about 770 m above sea level, perhaps changing the environment of the cone. Study of the recolonization process should prove rewarding. The plant collection of 1966 may serve as an interesting basis for comparison. Although the caldera is thought to be somewhat inaccessible, recent experience shows that work there is quite practicable (*6*).

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3 September 1968; revised 16 October 1968

Chemical Potential of Water from Measurements of Optic Axial Angle of Zeolites

Abstract. *Values of the uncorrected optic axial angle ($2H_\alpha$) of a crystal of the calcium zeolite stellerite ($CaAl_2Si_7O_{18} \cdot 7H_2O$) immersed in calcium chloride solutions of known activity of water (a_w) are directly proportional to log a_w. A general relationship between the chemical potential of water in the crystal and the optic axial angle is obeyed.*

Some of the water in zeolite crystals is loosely bound and can be transferred in and out of the crystal. Structural changes brought about by variation in the water content of zeolites are reflected in changes in the optical properties of the crystal. We here report that for the orthorhombic calcium zeolite stellerite ($CaAl_2Si_7O_{18} \cdot 7H_2O$), the uncorrected optic axial angle ($2H_\alpha$) (*1*) is related to the chemical potential of water in the crystal μ_w by the general equation:

$$\mu_w - \mu_w^0 = 2.303RTS^{-1} \times [(2H_\alpha) - (2H_\alpha)^0] \quad (1)$$

where R is the gas constant; T is the absolute temperature; S is a numerical constant for the system which consists of crystal plus solution having chemical potential of water; μ_w; μ_w^0 and $(2H_\alpha)^0$ are standard-state values at an activity of water (a_w) equal to unity. The specific equation for a stellerite crystal immersed in $CaCl_2$ solutions of varying a_w at 25°C is:

$$\mu_w - \mu_w^0 = -0.167\,[(2H_\alpha) - 35.4] \quad (2)$$

where μ_w is in kilocalories per mole and ($2H_\alpha$) is in degrees.

A small crystal of stellerite (0.25 by 0.25 by 0.6 mm) was selected from a purified sample collected at a new occurrence near Chena Hot Springs, Alaska. The chemical analysis of the sample from which the crystal was selected indicates a composition near the theoretical one (*2*), with 0.07 percent sodium (by weight) and no potassium (*3*). Principle indices of refraction at 25°C for sodium light were determined with immersion liquids of known refractive index and a spindle stage; indices of refraction for ($2V_\alpha$) were determined with a four-axis Fedorow stage; the results are $N_\alpha = 1.486 \pm 0.002$, $N_\beta = 1.494 \pm 0.002$, and $N_\gamma = 1.498 \pm 0.002$; $(2V_\alpha) = 45.0° \pm 0.2°$ (average deviation). The crystal was then mounted on a glass fiber and placed in a Waldmann hollow-glass sphere. The sphere was successively filled with eight different $CaCl_2$ solutions; the crystal was equilibrated with $CaCl_2$ solution at 25° ± 0.1°C for a minimum of 24 hours, after which ($2H_\alpha$) was measured. The solutions ranged from 0.460 to 7.89 molal, corresponding to a range in a_w of 0.978 to 0.259.

The $CaCl_2$ solutions were prepared by dissolving $CaCl_2 \cdot 2H_2O$ (Mallinckrodt analytical reagent grade) in de-ionized water. This reagent contains 0.169 percent maximum impurities, with insignificant amounts of cations that might exchange with the calcium of the stellerite. The molality of each solution was determined by measuring the density of the solution and converting it to concentration (*4*). Values of a_w, as a function of molality, were obtained from Robinson and Stokes (*5*).

Measurement of ($2H_\alpha$) of the crystal during immersion in each solution was accomplished by orienting the Waldmann sphere on the universal stage in such a way that the position of both melatopes could be reached by rotation about A_4 (outer east-west axis) with minimum and approximately equal angles of tilt. In each case three sets of readings were obtained; these were checked by three additional sets of measurements with the optic axial plane rotated 180° by appropriate adjustments of A_1 (inner vertical axis) and A_2 (north-south axis). The six values of ($2H_\alpha$) observed were averaged, and the average deviation was calculated. For the eight $CaCl_2$ solutions and pure water, the largest difference (Table 1) between maximum ($2H_\alpha$) and minimum ($2H_\alpha$) for a given solution is 1.8°; the average difference is 1.1°. The average of the six readings made for each solution is somewhat more precise, as indicated by the values of the average deviations. The molality of $CaCl_2$ and a_w are known precisely enough so that these values contribute no error to the measurements.

The transfer of water into and out of the stellerite is reversible; within experimental error, the same value of ($2H_\alpha$) is found for a solution of given a_w before and after the crystal is immersed in a solution of different a_w.

Table 1. Measured apparent optic axial angles ($2H_\alpha$) at 25°C of a stellerite crystal immersed in $CaCl_2$ solutions. Average values for ($2H_\alpha$) are based on six measurements.

