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Chitin Derived Carbon Mobilization into Chitooligosaccharides via Chemoenzymatic Approach

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Chitin is a major nitrogen-containing biopolymer in aquatic ecosystems and represents an important source of sedimentary organic carbon derived from crustacean, fungal, and planktonic biomass. The degradation and stabilization of chitin derived from coastal biowaste strongly influence carbon turnover, and long-term preservation in aquatic sedimentary environments. In this study, mechanistic controls on chitin-derived carbon transformation have been investigated using an integrated microbiological and chemoenzymatic approach. A thermophilic fungal strain, *Thermomyces dupontii* ITCC 9104, was optimized for chitinase production under submerged fermentation through response surface methodology modelling, resulting in a 1.7-fold enhancement in enzyme yield. The purified thermostable chitinase (TdChiT, 60 kDa) exhibited optimal activity at 70 °C and pH 5, with high specificity toward colloidal chitin and strong thermal stability. To simulate physicochemical modifications relevant to sedimentary environments, neutral binary deep eutectic solvents were employed for chitin pretreatment, inducing partial deacetylation, amorphization, and disruption of crystalline domains. Subsequent enzymatic hydrolysis significantly enhanced substrate accessibility and bioactive chitooligosaccharide production. The process of enzymatic hydrolysis led to a swift mobilization of around 44.8% of the chitin-derived carbon pool in just 60 minutes, equating to a release of 210.7 mg of carbon. The conversion exhibited first-order kinetics with a turnover constant of 0.59 h^{-1}, demonstrating highly efficient organic carbon mobilization under optimized conditions. Our findings demonstrate that coupled physicochemical pretreatment and thermophilic enzymatic activity strongly regulate the conversion of recalcitrant chitin into bioavailable dissolved organic carbon fractions. These processes influence whether chitin-derived carbon is rapidly remineralized or stabilized within sediment matrices. By integrating enzyme kinetics, chemical modification, and carbon turnover analysis, this study provides mechanistic insights into biopolymer degradation pathways relevant to aquatic sediment carbon cycling and climate-relevant sequestration dynamics.