Table 1. EFFECT OF 10^{-3} M ATP ON THE SPEED (RELATIVE UNITS) OF THE MOVEMENT IN LIGHT AND DARK

	Control	10^{-3} M ATP
200 Lux	62	68
Dark	41	70

and the photokinetic effect of light must be produced by an additional energy supply from photophosphorylation.

W. NULTSCH
G. THROM

Department of Botany,
University of Marburg,
Germany.

Received January 23; revised March 21, 1968.

[1] Hoffmann-Berling, H., *Biochim. Biophys. Acta*, **16**, 146 (1955).
[2] Jahn, T. L., and Bovee, E. C., *Ann. Rev. Microbiol.*, **19**, 21 (1965).
[3] Hoffmann-Berling, H., *Comp. Biochem.*, **1**, 341 (Academic Press, New York, 1960).
[4] Clayton, R. K., *Arch. Microbiol.*, **29**, 189 (1958).

APPLIED SCIENCES

Sensitive Microbiological Detector for Air Pollution

THERE is an extensive literature on the photochemical reactions involved in the production of smog, which is reviewed in refs. 1 and 2. Early investigations of this problem[3–5] revealed that at extremely low concentrations the oxidative constituents could damage the leaves of certain plants, and that differences in the leaf damage of plants at specified stages in their development could be used to characterize various types of smog oxidants[6–8]. Went[9] contrasts the vulnerability of the photosynthetic cells in a leaf, which must operate by gaseous diffusion in very low carbon dioxide gradients between the free air and the cell contents, with the relatively protected position of the corresponding cells in the human respiratory system. He points out the advantages of exploiting the sensitivity of plant cells to give warning that the tolerance levels in pollution are being exceeded.

The growth of *E. coli* can be inhibited by the oxidative constituents of the atmosphere[10,11,18]; *E. coli*[11–13] and bioluminescent organisms (*Photobacterium phosphorescens*)[14] have been used to test the biological activity of a pollutant atmosphere.

The presence of pollutants in very low concentrations can be demonstrated by the microthread technique[15]. Particles containing single bacterial cells are generated by a modified Henderson[16] apparatus from a suspension of *E. coli* strain *MRE* 162 and "*BG*" (*B. subtilis* var. 'Niger') spores. The aerosol is passed over spider "escape line" held on a stainless steel frame and some particles become attached. The "frame" of spider threads with its captive aerosol is a sensitive test for air pollution and can be placed wherever it is wanted. Because the generated particles contain single cells of *E. coli* the organism is in direct contact with the oxidative substances in the surrounding air and is very susceptible to their action. The survival of the *E. coli* can be determined after a given period by immersing the "frame" in a suitable collecting fluid, agitating to detach the *E. coli* and "*BG*" from the threads, and plating on tryptone agar after the appropriate dilution. The survival of *E. coli* is expressed as the *E. coli*/*BG* ratio found on the culture plates taken from the captive aerosol divided by the corresponding ratio present in the suspension sprayed. Full details of this process are given in ref. 15. In the conditions of these experiments we found no evidence of loss of viability among the "*BG*" spores in the captive aerosol. With other phytotoxicants it might prove necessary to use a radioactive tracer, but radioactive iodine compounds are unsuitable for this purpose because we have found that iodine is lost from small particles when they are exposed to an atmosphere containing oxidant.

We chose as our "smog" component the class *B* phytotoxicant[3,4,8]. This was generated in a 20 m³ chamber in the dark. Ozone was produced by passing oxygen over 2–*OZ* 4 W Philips lamps and this gave an equilibrium value of 2·6 parts per hundred million (p.p.h.m.) as determined by an 'Ozomat'. Care was taken to prevent the escape of any ultraviolet light into the chamber, and the air in it was fanned continuously and maintained at 25° C and 90 per cent relative humidity. When equilibrium had been attained an excess of 2-pentene at a concentration of 1 part per million (p.p.m.) was added. The 'Ozomat' reading fell rapidly and equilibrium was re-established below 0·5 p.p.h.m. of ozone as would be predicted from the rate of its generation and the kinetics of the reaction.