Molality	a_w (25°C)	($2H_\alpha$) (degrees)			
		Maximum	Minimum	Average	Av. dev.
0	1	36.2	35.0	35.4	0.5
0.460	0.978	35.8	35.1	35.4	.3
1.97_8	.864	36.1	35.7	35.9	.1
3.28_2	.714	37.2	36.1	36.6	.4
4.13_9	.588	37.6	36.5	37.2	.3
5.03_8	.496	38.6	37.2	37.9	.4
6.25	.369	39.5	38.3	38.8	.4
7.37	.289	41.0	39.2	39.8	.6
7.89	.259	40.8	39.9	40.2	.3

If the experimental values of $(2H_\alpha)$ are plotted against the corresponding values of log a_w, the points fall nearly on a straight line with the fit of the line well within experimental error. Least-squares analysis yields for the line

$$(2H_\alpha) = 35.3_7 - 8.17_8 \log a_w \quad (3)$$

The general equation for a straight line with coordinates $(2H_\alpha)$ and log a_w is

$$(2H_\alpha) = (2H_\alpha)^0 + S \log a_w \quad (4)$$

where $(2H_\alpha)^0$ is the value of $(2H_\alpha)$ at log $a_w = 0$, and S is the slope of the line. For any system, by definition

$$\mu_w - \mu_w^0 = 2.303\, RT \log a_w \quad (5)$$

Combining Eqs. 4 and 5, we obtain Eq. 1; by substituting the values of $(2H_\alpha)^0$ and S from Eq. 3 into Eq. 1, we obtain Eq. 2.

The apparent optic axial angle $(2H_\alpha)$ depends on both $(2V_\alpha)$, the true optic axial angle of the crystal, and the refractive index of the medium in which the crystal is immersed. Thus, it is surprising that $(2H_\alpha)$, a property of the total system, should be related in such a simple manner to the chemical potential of water. Furthermore, for a system at equilibrium μ_w is everywhere the same, so that $(2H_\alpha)$ also is a measure of μ_w in the crystal.

We have also investigated a stellerite containing a small percentage of sodium ions. For this crystal the same straight-line relationship between $(2H_\alpha)$ and log a_w holds, although values of the equation constants are different.

It seems likely that Eq. 1 can be used to measure a_w in aqueous solutions either to establish thermodynamic properties or to monitor systems. Similar relationships may exist between the optic axial angle and the activity of a component in solid solutions for other systems.

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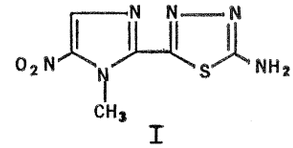
14 June 1968; revised 3 October 1968

2-Amino-5-(1-methyl-5-nitro-2-imidazolyl)-1,3,4-thiadiazole: A New Antimicrobial Agent

Abstract. *The title compound has been prepared and shown to be highly active against a wide variety of gram-positive and gram-negative bacteria in mice and chicks, as well as against a number of parasitic infections in rodents.*

We have prepared a compound which we believe to be one of the most active synthetic, broad spectrum, antibacterial-antiparasitic agents known: 2-amino-5-(1-methyl-5-nitro-2-imidazolyl)-1,3,4-thiadiazole (I).



I

As a consequence of a program of synthesis (*1*) of novel nitroheterocyclic aldehydes and their elaboration into structures suggested by the antibacterial nitrofurans, structure I was prepared in 81 percent yield by the ferric ammonium sulfate oxidative cyclization of 1-methyl-5-nitroimidazole-2-carboxaldehyde thiosemicarbazone (*2*) in hot water. Recrystallized from dimethylformamide, the sample had a melting point of 270°–271°C; microanalysis for C, H, N, and S was satisfactory; and the nuclear magnetic resonance spectrum (dimethylsulfoxide-d_6) showed bands at τ 1.73 (singlet, ring H), τ 2.13 (broad singlet, NH_2), and τ 5.59 (singlet, CH_3).

In the chick, compound I was approximately equivalent to furazolidone orally against both *Salmonella gallinarum* and *Escherichia coli* and was highly effective against *Pasteurella multocida*. In the mouse, it was at least as effective as furazolidone orally against *Salmonella choleraesuis* and highly efficacious versus *Pasteurella multocida*. The median effective oral dose was less than 1 mg/kg against *Neisseria meningitidis* and between 10 and 90 mg/kg for *Klebsiella pneumoniae, Salmonella typhosa, Escherichia coli, Aerobacter aerogenes,* and *Shigella flexneri* infections in the mouse. It was highly effective against *Streptococcus pyogenes* and a number of strains of *Staphylococcus aureus*. In rodents, the agent was active against the following parasitic infections: *Trichomonas vaginalis, Entamoeba histolytica, Trypanosoma equiperdum, Trypanosoma cruzi,* and *Leishmania donovani*. Compound I was also active against *Eimeria tenella* in the chick at 125 parts per million in the diet.

Test results on a large number of analogs of compound I indicate that several types of structural changes can be made, including the substitution of an aminooxadiazole for the aminothiadiazole ring, with the retention of a substantial degree of biological activity.

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27 September 1968

Size-Detecting Mechanisms in Human Vision

Abstract. *Inspecting a pattern of alternating dark and light bars makes it difficult to see a similar pattern presented afterward. This phenomenon can be used to isolate mechanisms responsive to bars of a given width. Our results suggest that the human visual system contains several different classes of size detectors, each maximally sensitive to visual targets with sizes in a particular range.*

The ability to appreciate the size of an object is a basic visual perceptual function, and much research has been concerned with the indirect or higher-order processes contributing to this ability (*1*). We tried to determine whether, in addition to use of these indirect cues, the human visual system can directly encode the area of retinal images produced by objects of different sizes.

The observation of a pattern of alternating dark and light bars reduces the visibility of a similar pattern presented thereafter (*2*). This phenomenon may be exploited to isolate mechanisms responding to patterns whose bars are of a particular size. One measure of the size of a bar in a pattern of alternating light and dark bars is the number of such alternating pairs (or cycles) occupying a given area. This quantity is termed spatial frequency, with values expressed in number of cycles per degree (cycle/deg) of visual angle. In