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Anaerobic reductive dechlorination of tetrachloroethene: how can dual Carbon-Chlorine isotopic measurements help elucidating the underlying reaction mechanism?

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Chlorinated ethenes (CEs) such as tetrachloroethene (PCE) are common persistent groundwater contaminants. Among clean-up strategies applied to sites affected by such pollution, bioremediation has been considered with a growing interest as it represents a cost-effective, environmental friendly approach. This technique however sometimes leads to an incomplete and slow biodegradation of CEs resulting in an accumulation of toxic metabolites. Understanding the reaction mechanisms underlying anaerobic reductive dechlorination would thus help assessing PCE biodegradation in polluted sites.

Stable isotope analysis can provide insight into reaction mechanisms. For chlorinated hydrocarbons, carbon (C) and chlorine (Cl) isotope data (δ^{13}C and δ^{37}Cl) tend to show a linear correlation with a slope (m $\approx \varepsilon$C/εCl) characteristic of the reaction mechanism [1]. This study hence aims at exploring the potential of a dual C-Cl isotope approach in the determination of the reaction mechanisms involved in PCE reductive dechlorination.

C and Cl isotope fractionation were investigated during anaerobic PCE dechlorination by two bacterial consortia containing members of the *Sulfurospirillum* genus. The specificity in these consortia resides in the fact that they each conduct PCE reductive dechlorination catalysed by one different reductive dehalogenase, i.e. PceA$_{DCE}$ which yields trichloroethene (TCE) and cis-dichloroethene (cDCE), and PceA$_{TCE}$ which yields TCE only.

The bulk C isotope enrichment factors were -3.6±0.3 ‰ for PceA$_{TCE}$ and -0.7±0.1‰ for PceA$_{DCE}$. The bulk Cl isotope enrichment factors were -1.3±0.2 ‰ for PceA$_{TCE}$ and -0.9±0.1 ‰ for PceA$_{DCE}$. When applying the dual isotope approach, two m values of 2.7±0.1 and 0.7±0.2 were obtained for the reductive dehalogenases PceA$_{TCE}$ and PceA$_{DCE}$, respectively. These results suggest that PCE can be degraded according to two different mechanisms. Furthermore, despite their highly similar protein sequences, each reductive dehalogenase seems to catalyse PCE reductive dechlorination according to a different mechanism. In another study, an m value of 2.5±0.8 was found for PCE anaerobic dechlorination by a bacterial consortium dominated by species closely related to *Desulfitobacterium aromaticivorans* strain UKTL (consortia A) [2]. This value is indistinguishable from the one found for PceA$_{TCE}$ within a 95% confidence interval although the reductive dehalogenase protein sequence of consortia A is distinctly different from the sequences of our two cultures. This suggests that the reaction mechanism is not related to the similarities between reductive dehalogenases.

References

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