

plete radiolarian skeletons seem to distinguish two bullion horizons containing the *H. subglobosum* group in north Staffordshire and south-west Derbyshire.

Radiolarian morphology reflects environment⁸, and study of the new microfaunas promises to provide fresh information regarding the habitat of the thicker-shelled goniatites. Prevalence of delicate lattices and elaborate spines suggests that the Namurian spumellinids may have lived pelagically in comparatively shallow water. Variation in richness and composition of radiolarian assemblages at a single, well-defined goniatite horizon could in future provide indications of regional environmental variation not otherwise detectable. Similarly, variation in assemblages between faunal bands may prove indicative of local fluctuations in environment with time. The presence of radiolarian bullions in normal shale marine bands leaves little doubt that the original shale-forming sediment was equally rich in radiolaria, even though no trace of the micro-organisms now remains. Such sediments would be particularly susceptible to subsequent diagenetic alteration, and in interpreting the results of geochemical investigations of shale and mudstone goniatite bands it may be necessary to reassess the degree to which present chemistry reflects that of the original sediment.

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CHEMISTRY

Rotational Structure in the Electronic Spectrum of Tellurium Monoxide

A LARGE number of bands have been assigned¹ to the molecule tellurium monoxide (TeO); but little agreement has yet been reached on their vibrational analysis, and no rotational analysis has yet been reported. By analogy with SeO (ref. 2), it is to be expected that the visible and near ultra-violet bands arise from a transition ${}^3\Sigma^- - {}^3\Sigma^-$ in which the spin-splitting constants λ' and λ'' are large. In the limit of case-c, the predicted ${}^3\Sigma^- - {}^3\Sigma^-$ system will appear as two separate systems, $1 - 1$ and $0^+ - 0^+$. Some preliminary observations of the absorption spectrum taken in a second order of a 6.65-m concave grating spectrograph support this view.

In particular, one band at $31,301\text{ cm}^{-1}$ shows the simple two-branch structure expected for a $0^+ - 0^+$ transition. The band is so strongly degraded to longer wave-lengths that the rotational analysis is unambiguous in the range $J = 20-45$. The vibrational analyses agree in assigning $v'' = 0$ to this band, but the vibrational constants for the upper state are too uncertain to enable v' to be established by the isotope shifts: the band has been regarded as the 6-0 band of system $B - X$, but it appears that the value of v' should be increased by two or three units.

R and P branches of the three most abundant molecules, ${}^{130}\text{TeO}$, ${}^{128}\text{TeO}$, ${}^{126}\text{TeO}$, are well resolved, and the analysis leads to the following values of B_0'' for these species respectively: 0.3541_7 , 0.3549_8 , 0.3556_0 cm^{-1} . If the values for ${}^{128}\text{TeO}$ and ${}^{126}\text{TeO}$ are corrected to ${}^{130}\text{TeO}$ by division by ρ^2 , we obtain the three estimates, 0.3541_7 , 0.3543_7 , 0.3543_0 cm^{-1} , giving the mean value 0.3543 cm^{-1} for B_0'' , ${}^{130}\text{TeO}$. B' is found to be 0.226 cm^{-1} . This estimate of B_0 for the ground-state, $X^3\Sigma^-(F_1)$ or X^0^+ , is smaller³ than

the true value by $2B^2/(\lambda^2 - 2\lambda B)^{1/2}$. However, values of λ for the ground-states of S_2 (ref. 4) and of SeO (ref. 3) are 11.6_5 and 86.0_5 cm^{-1} , respectively, so that in the present case, λ may well be greater than 100 cm^{-1} . The uncorrected value of B_0'' may then be used to derive the internuclear distance, giving $r_0'' = 1.828\text{ \AA}$, about 0.19 \AA larger than the internuclear distance in SeO.

Further elucidation of this spectrum will require the use of isotopically pure TeO: this work is now in progress.

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High-performance Propane Fuel Cells

IN April 1963, a high-performance fuel cell for saturated hydrocarbons was announced¹. The cell contained platinum electrodes, a phosphoric acid electrolyte, and operated in the range $150^\circ-200^\circ\text{ C}$. It was noted also that a number of hydrocarbons, including methane, propane, n -octane, and n -cetane, could be utilized by the cell with complete oxidation to carbon dioxide and water being achieved. More recently an E.M.F.-current density curve and carbon dioxide yield data were published for a propane-oxygen fuel cell operating at 150° C with an electrolyte of 85 per cent (14.6 M) H_3PO_4 (refs. 2 and 3).

The performance of propane-oxygen cells operating between 150° and 200° C was recently described in detail⁴.

The foregoing information on complete cells has recently been supplemented by the work of Oswin *et al.*⁵, who reported results on a propane half-cell using platinum electrodes and 85 per cent H_3PO_4 electrolyte at 160° C and concluded that direct hydrocarbon-air fuel cells are feasible. Oswin's data show a limiting current density near 280 m.amp/cm^2 . In this connexion, I have recently observed in a complete propane-oxygen fuel cell the E.M.F.-current density curve shown in Fig. 1. It is to be noted that the limiting current density exceeds 500 m.amp/cm^2 . The form of the E.M.F.-current density curve indicates that the current density is limited by a diffusion process (probably one involving a gas such as propane or carbon dioxide). It appears then that the current density limit imposed by the kinetics of electro-oxidation of propane at this temperature would exceed 500 m.amp/cm^2 .

Electrode structure is a critical factor in determining limiting current densities in hydrocarbon fuel cells. The

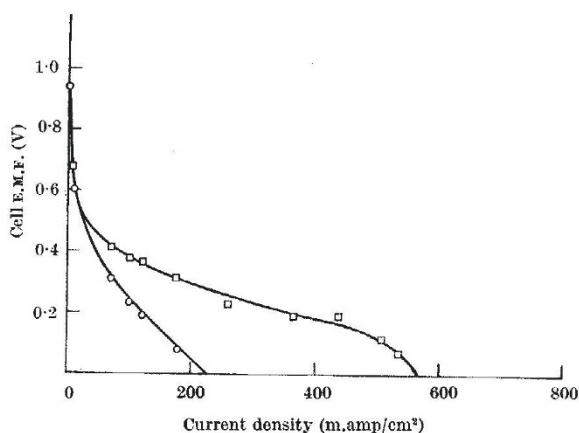


Fig. 1. E.M.F. versus geometric current density for propane-oxygen cell operating at 150° C with platinum electrodes and 85 per cent (14.6 M) H_3PO_4 electrolyte. ○, Total cell E.M.F.; □, R free E.M.F.