We found that there was a powerful germicidal effect on the *E. coli* with decay rates of more than 20 per cent per minute. Similar results were obtained with 2-hexene, 2-heptene and 2-octene. Olefine at 1 p.p.m. in pure air does not affect the survival of *E. coli*. In pure air the decay rate of a single cell aerosol of *E. coli* 162 under the conditions used does not exceed a few per cent per hour. In pure air the decay produced by 0·5 p.p.h.m. of ozone is negligible.

The experiments of Arnold[17] indicate a half-life of 6 min for the ozone–pentene complex, the precise nature of which remains undefined in spite of much investigation[1]. Because the ozone output from the lamps was 0·25 p.p.h.m. min^{-1} the concentration of complex present at equilibrium could not have exceeded 2 p.p.h.m. This suggests a sensitivity of the order of 1 part per thousand million for the microthread method as a detector of pollution, which is beyond the present limits of analysis.

The complex exerts an extremely rapid germicidal action at very low concentrations and is itself rapidly removed. This suggests that a possible use of the material would be to suppress airborne non-sporulating bacteria and viruses in special environments where rapid kill rather than long term efficiency is required—for example, when burns are being dressed.

We thank Dr P. J. Lawther of the MRC Air Pollution Unit for the loan of the chamber, and Dr S. G. Perry of the Research Department, Esso Petroleum Company, and Mr P. R. Morris of the Chemical Inspectorate, Ministry of Defence, for help and advice.

H. A. DRUETT
L. P. PACKMAN

Microbiological Research Establishment,
Ministry of Defence,
Porton,
Salisbury, Wilts.

Received April 5, 1968.

[1] Leighton, P. A., *Photochemistry of Air Pollution* (Academic Press, New York, 1961).
[2] Stern, A., *Air Pollution* (Academic Press, New York, 1962).
[3] Darley, E. F., Stephens, E. R., Middleton, J. T., and Hanst, P. L., *Amer. Pet. Inst. Proc.*, **38** (iii), 313 (1958).
[4] Darley, E. F., Stephens, E. R., Middleton, J. T., and Hanst, P. L., *Intern. J. Air Poll.*, **1**, 115 (1959).
[5] Haagen Smit, A. J., Darley, E. F., Zaitlin, M., Hull, H., and Noble, W., *Plant Physiol.*, **27** (i), 18 (1952).
[6] Darley, E. F., Middleton, J. T., and Garber, M. J., *Amer. Chem. Soc.*, 136th Meeting (1959).
[7] Darley, E. F., Middleton, J. T., and Hanst, P. L., *Intern. J. Air Poll.*, **1**, 155 (1959).
[8] Stephens, E. R., Darley, E. F., Taylor, O. C., and Scott, W. E., *Intern. J. Air Water Poll.*, **4**, 79 (1961).
[9] Went, F. W., *Desert Research Inst.*, Preprint Series No. 31, University of Nevada, 1966.
[10] Goetz, A., and Tsunaishi, N., *AMA Arch. Ind. Health*, **20**, 167 (1959).
[11] Pan Chao Han, Gast, J. H., and Estes, F. L., *J. Appl. Microbiol.*, **9**, 45 (1961).
[12] Este, F. L., *Anal. Chem.*, **34**, 998 (1962).
[13] Este, F. L., *Atm. Env.*, **1**, 159 (1967).
[14] Serat, W. F., and Mueller, P. K., *Amer. Chem. Soc.*, 148th Meeting (1964).
[15] May, K. R., and Druett, H. A., *J. Gen. Microbiol.* (in the press, 1968).
[16] Henderson, D. W., *J. Hyg. Camb.*, **50**, 53 (1952).
[17] Arnold, W. N., *Intern. J. Air Poll.*, **2**, 167 (1959).
[18] Goetz, A., and Tsunaishi, N., *Ind. Eng. Chem.*, **51**, 772 (1959).