

very slow fumarate oxidation in the facultative group.

Correlation between rapid fumarate oxidation and the presence of a particulate malate oxidase has been found in a further range of bacteria including pseudomonads, although the malate dehydrogenase in *Pseudomonas B₂aba* has been found to be more easily detachable (Kornberg & Gotto, 1961).

The particulate malate oxidase system has been studied in the strict aerobes, especially *Sarcina lutea* and *Moraxella lwoffii*, which both contain a soluble and a particulate malate dehydrogenase. In *S. lutea* malate dehydrogenase activity was found by Sephadex column chromatography to be associated with the carotenoids and membranes (see also Erickson & Parker, 1969). Preliminary results with *M. lwoffii* show the particulate malate oxidase to be very firmly bound to the membranes and associated with the electron-transport chain as in other strict aerobes studied, e.g. *Azotobacter vinelandii* (Jurtshuk, Bednarz, Zey & Denton, 1969).

We gratefully acknowledge financial assistance from the Science Research Council.

Erickson, S. K. & Parker, G. L. (1969). *Biochim. biophys. Acta* **180**, 56.

Jones, M. (1969). M.Sc. Thesis: University of Wales.

Jones, M. & King, H. K. (1968). *Biochem. J.* **108**, 11 p.

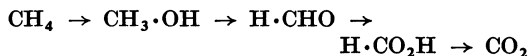
Jurtshuk, P., Bednarz, A. J., Zey, P. & Denton, C. H. (1969). *J. Bact.* **98**, 1120.

Kornberg, H. L. & Gotto, A. M. (1961). *Biochem. J.* **78**, 69.

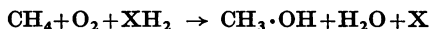
Oxygenation of Methane by Methane-Utilizing Bacteria

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Studies with intact cells of *Methanomonas methanooxidans* (Brown, Strawinski & McCleskey, 1964) indicate that the route of methane oxidation in this micro-organism is:

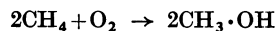


Enzymes catalysing the stepwise oxidation of methanol to carbon dioxide have been reported in cell-free preparations of *Pseudomonas methanica* (Johnson & Quayle, 1964), but little is known about the mechanism of the oxidation of methane to methanol. By analogy with higher-alkane oxidation (Peterson, Kusunose, Kusunose & Coon, 1967) the reaction might be mediated by a mono-oxygenase:

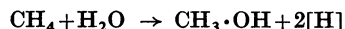


where XH_2 is a reducing agent. Another possibility

might be an oxygenase system in which two molecules of methane are oxygenated in the overall reaction:



Leadbetter & Foster (1959) obtained indirect evidence in favour of oxygenase involvement in *P. methanica* by measuring the extent of ^{18}O incorporation into intact cells. On the other hand, Whittenbury (1969) pointed out that cell-yield data obtained in his laboratory and the inhibitor studies by Brown *et al.* (1964) might not be consistent with involvement of an oxygenase. Accordingly he suggested the possibility of a hydroxylation reaction giving methanol and two electrons for energy transduction:



Direct measurements of the incorporation of ^{18}O into methanol during oxidation of methane by whole cells of *M. methanooxidans* and *P. methanica* have now been made by using a combined gas chromatograph-mass spectrometer. When incubations were carried out under mixtures of methane and ^{18}O -enriched oxygen (55.93 atom % excess of ^{18}O) in the presence of unenriched water, the proportion of ^{18}O in the methanol varied between 53.9 and 59.8 atom % excess. In control experiments with mixtures of methane-unenriched oxygen in the presence of enriched water (19.0 atom % excess of ^{18}O) there was negligible incorporation of ^{18}O into the methanol. These results show that the conversion of methane into methanol by these micro-organisms involves an oxygenase.

We thank Dr H. F. West, Dr E. Bailey and Dr W. J. Cole of Nether Edge Hospital, Sheffield, for their help and for the use of their Perkin-Elmer 270 instrument.

Brown, L. R., Strawinski, R. J. & McCleskey, C. S. (1964). *Can. J. Microbiol.* **10**, 791.

Johnson, P. A. & Quayle, J. R. (1964). *Biochem. J.* **93**, 281.

Leadbetter, E. R. & Foster, J. W. (1959). *Nature, Lond.*, **184**, 1428.

Peterson, J. A., Kusunose, M., Kusunose, F. & Coon, M. J. (1967). *J. biol. Chem.* **242**, 4334.

Whittenbury, R. (1969). *Process Biochem.* **4**, 51.

Coproporphyrinogenase Activities in Extracts of *Rhodopseudomonas spheroides*

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A crude extract of *Rhodopseudomonas spheroides* catalyses the conversion of coproporphyrinogen into protoporphyrin when incubated aerobically or anaerobically (Tait, 1969). Under anaerobic conditions there is no conversion unless MgSO_4 , L-