however, a marked difference in performance compared with the earlier experiments.

In April 1969, when we made the trials with the new equipment, high cirrus clouds were common. When they were present the "cold" signal was considerably reduced, and the clouds gave a highly variable background causing fluctuations in intensity that were as much as 50 per cent of the total signal. This made recording of satisfactory interferograms impossible, in marked contrast with the experience of 1967 using the 150 μm band in similar atmospheric conditions. Then the fluctuations in signal from the cirrus background were very small, and observations giving satisfactory spectra were easily made.

Some support for this result came from observations with radiometric equipment which was flown at the same time. A chopper bolometer measuring sky emission within a two degree total solid angle could be operated in spectral bands from 6·1 to 6·8 μm (bandpass = 160 cm^{-1}) and from 17 to 31 μm (bandpass = 260 cm^{-1}). The mean power derived from 100 individual observations from the cloudless zenith sky above 39,000 feet in the shorter wavelength band was $7{\cdot}2 \times 10^{-9}$ W cm^{-2}, and increased by a factor of 2·7 in the presence of cirrus. For the longer wavelength band the corresponding increase was only a factor of 1·4 above a clear sky value of 8×10^{-7} W cm^{-2} even though the long wave bandpass was nearly twice that at the shorter wavelength. Thus, although the contribution to the radiation flux from the cirrus gets smaller as we go to longer wavelengths, it is still not negligible at 30 μm. It follows that, to make measurements of stratospheric water vapour without complications from cirrus, long wavelengths should be used in spite of the disadvantage of smaller available energy. On the other hand, if our interest is in the cirrus itself, the difference in behaviour between different wavebands should be a useful diagnostic tool.

Studies of this kind, in which the time variation of sky flux is studied in different spectral bands, could also give us valuable information about the highly variable sky noise phenomena observed by infrared astronomers, for it could have its origins in the high cirrus clouds.

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[1] Kuhn, P. M., Lojko, M. S., and Petersen, E. W., *Nature*, **223**, 462 (1969).
[2] Gebbie, H. A., Burroughs, W. J., Harris, J. E., and Cameron, R. M., *Astrophys. J.*, **154**, 405 (1968).
[3] Eddy, J. A., and MacQueen, R. M., *J. Geophys. Res.*, **74**, 3322 (1969).

Terminal Velocities of Balls dropping through Dilute Colloid Solutions

WHITE[1] has reported drag reduction of spheres in the Reynolds number range of 10^4 to 10^5 in equimolar mixtures of an association colloid cetyl–trimethyl ammonium bromide and α-naphthol. We have repeated his experiments using a range of steel, brass, glass and plastic balls and the same gel using concentrations of 650, 520 and 360 p.p.m., but do not detect any drag reduction. The balls were dropped down a 'Perspex'-fronted tank nine feet high and the terminal velocities measured by a photographic technique of Ulherr *et al.*[2]. A range of sphere Reynolds numbers of $8{\cdot}2 \times 10^3$ to $3{\cdot}3 \times 10^5$ was obtained basing the kinematic viscosity in the Reynolds number on measurements taken for each gel in an Ostwald viscometer.

The kinematic viscosities of a 360 p.p.m. and a 650 p.p.m. gel were about 1·1 and 1·65 centistokes respectively. Those values depend on the actual molecular weights of the gel micelles, which are affected by quantities of impurities such as alcohols. In the present experiments ethanol was used to get the α-naphthol in solution. The kinematic viscosities of the gels will therefore vary according to the recipe used to produce them and the present results cannot be directly applied to White's work[1]. His data, however, base kinematic viscosity on that of water and if the larger viscosities of the gel are taken into account his gel results would be pushed nearer to the line for water.

In the present work, we were unable to obtain any drag reduction and any changes in drag coefficient lay within the region of experimental error. In turbulent pipe flow all the gel solutions used in these experiments are very efficient drag reducers, giving results on "Virk's" maximum drag reduction asymptote[3]. When stirred in a glass beaker the solutions gave no detectable recoil[4]. Nash[7] has shown that concentrated solutions of this gel system have shorter swirl decay times than pure water and sometimes recoil noticeably. Recoil would give a clear indication of laminar visco-elasticity and the absence of recoil in the present instance can be taken as indicating that the present dilute solutions were not highly visco-elastic.

These results are further evidence of the observation made by Granville[5] that drag reduction occurs in solutions which do not exhibit laminar visco-elasticity. In the present experiments visco-elasticity would have manifested itself as an increase in terminal velocities already reported for polyethylene oxide[1,6].

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[1] White, A., *Nature*, **216**, 995 (1967).
[2] Ulherr, P. H. T., *et al.*, *Chem. Eng. Sci.*, **20**, 997 (1965).
[3] Virk, P. S., *et al.*, *J. Fluid Mechanics*, **28**, 195 (1967).
[4] Frederickson, A. G., *Principles and Application of Rheology*, 120 (Prentice-Hall, 1964).
[5] Granville, P. S., *ONR Drag Red. Monitor Report* (1968).
[6] White, D. A., *Nature*, **212**, 277 (1966).
[7] Nash, T., *J. Colloid Sci.*, **13**, 134 (1958).

Microelectrophoresis Measurements on Polymeric Flocculants Alone and in Excess with Model Colloids

REMARKABLE agreement has been observed between the zeta potential (ζ) of colloidal particles of polymeric flocculants alone and that of model colloids to which an excess of flocculant has been added. The implications are basic to the broad field of colloid chemistry and bear on many areas of water-pollution control[1–3].

Because essentially all colloidal and microemulsion contaminants in waste water are negatively charged, the principal emphasis has been on the study of cationic flocculants[4]. Closely related work, however, has also been performed on anionic polymers; some experiments involved the sequential addition of oppositely charged flocculants, others involved the ability of anionics to increase the negative ζ and consequently the stability of negatively charged colloids[5]. To clarify some of the unexpected effects, microelectrophoresis measurements were made with particles of both types of flocculant alone; that is, in the absence of the colloidal contaminants.