

The Piezoelectric Properties of Rochelle Salt

In a recent paper,¹ I tested the hypothesis that the piezoelectric deformation of Rochelle salt is proportional to the inner field F . A satisfactory check was found at temperatures above the Curie point and for frequencies above 100 cycles/sec. Below the upper Curie point the piezoelectric modulus d_{14} increases with the applied field which I thought to be contrary to Mueller's² theory.

Dr. Mueller has called to my attention that this conclusion is wrong. Mueller's theory predicts that d_{14} should have the same value above and below the Curie point when the applied field is small compared to the inner field. An error was made in the calculation of curve B of Fig. 13 in my paper.¹ The corrected curve B of Fig. 13 should have approximately the same slope but should be displaced 0.6 to larger values of $d_{14} \times 10^{10}$. The new intersection of curves A and B is almost at zero voltage. Hence this point of the theory is verified.

The permanent inner electric field F_0 can have the values $+F_0$ and $-F_0$. For a.c. measurements both directions are equivalent and we may therefore assume that one-half the crystal has the field $+F_0$ and the other half $-F_0$. If a field E is applied, the inner field during the first half-cycle becomes $F_0 + F_1$, in the other half-cycle $-F_0 + F_2$. The experiment records the average $\frac{1}{2}(F_1 + F_2)$. In the first approximation F_1 and F_2 are equal and proportional to E . This approximation leads to Eq. (15)¹ and is correct if E is very small in comparison with the field F_0 . Near the Curie point the field F_0 is about 100 volt/cm. The experiments were carried out with applied fields up to 47.2 volt/cm. For such large fields F_1 and F_2 are not equal. This may be seen from Fig. 3 of Mueller's paper.² Eq. (14)¹ in my paper is incorrect for large applied fields because it was derived on the assumption that F_1 and F_2 were equal. F_1 increases very slightly slower than $\text{const.} \times E$, but F_2 increases considerably faster than $\text{const.} \times E$. Hence the average of both fields increases faster than the applied field E , which explains the observed increase of d_{14} with voltage. The order of magnitude of the observed increase is in good agreement with the theory, but we cannot expect an accurate check since the observed hysteresis curves differ from the theoretical ones.

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¹ Oscar Norgorden, Phys. Rev. **49**, 820 (1936).

² Hans Mueller, Phys. Rev. **47**, 175 (1935).

Effects of Chemical Combination on X-Ray Emission Spectra

The discrepancy noted between the wave-lengths determined by Tanaka and Okuno¹ and McDonald² for the Fe $K\beta_1$ from FeS₂ raised a question as to the origin of this difference. With the idea of checking the Japanese results further, the $K\beta$ lines of 26 Fe, 25 Mn, and 24 Cr in Fe₂O₃, KMnO₄, and K₂Cr₂O₇ were photographed with the focusing crystal spectrograph heretofore described.² The results in iron are again contrary to those of Tanaka and Okuno. In Cr and Mn, results checking theirs, as well as those of

TABLE I. Wave-lengths in X.U. of the $K\beta$ lines of 24 Cr, 25 Mn, and 26 Fe from various compounds.

	$K\beta'$	$K\beta_1$	$K\beta_5$
Cr		2080.39 ± 5	
Cr ₂ O ₃	2086.1 ± 1	2080.41 ± 5	2067.5 ± 1
Mn ²	1910.3 ± 1	1905.97 ± 5	
Fe ₂ O ₃	1756.9 ± 1	1753.01 ± 5	1741.7 ± 1

Yoshida³ and Wetterblad,⁴ for the wave-lengths from Cr₂O₃ and divalent Mn, were obtained. Evidently the KMnO₄ and K₂Cr₂O₇ decomposed rapidly under the fairly high power which was used because of the limited time at the writer's disposal.

The results are listed in Table I. In the light of the report of Roseberry and Bearden,⁵ who found by direct bombardment of Fe₂O₃ no change in width or asymmetry from the pure metal, the shift shown by the $K\beta_5$ of Fe is interesting.

Tanaka and Okuno also report the $K\beta_1$ in pure Cr at about 0.2 X.U. shorter wave-length than the value of about 2080.6 X.U. given by Eriksson⁶ and Bearden and Shaw.⁷ This would seem to show that the surface of the Cr becomes oxidized very rapidly from the residual vapors present in the tubes. Parratt⁸ mentions the possibility of such oxidation as an explanation of the difference between his work and that of Bearden and Shaw on the widths of the $K\alpha$ lines of Cr and Ti.

If the positions of the K edge of Cr and Fe in Cr₂O₃ and Fe₂O₃, as measured by Coster⁹ and Lindh,¹⁰ are used in conjunction with the wave-lengths of the $K\beta_5$ line for calculating the term values of the MIV , V shell, we get values, in Rydberg units, of 1.41 and 1.35, respectively, much larger than the corresponding values for the metals of 0.2 and 0.4.

Preliminary results have been attained in an extension of Valasek's work¹¹ on the potassium halides. Using the K $K\beta_1$ as a standard, the wave-lengths of the K $K\beta''$ and $K\beta_5$ in KCl were found at 3442.7 ± 2 and 3435.1 ± 2 X.U., respectively. The characteristic violet coloration of KCl obtained on exposure to x-rays was noted. If the $K\beta''$ is not considered a spark line, and the second ionization potential of K is computed from it in the way Valasek used the $K\beta_1$ for the same purpose, a value of 28.1 volts, lower than the true value of 31.7 volts, is obtained. Even if the mean of this value and that gotten from the $K\beta_1$, 33.1 volts, or a mean of 30.8 volts, is considered, we see that it differs by more than the experimental error from the true value. The $K\beta''$ may be a spark line, however.

With KI, wave-lengths of 3447.11 ± 5 X.U., and 2142.1 X.U. for the K $K\beta_1$ and I $L\alpha_1$, respectively, were found.

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¹ Tanaka and Okuno, Jap. J. Phys. **9**, 75 (1934); **10**, 1 (1935).

² McDonald, Phys. Rev. **50**, 694 (1936).

³ Yoshida, Inst. Phys. Chem. Res. Tokyo **20**, 298 (1933).

⁴ Wetterblad, Zeits. f. Physik **49**, 670 (1928).

⁵ Roseberry and Bearden, Phys. Rev. **50**, 204 (1936).

⁶ Eriksson, Zeits. f. Physik **48**, 360 (1928).

⁷ Bearden and Shaw, Phys. Rev. **48**, 18 (1936).

⁸ Parratt, Phys. Rev. **50**, 1 (1936).

⁹ Coster, Zeits. f. Physik **25**, 83 (1924).

¹⁰ Lindh, Zeits. f. Physik **31**, 210 (1925).

¹¹ Valasek, Phys. Rev. **47**, 896 (1935).