Oxidation of Polychlorinated Biphenyls by Achromobacter pCB

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Polychlorinated biphenyls (PCBs) have been used extensively in various commercial products since the 1920's. The widespread occurrence of these chemicals has been documented by Risebrough et al. (2). Despite the extensive usage of PCBs, data pertaining to the longevity of these chemicals in soil and water are unavailable. We had reported previously that certain mono and dichlorinated biphenyls were degraded readily by a species of Achromobacter pCB isolated from sewage effluent (1). It is the intention of this investigation to study the biodegradation of other isomers of PCBs with 2 to 5 chlorine atoms.

MATERIALS AND METHODS

The following chemicals were purchased from Analabs, Inc., North Haven, Connecticut: 2,3-dichlorobiphenyl (2,3-DCB), 2,4-dichlorobiphenyl (2,4-DCB), 3,4-dichlorobiphenyl (3,4-DCB), 3,5-dichlorobiphenyl (3,5-DCB), 3,3'-dichlorobiphenyl (3,3'-DCB), 3,4,2'-trichlorobiphenyl (3,4,2'-tCB), 2,3,2',3'-tetrachlorobiphenyl (2,3,2',3'-TCB), 2,5,3',4'-tetrachlorobiphenyl (2,5,3',4'-TCB) and 2,3,4,5,6-pentachlorobiphenyl (2,3,4,5,6-PCB).

Resting cell suspensions of Achromobacter pCB grown on p-chlorobiphenyl (pCB) were tested for their ability to metabolize 2,3-DCB, 2,4-DCB, 3,4-DCB, 3,5-DCB, 3,3'-DCB, 3,4,2'-tCB, 2,3,2',3'-TCB. 2,5,3',4'-TCB, and 2,3,4,5,6-PCB. Cultural, manometric, and analytical techniques used in this study have been described previously (1).

RESULTS AND DISCUSSION

Manometric studies indicated that with the exception of 2,5,3',4'-TCB, all the above listed PCBs were oxidized by bacteria grown on pCB. Except for a brief lag observed in the degradation of 3,3'-DCB, all other PCBs were oxidized without lag. The results are given in Figures 1 and 2. The manometric data also suggested that 2,3-DCB, 2,4-DCB, 3,4-DCB, 3,5-DCB, and 3,5-DCB were oxidized to an appreciable extent by pure cultures of Achromobacter pCB; 3,4,2'-tCB, 2,3,2',3'-TCB and 2,3,4,5,6-PCB were oxidized only slightly. The high degree of oxidation of dichlorinated biphenyls in which one of the biphenyl rings was

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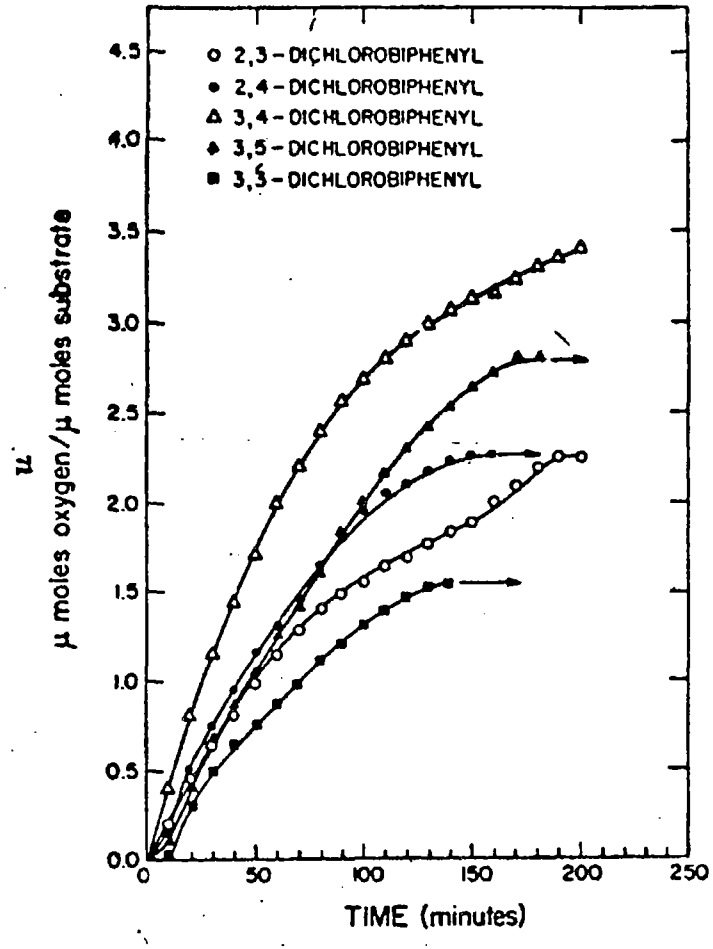


