

Mead, Fuoss and Kraus⁶. In a mixed aqueous solution of two completely dissociated electrolytes containing two cations of practically equal mobility and a common anion, this effect should be negligible, and the conductivity of such a mixture should depend only on the mobilities of the ions and on the total concentration. In other words, if the equivalent conductivities of the two electrolytes separately are known over the appropriate range of low concentrations, it should be possible to calculate the conductivity of any mixture of the two, assuming that the conductivities are additive and depend only on the total concentration.

To test this point, I have measured the conductivities at 25° C. of very dilute aqueous solutions over the range 0.00005-0.001 equivalent of calcium and strontium dithionates and the corresponding sulphates, and of their mixtures in which dithionate and sulphate respectively are the common negative ions. The following results appear:

(1) The corresponding calcium and strontium salts have almost the same equivalent conductivity throughout the range of concentrations examined. (2) The graph of the equivalent conductivity plotted against the square root of the equivalent concentration deviates sensibly from a straight line only at the highest concentrations examined. (3) The slope of this line is in all cases much greater than that predicted by Onsager's equation, using values for equivalent conductivity at infinite dilution obtained by linear extrapolation over a range of a few units. (4) For calcium and strontium dithionates the observed slope is 506, the calculated slope 366 and the equivalent conductivity at infinite dilution 152; the corresponding figures for the two sulphates are 646, 354 and 142 respectively. (5) The salts with the higher equivalent conductivity at infinite dilution give the smaller slope, a result at variance with Onsager's equation. (6) The conductivities of all mixtures examined are additive, usually within the probable limits of experimental error, indicating complete dissociation.

It is intended to extend this work as opportunity offers to the selenates of calcium and strontium and to other bi-bivalent salts. The determination of activity coefficients in dilute mixed solutions, if practicable, should yield results interesting in this connexion.

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¹ *J. Amer. Chem. Soc.*, **54**, 1411 (1932).

² *Phys. Z.*, **28**, 277 (1927).

³ *Trans. Faraday Soc.*, **23**, 351 (1927).

⁴ *J. Amer. Chem. Soc.*, **53**, 2040 and 4333 (1931).

⁵ *J. Phys. Chem.*, **36**, 2689 (1932).

⁶ *Trans. Faraday Soc.*, **32**, 594 (1936).

Surface Temperature of Rubbing Solids and the Formation of the Beilby Layer

RECENT letters¹ have discussed the structure of the Beilby layer, and it may be of interest to describe experiments which throw some light on the mechanism of its formation. Macaulay² has suggested that polishing is due to a melting of the surface, but the majority of investigators, Newton³, Rayleigh⁴, Herschel⁵, French⁶, Adam⁷, Hamburger⁸, considered that the process is essentially one of abrasion. French embedded a thermometer in the polisher, and concluded that the rise in temperature of the surfaces was negligibly small.

If the sliding contact of two different metals is used as a thermo-couple, the surface temperature can be measured. Experiments show that the local temperatures at the points of contact may be very high; under many conditions of sliding, sufficiently high to cause a real melting of the metal⁹. Even if the surfaces are well lubricated or flooded with water, these local high temperatures still occur. In the case of non-metals of low thermal conductivity such as glass, silk, alumina, etc., the surface temperatures will be very much higher. This localized frictional heating should play a large part in the process of wear, surface flow and polishing of solids. If this view is correct, we should expect the process to be greatly influenced by the *relative melting point* of the polisher and solid. If the polisher melts or softens at a *lower* temperature than the solid, it will melt and flow first, and will have comparatively little effect on the solid. Experiment has shown this to be the case. Surface flow, polish and the formation of the Beilby layer readily occurred on metals, crystals and glasses, provided the melting point of the polisher was higher than that of the solid. The *relative hardness* as normally measured at room temperature was comparatively unimportant.

For example, *camphor* (m.p. 178° C.) readily polished Wood's alloy (m.p. 69° C.) which melts below it, but would not polish higher melting metals such as tin (m.p. 232° C.). *Oxamide* (m.p. 417° C.) polished tin, type metal, etc. and all solids melting below 417° C., but had no effect on speculum metal (m.p. 745° C.). *Lead oxide* (m.p. 888° C.) polished speculum metal, but had no effect on nickel (m.p. 1452° C.) and molybdenum (m.p. 2470° C.). Similar results were obtained for numerous glasses and crystals. Calcite, for example, which melts at 1333° C., was readily polished by *zinc oxide* (m.p. about 1800°) but not by *cuprous oxide* (m.p. 1235° C.) or *oxamide* (m.p. 417° C.). The mechanical strength of many solids falls to a low value at temperatures well below the melting point, so that appreciable surface flow can occur at these lower temperatures. This has been observed in many cases.

The process of polishing is a complicated one, and will be discussed more fully elsewhere. These experiments indicate, however, that an important part of the process is an intense local heating at the points of contact. The melted or softened solid flows, or is smeared, over the surface, and very quickly solidifies to form the characteristic Beilby layer. The extent to which this layer is microcrystalline or 'amorphous' will naturally depend upon the conditions of polishing, rate of cooling, etc., and upon the physical properties of the solid. If oxidizable solids are polished in air, we should expect this local heating to cause rapid surface oxidation. Electron diffraction experiments¹⁰ have shown that the polished layer on copper and aluminium is, in reality, metallic oxide.

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¹ Finch, *NATURE*, **138**, 1010; **137**, 516 (1936).

² *NATURE*, **118**, 339 (1926).

³ "Opticks" (Book II), 68 (1704).

⁴ "Coll. Works", **4**, 452.

⁵ "Encyclopedia Metropolitana", Optics, 447 (1830).

⁶ *NATURE*, **119**, 527 (1926).

⁷ *NATURE*, **119**, 162, 279 (1926).

⁸ *NATURE*, **130**, 435 (1932).

⁹ Bowden and Ridler, *Proc. Roy. Soc., A*, **154**, 640 (1936).

¹⁰ Dobrinski, *NATURE*, **138**, 31 (1936). Preston and Bircumshaw, *Phil. Mag.*, **148**, 654 (1936).