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Evaluation of biodegradable plastics as solid hydrogen donors for the reductive dechlorination of fthalide by *Dehalobacter* species

Naoko Yoshida[a,b,*], Lizhen Ye[b], Fengmao Liu[b,c], Zhiling Li[b], Arata Katayama[b]

[a] Electronics-Inspired Interdisciplinary Research Institute (EIIRIS), Toyohashi University of Technology, Hibarigaoka, Tempaku-cho, Toyohashi, Aichi 441-8580, Japan
[b] EcoTopia Science Institute, Nagoya University, Nagoya 464-8603, Japan
[c] Department of Applied Chemistry, China Agricultural University, Beijing 100094, PR China

HIGHLIGHTS

- A starch-based plastic (SP) functioned as an H_2 donor for microbial dechlorination.
- Newly isolated *Clostridium* sp. Ma13 transferred H_2 from SP to a dechlorinator.
- SP exhibited significantly more efficient H_2 transfer to dechlorinators than lactate.

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ABSTRACT

Biodegradable plastics (BPs) were evaluated for their applicability as sustainable and solid H_2 donors for microbial reductive dechlorination of 4,5,6,7-tetrachlorophthalide (fthalide). After a screening test of several BPs, the starch-based plastic (SP) that produced the highest levels of H_2 was selected for its use as the sole H_2 donor in this reaction. Fthalide dechlorination was successfully accomplished by combining an H_2-producing SP culture and a KFL culture containing *Dehalobacter* species, supplemented with 0.13% and 0.5% SP, respectively. The efficiency of H_2 use in dechlorination was evaluated in a combined culture containing the KFL culture and strain *Clostridium* sp. Ma13, a new isolate that produces H_2 from SP. Results obtained with this culture indicated increased H_2-fraction for fthalide dechlorination much more in this culture than in compared with a KFL culture supplemented with 20 mM lactate, which are 0.75 $H_2{\cdot}glucose^{-1}$ and 0.015 $H_2{\cdot}lactate^{-1}$ in mol ratio, respectively.

1. Introduction

Polychlorinated-polyaromatic-hydrocarbons (PCPAHs) such as polychlorinated biphenyls (PCBs) and dibenzo-*p*-dioxins (PCDDs) are problematic contaminants that persist in the environment for remarkably long periods. Dioxygenase from aerobic bacteria can easily oxidize polyaromatic hydrocarbons with fewer than four chlorine substitutions, but not PCPAHs with more than four chlorine atoms. In polluted environments, PCPAHs are believed to precipitate with organic substances and persist in anoxic environments owing to the reduced solubility of these compounds in water. Dehalorespiring bacteria have received much attention because of their ability to reductively dechlorinate organohalides as in the biodegradation process of PCPAHs, as well as in the first biodegradation step prior to oxidative mineralization (Kaiya et al., 2012; Okabe et al., 2010). To date, a number of dehalorespiring bacteria capable of dechlorinating PCBs or PCDDs have been identified, including *Dehalococcoides* species of the phylum Chloroflexi (Bunge et al., 2003; Fennell et al., 2004) and other Chloroflexi species (Cutter et al., 2001; May et al., 2008; Yoshida et al., 2005), and the *Dehalobacter* species of phylum Firmicutes (Yan et al., 2006; Yoshida et al., 2005; Yoshida et al., 2009a). These bacteria reductively dechlorinate PCBs or PCDDs during respiration by using H_2 or organic acids as electron donors. Therefore, supplementation with electron donors is essential for dechlorination, and is also an important factor that determines the outcome of bioremediation.

The most important electron donor for reductive dechlorination is H_2, because it is the sole source used by major dehalorespiring bacteria such as *Dehalococcoides* and *Dehalobacter* species (Bunge et al., 2003; Holliger et al., 1998), and is used as an alternative electron donor by other dehalorespiring bacteria (May et al., 2008). In the environment, H_2 is not only involved in dechlorination, but also involved in some competitive microbial reactions that reduce carbon dioxide, sulfate, nitrate, and metals. Based on the results of

* Corresponding author. Present address: Electronics-Inspired Interdisciplinary Research Institute (EIIRIS), Toyohashi University of Technology, Tenpaku-cho, Toyohashi 441-8580, Japan. Tel.: +81 532 81 5137; fax: +81 532 81 7244.
E-mail address: yoshida@eiiris.tut.ac.jp (N. Yoshida).

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