Figure 1. Oxidation of dichlorobiphenyls.

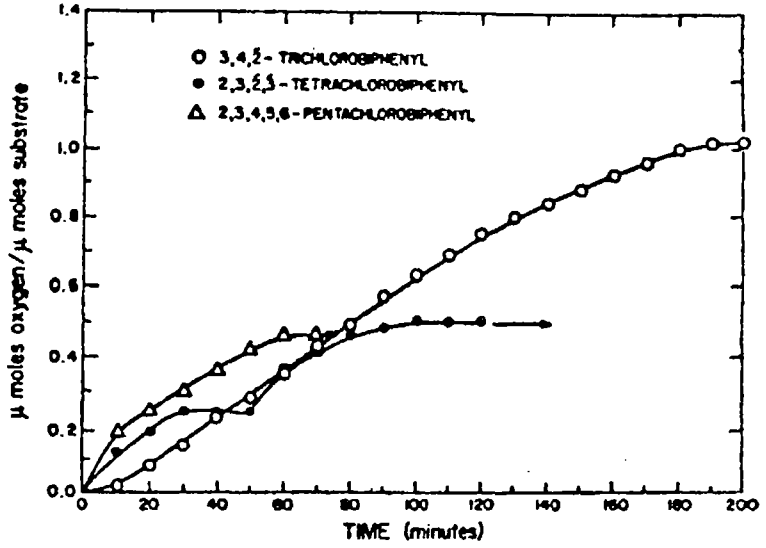


Figure 2. Oxidation of tri, tetra, and penta chlorobipheryl.

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unsubstituted may be due to the preferential degradation of the unsubstituted ring as noted by the extent of oxidation between 3,3'-DCB and all other dichlorobiphenyls having one unsubstituted ring. Even 2,3,4,5,6-PCB was oxidized comparably to 2,3,2',3'-TCB and more than 2,5,3',4'-TCB.

The Warburg flask contents were withdrawn upon completion of the experiments—as determined by the return of respiration rate to that of endogenous—and centrifuged to obtain clear supernatant solutions. The supernatant solutions were assayed for liberation of chloride and were analyzed spectrophotometrically to obtain absorption maxima of products that might have accumulated during degradation. The absorption maxima of the substrates and the intermediates are shown in Table 1.

TABLE 1
Oxygen uptake and absorption maxima (λ max) of substrates and products

Substrate	Oxygen uptake†	λ max of substrate	λ max of products
2,3-Dichlorobiphenyl	2.25	265	235
2,4-Dichlorobiphenyl	2.25	265	235
3,4-Dichlorobiphenyl	3.40	265	290*, 280, 235
3,5-Dichlorobiphenyl	2.75	265	290*, 280*, 235
3,3'-Dichlorobiphenyl	1.60	265	400, 235
3,4,2'-Trichlorobiphenyl	1.00	265	400, 290, 235
2,3,2',3'-Tetrachlorobiphenyl	0.5	265	320, 280
2,5,3',4'-Tetrachlorobiphenyl	0	265	265
2,3,4,5,6-Pentachlorobiphenyl	0.5	265	280

†mmoles oxygen/mmoles substrate
*shoulder only

Inasmuch as the bacterium was unable to dehalogenate any of the chlorinated biphenyls, as noted by the absence of chloride in all supernatants, it appears likely that increasing chlorine substitution renders the biphenyl molecule more resistant to microbial attack as the manometric results further indicate.

REFERENCES

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