Dielectric Strengths of CCl₂F₂ Air and SO₂ Air Mixtures

Measurement on CCl_4 air mixtures made at this laboratory several years ago indicated that CCl_4 in air may be of considerable value for high potential work. These results suggested that it might be of interest to look for similar effects due to other compounds.

With the apparatus constructed by Rodine and Herb for their work on CCl_4 ,¹ two other compounds, CCl_2F_2 and SO₂, have been investigated for breakdown potential as a function of concentration in air.

Results on CCl_2F_2 are shown by the curves of Fig. 1, where sparking potentials across a 3 mm sphere gap are plotted as a function of partial pressure of CCl_2F_2 for several values of total pressure. Because of the limited potential available, some of the data were taken with smaller sphere separations, but all were reduced to the common separation of 3 mm.

Each of the points plotted is an average of many determinations. However, for pressures of CCl_2F_2 in the vicinity of its vapor pressure, sparking potentials were very incon-



FIG. 1. Curve A gives sparking potential in pure air as a function of pressure. Abscissae for this curve are air pressure in pounds per sq. in. with scale as indicated. For curves C, D, E, and F, sparking potentials in CCl₂F₂ air mixtures are given as a function of partial pressure of CCl₂F₂ with total pressures as follows: curve C, 14.3 lb.; curve D, 42.9 lb.; curve E, 71.5 lb.; curve F, 100.1 lb.



FIG. 2. Curve A gives sparking potential in pure air as a function of pressure. Abscissae for this curve are air pressure in pounds per sq. in. with scale as indicated. For curves C, D, E, and F, sparking potentials in SO₂ air mixtures are given as a function of partial pressure of SO₂ with total pressures as follows: curve C, 14.3 lb.; curve D, 28.6 lb.; curve E, 42.9 lb.; curve F, 100.1 lb.

sistent, occasionally as much as 30 percent below the value indicated, and therefore no claim of great accuracy can be made for the data in these regions.

That particular ordinate on each of curves C, D, and Ewhich corresponds to the point at which the partial pressure of CCl_2F_2 is equal to the total pressure for that curve, is the breakdown potential for pure CCl_2F_2 at that pressure. Curve B is the line drawn through these points and is taken as linear to an approximation. Since curves Fin both the case of CCl_2F_2 and the case of SO_2 were taken with total pressures in excess of the vapor pressure of the compounds at the temperature of the experiment, there exists no pure vapor point on curves F. From curve B, which shows sparking potential of pure CCl_2F_2 as a function of its pressure, and curve A, which is for pure air, the dielectric strength of pure CCl_2F_2 is seen to be approxi-

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mately 3.0 times as great as the dielectric strength of pure air.

Curves C, D, E, and F are seen to be convex upward; and for high total pressure, the curves rise very steeply in the region of low CCl_2F_2 concentrations. If the dielectric strengths of the two components were simply additive, these curves would be straight lines connecting the endpoints. The shape observed shows that the dielectric strength of the mixture is greater than the sum of the dielectric strengths of the components.

Sparking potential of the CCl_2F_2 air mixtures did not appear to depend greatly on the number of sparks that had passed. High concentrations of CCl_2F_2 appeared to have no effect on brass, Bakelite, Textolite, rubber, Picein wax, or red sealing wax.

Figure 2 shows results obtained from work on SO₂ air mixtures. The curves shown are plotted in the same manner as in the case of CCl_2F_2 . To judge by the fairly permanent fog observed after sparking, the vapor seemed to be decomposed in the vicinity of the discharge.

It was also observed that the vapor corroded the spheres and pressure vessel. From a comparison of curves A and B of Fig. 2, the dielectric strength of pure SO₂ is seen to be approximately 2.7 times as great as the dielectric strength of pure air. This value, however, is very approximate since the data showed great spread.

We wish to express our appreciation to Dr. R. G. Herb for his guidance in this work, and to J. C. Bellamy, for valuable help.

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The Elastic Constants of Crystalline Sodium at 80°K

In a recent issue of this journal¹ one of us reported values of the principal elastic constants of crystalline sodium at 80°K. These results are entirely erroneous, because an inappropriate formula was used in reducing the observations.

The experimental method is a dynamical one,² and the calculation of the principal elastic constants demands, in part, a relation between these quantities and the rigidity modulus corresponding to a given direction in the crystal lattice. Two such relations are available, one of which describes the behavior of a right circular cylinder over the end faces of which torsional stresses are applied. Under such a stress system the cylinder will, in general, bend as well as twist. The second relation describes the behavior of the cylinder when this bending is prevented. It appears that the propagation of supersonic torsional vibrations along thin cylinders of crystalline material is governed by the second of these relations, and not by the first.

The three crystals which yielded the data now under review were grown from sodium prepared by heating C.P. NaCl with metallic Ca. The correct values of the elastic constants of these crystals are as follows: $s_{11}=4.69$, $s_{12}=$ -1.94 and $s_{44}=1.76$, all times 10^{-11} cm²/dynes. The high value of the compressibility of this material, namely 2.43×10^{-11} , suggests the presence of impurity. Accordingly we have redetermined the elastic constants from measurements made upon six crystals grown from triply distilled Mallinckrodt sodium.

The newly determined values of the principal elastic constants at 80°K are: $s_{11}=4.86$, $s_{12}=-2.17$, $s_{44}=1.76$, all times 10^{-11} cm²/dynes. The data immediately obtained from the experimental observations are the values of the velocities of propagation of longitudinal and torsional vibration along thin cylinders of the specimen material. The concordance of the observations here reported is exhibited in Table I, in which the observed velocities

 TABLE I. Observed and computed values of the longitudinal and torsional velocities in cylinders of crystal sodium.

	Longitudinal Velocity ×10 ⁻⁵ cm/sec.		Torsional Velocity ×10 ⁻⁵ cm/sec.	
Direction Factor	Observed	Computed	Observed	Computed
0.0130 0.1175	1.457	1.454	2.260 1.793	2.299 1.816
0.1476 0.2128	1.803 2.104	1.806 2.104	1.648 1.387	1.647 1.378
$0.2907 \\ 0.3044$	2.792 2.964	2.779 2.981	1.188 1.072	1.174 1.081

may be compared with those computed from the values of the elastic constants given above. The first column contains the factor $\sum \alpha_i^2 \alpha_j^2$, where the α 's are the direction cosines of the specimen cylinder axis with respect to the principal axes of the crystal. This factor, whose value must lie between 0 and 1/3, governs the variation of the longitudinal velocity with direction, and principally that of the torsional velocity as well. It will be seen that range of possible values is well covered by the present six crystal cylinders.

Bridgman³ has measured the variation of the compressibility of polycrystalline sodium with pressure between 2000 and 20,000 kg/cm². As the pressure is lowered the compressibility increases toward the (extrapolated) value 1.7×10^{-11} cm²/dynes at zero pressure and room temperature. The present value at 80°K is 1.56×10^{-11} .

Fuchs⁴ has given a wave mechanical calculation of the quantities $(c_{11}-c_{12})$ and c_{44} for sodium at 0°K, which yields the values 1.41×10^{10} and 5.8×10^{10} , respectively. The corresponding experimental values at 80°K are 1.42×10^{10} and 5.7×10^{10} .

A complete description of the experiments will shortly be submitted for publication in this journal. The authors gratefully acknowledge their indebtedness to the Ernest Kempton Adams Fellowship of Columbia University for the financial assistance which made this work possible.

Pupin Physics Laboratories, Columbia University, New York, N. Y. August 25, 1937.	S. L. QUIMBY Sidney Siegel
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