ories can only be tested with good data. Beliefs and preconceptions about the way nature should work provide no scientific basis for rejecting predictive empirical models.

R. J. CORNETT
F. H. RIGLER
Department of Biology,
McGill University, Montreal,
Quebec, Canada H3A 1B1

References and Notes

1. R. J. Cornett and F. H. Rigler, *Science* **205**, 580 (1979).
2. W. Y. B. Chang and R. A. Moll, *ibid.* **209**, 722 (1980).
3. M. Kleiber, *The Fire of Life: An Introduction to Animal Energetics* (Wiley, New York, 1961).
4. B. T. Hargrave, *Limnol. Oceanogr.* **14**, 801 (1969).
5. W. W. Walker, *Water Resour. Res.* **15**, 1463 (1979); R. J. Cornett and F. H. Rigler, *Limnol. Oceanogr.*, in press.
6. M. N. Charlton, *Can. J. Fish. Aquat. Sci.* **37**, 72 (1980).
7. S. C. Chapra and H. F. H. Dobson, Contribution No. 113 (Great Lakes Environmental Research Laboratory, University of Michigan, Ann Arbor, 1979).
8. N. M. Burns, *J. Fish. Res. Board Can.* **33**, 512 (1976).
9. W. J. Snodgrass, thesis, University of North Carolina (1974).
10. Lake Erie temperatures were taken from (*8*). We assumed a mean temperature of 4°C for Lake Superior, Lake Michigan, and Lake Ontario and, because it is shallower, a temperature of 4.5°C for Lake Huron.

11 June 1980

Synergistic Effects in Trace Gas–Aerosol Interactions

Baldwin and Golden (*1*) recently reported some results of a study of the reaction of various atmospheric gases with both H_2SO_4 and soot surfaces. They reported that SO_2 and NO_2 (as well as several other gases) did not react appreciably with the soot. We have similarly observed no effect when dry SO_2 and NO_2 are exposed to carbon surfaces individually, but significant reaction is observed when SO_2 and NO_2 are exposed to such surfaces in combination.

Our experimental procedure (*2*) consists of a microgravimetric determination of chemisorption with subsequent analysis of the chemisorbed species by various techniques. A substrate sample is placed on the pan of a continuously recording microbalance and is exposed for a given time to a measured flow of carrier gas (dry or humidified) which contains small quantities (10 to 100 parts per million) of one or more test gases. The sample is then exposed to a flow of dry N_2 to desorb any physically adsorbed species. In control measurements, the substrate is exposed to pure carrier gas and the system with an empty pan is exposed to the various gases.

When samples of commercially available carbon black (used as a soot surrogate to maintain uniformity) are exposed to either SO_2 or NO_2 in dry air or N_2 as the carrier gas, no quantitative chemisorption ($< 5\ \mu g$ on $\simeq 1$ mg of substrate) is observed. However, exposure of the same grade of carbon to a combination of SO_2 and NO_2 in dry air or N_2 results in significant chemisorption (180 to 280 $\mu g/mg$), a major fraction of which is analyzed as sulfate. The NO_2 appears to be an oxidizing agent, since reaction occurs in either N_2 or air. In fact, a slightly higher yield is observed with N_2 than with air; some constituent of air (perhaps NO) may inhibit the reaction somewhat. The reaction is believed to be heterogeneous and to occur on the substrate because no reaction is observed in appropriate control measurements. Humidification of the carrier gas, whether air or N_2, increases both the total chemisorption and the amount of sulfate by about an order of magnitude. These values are measured after desorption of the samples by dry N_2 and therefore do not merely represent adsorbed water.

The effect of humidity in converting SO_2 on carbon black is so pronounced that some chemisorption and sulfate yield is observed with SO_2 in humid air without the addition of NO_2, but addition of NO_2 increases the yield by an order of magnitude or more. Quantitative chemisorption on carbon black has not been observed (i) with SO_2 in dry air, in dry N_2, or in humidified N_2 in the absence of NO_2 or (ii) with NO_2 in these carriers in the absence of SO_2.

We have also observed chemisorption and sulfate formation on an Al_2O_3 substrate with $SO_2 + NO_2$ in humidified air, but with lower yields than on carbon black. Barbaray *et al.* (*3*) have reported enhancement of the chemisorption and oxidation of SO_2 by NO_2 and H_2O on a V_2O_5 substrate, and Novakov and his coworkers (*4*) have demonstrated the importance of both gaseous and liquid H_2O on heterogeneous SO_2 oxidation in the presence of carbon surfaces.

We agree with Baldwin and Golden on the potential importance of heterogeneous processes in the atmosphere. We strongly urge, however, that research on such processes should consider synergistic effects among atmospheric trace gases. Baldwin and Golden considered such effects in their studies with the H_2SO_4 surface, with negative results for O_3 + NO and O_2 + NO.

DAVID R. SCHRYER
WESLEY R. COFER III
ROBERT S. ROGOWSKI
NASA Langley Research Center,
Hampton, Virginia 23665

References

1. A. C. Baldwin and D. M. Golden, *Science* **206**, 562 (1979).
2. W. R. Cofer III, D. R. Schryer, R. S. Rogowski, *Atmos. Environ.*, in press; D. R. Schryer *et al.*, *Environ. Sci. Technol.* **13**, 1419 (1979).
3. B. Barbaray, J.-P. Contour, G. Mouvier, *Environ. Sci. Technol.* **12**, 1294 (1978).
4. T. Novakov, S. G. Chang, A. B. Harker, *Science* **186**, 259 (1974); S. G. Chang and T. Novakov, in *Man's Impact on the Troposphere—Lectures in Tropospheric Chemistry*, J. S. Levine and D. R. Schryer, Eds. (Publication TN-1022, National Aeronautics and Space Administration, Washington, D.C., 1978), pp. 349–369.

20 December 1979

0036-8075/80/0808-0723$00.50/0