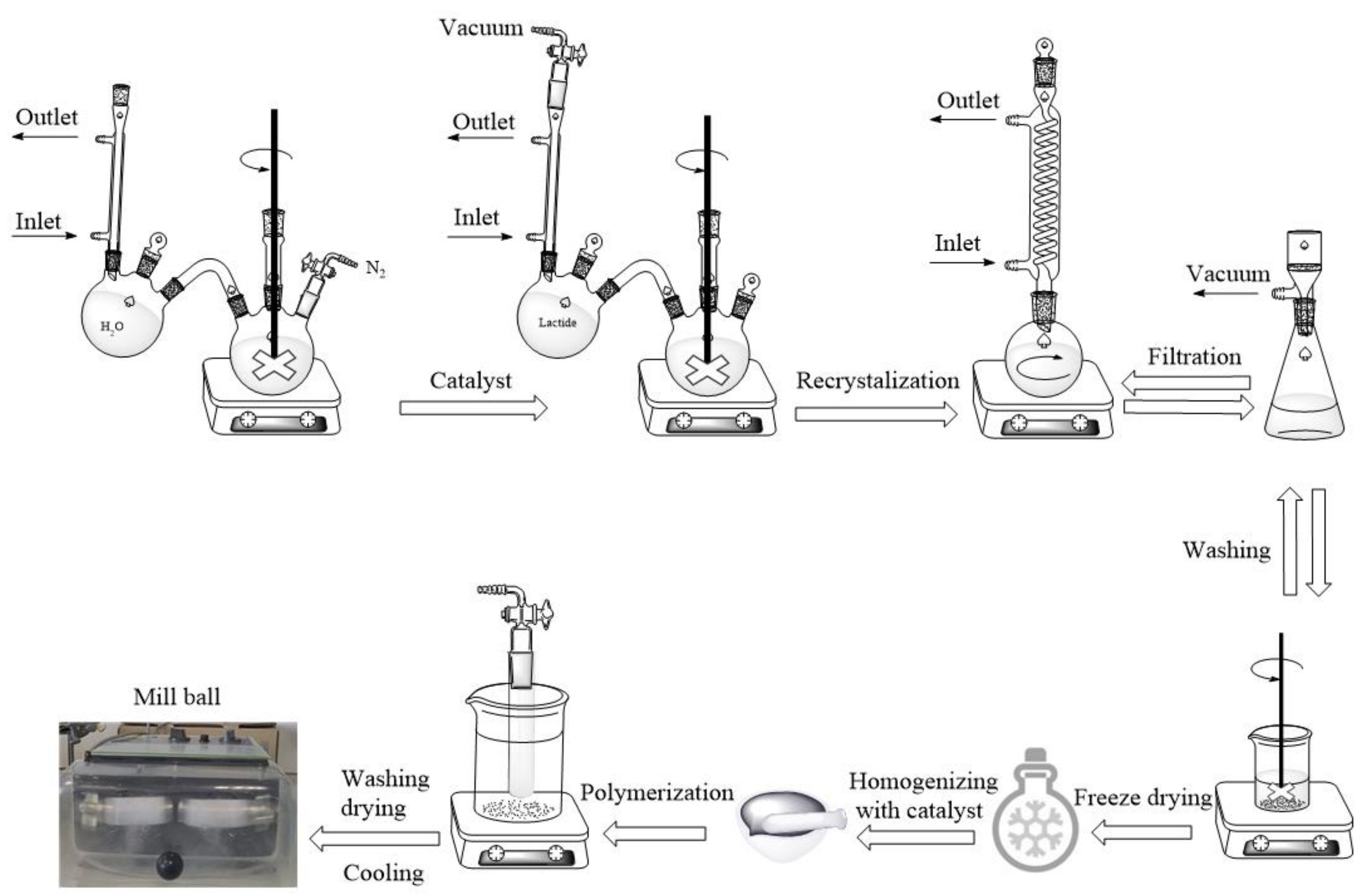
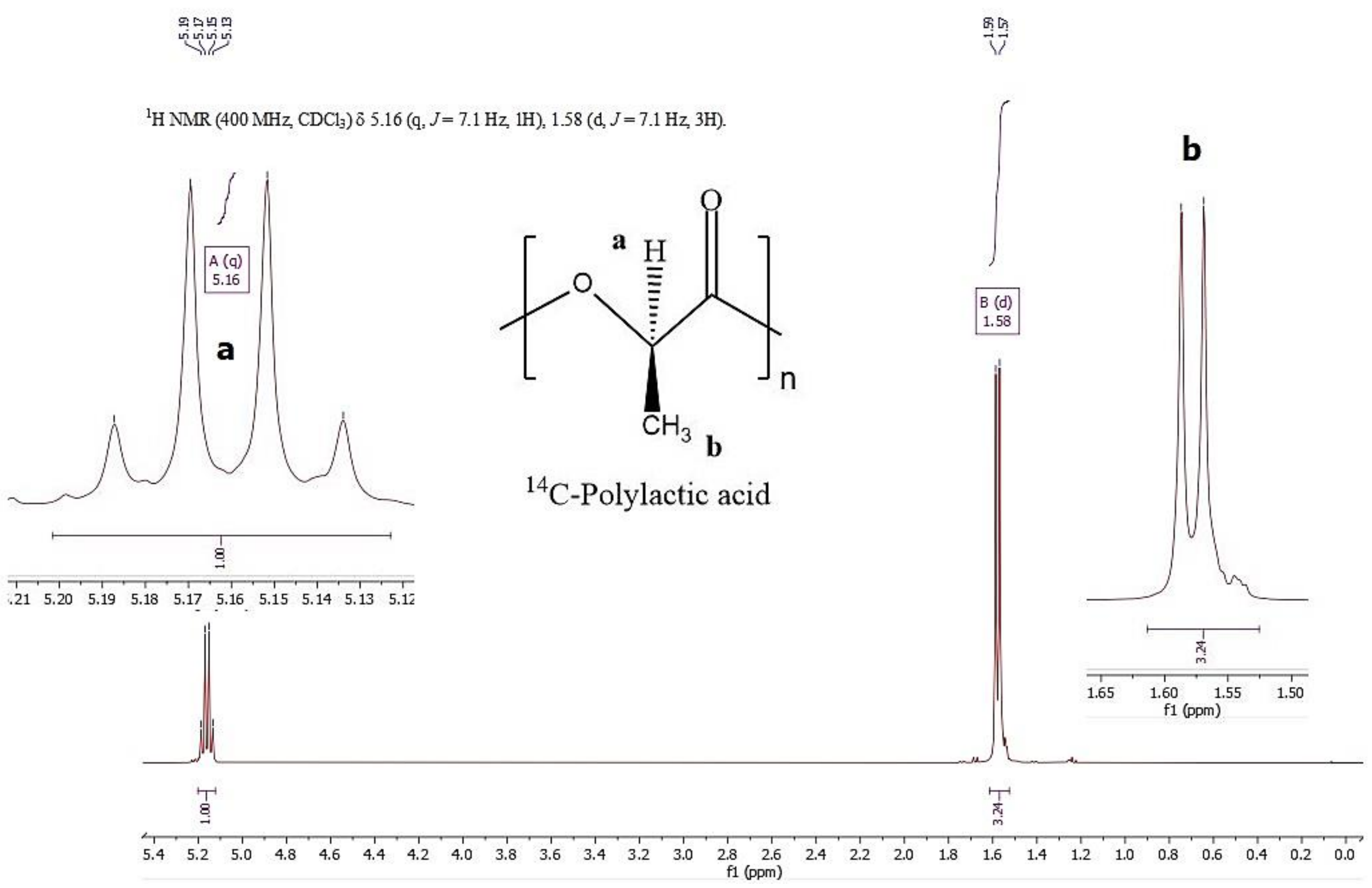
Background

The growing use of PLA has highlighted the need for research into its behavior in natural environments like soil.[1] Currently, there is limited understanding of how environmental factors such as microorganisms, weathering, pH, water, and the material's structural properties influence the degradation of bioplastics. It remains uncertain whether polymers in these settings primarily fragment into smaller particles or are fully converted into carbon dioxide, water, or microbial biomass, particularly when degradation processes are slow.[2] The application of carbon isotopes has made it easier to interpret polymer degradation studies. By introducing ^{14}C-labeled microplastics into soil, researchers can trace their breakdown, ultimately monitoring their conversion into $^{14}CO_2$ under controlled conditions.[3]

Overview of Synthesis Setups





^{14}C-PLA production

Access to affordable ^{14}C-labeled lactic acid is crucial for advancing soil microplastic degradation research. We have established a modified ^{14}C-labeled polylactic acid synthesis method that enables the production of ^{14}C-PLA for degradation studies in soil.

Temperature, pressure, and catalysts are the three key factors influencing the reaction in the production of PLA. Additionally, recrystallization and purification steps help eliminate by-products with varying optical rotations.[4,5]

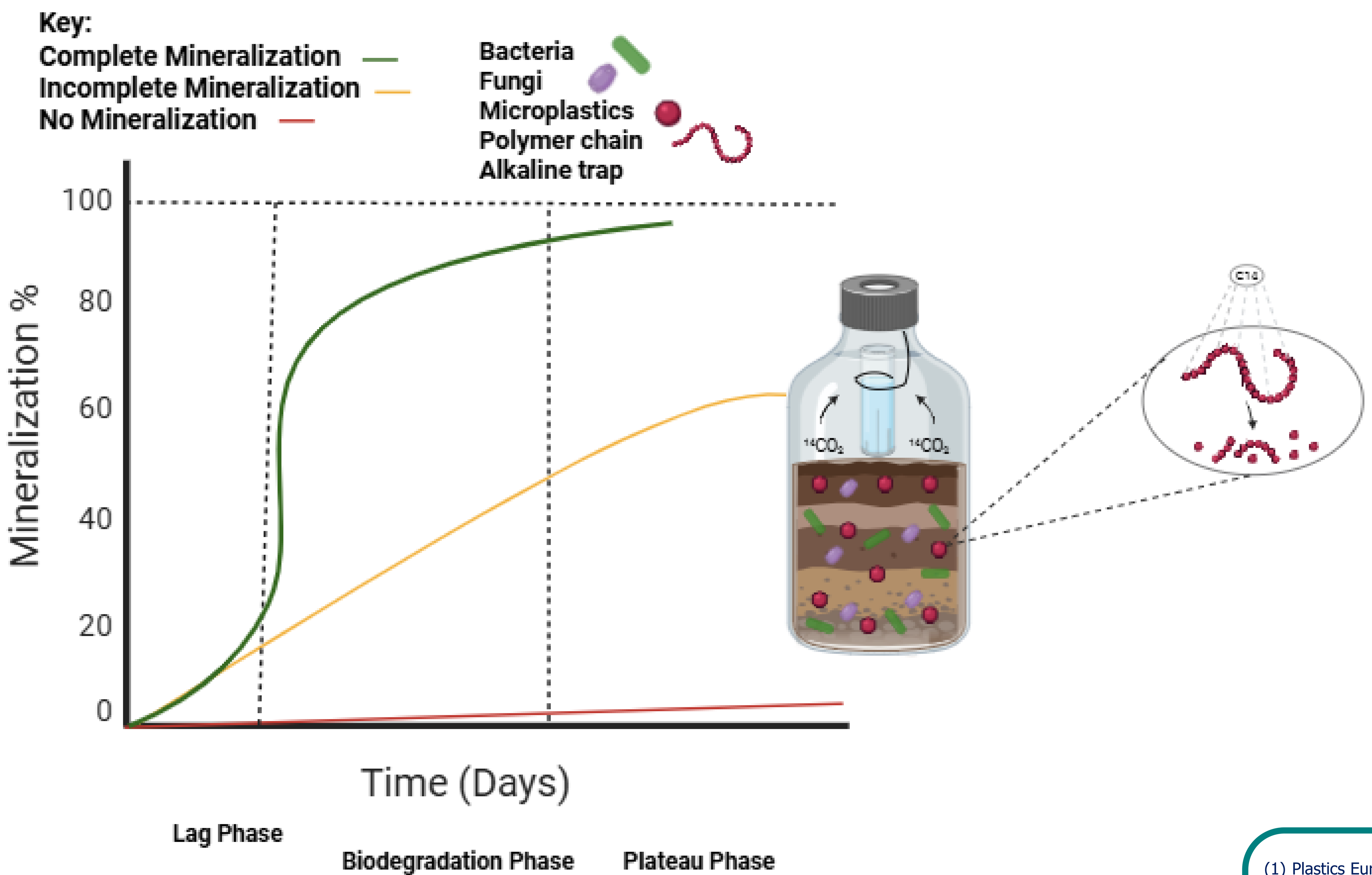
The 1H-NMR spectrum of the final product distinctly displays two major peaks for the methyl and methine protons of the PLA backbone: a doublet with chemical shift at 1.58 ppm corresponding to the methyl protons ($-CH_3$ group) and a quartet with chemical shift at 5.16 ppm corresponding to the methine proton (-CH-) in the polymer chain.

^{14}C-PLA
20-500 µm

Radioactive

Degradation study overview

The fate of ^{14}C-labeled PLA is being studied in a sandy soil (Kaldenkirchen) and a silty soil (Merzenhausen) to assess the impact of temperature, soil moisture, and organic amendments on the release of $^{14}CO_2$. Experiments are being conducted under 70% humidity at three different temperatures (Ambient, 30 and 60 ℃) over 180 days, with three replicates for each condition.



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Grant info

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