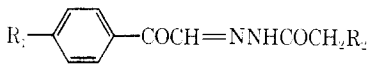
TABLE I



| No. | $R_1$ | $R_2$ | Yield, % | Mp, °C | Solvent of crystn[a] | Formula | Calcd, % C | H | N | Cl | Found, % C | H | N | Cl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | H | N-Pyrrolidino | 40 | 212–213 | E | $C_{13}H_{17}N_3O_2 \cdot HCl$ | 56.85 | 6.43 | 14.21 | 11.90 | 57.09 | 6.22 | 14.27 | 11.83 |
| 2 | H | N-Piperidino | 50 | 214–215 | E–Et | $C_{14}H_{19}N_3O_2 \cdot HCl$ | 58.15 | 6.59 | 13.56 | 11.41 | 58.15 | 6.65 | 13.30 | 11.63 |
| 3 | H | N-Morpholino | 72 | 138 | I | $C_{13}H_{17}N_3O_3$ | 61.08 | 6.22 | 15.26 | | 61.17 | 6.15 | 14.35 | |
| 4 | $C_6H_5$ | N-Diethylamino | 60 | 130 | E | $C_{21}H_{25}N_3O_2$ | 71.10 | 6.87 | 12.45 | | 71.12 | 6.50 | 12.21 | |
| 5 | $C_6H_5$ | N-Pyrrolidino | 71 | 159–160 | E–M | $C_{20}H_{21}N_3O_2$ | 71.62 | 6.31 | 12.53 | | 71.57 | 6.40 | 12.83 | |
| 6 | $C_6H_5$ | N-Piperidino | 71 | 170–171 | E | $C_{21}H_{23}N_3O_2$ | 72.18 | 6.63 | 12.03 | | 71.97 | 6.77 | 11.92 | |
| 7 | $C_6H_5$ | N-Morpholino | 60 | 194 | M | $C_{20}H_{21}N_3O_3$ | 68.36 | 6.02 | 11.96 | | 68.64 | 6.20 | 11.75 | |
| 8 | $C_6H_5S$ | N-Pyrrolidino | 68 | 140 | E | $C_{20}H_{21}N_3O_2S$ | 65.38 | 5.76 | 11.45 | 8.69[b] | 65.35 | 6.04 | 11.58 | 8.78 |
| 9 | $C_6H_5S$ | N-Piperidino | 68 | 161 | E | $C_{21}H_{23}N_3O_2S$ | 66.12 | 6.08 | 11.03 | 8.38[b] | 65.99 | 6.15 | 10.90 | 8.37 |
| 10 | $C_6H_5S$ | N-Morpholino | 70 | 144 | M | $C_{20}H_{21}N_3O_3S$ | 62.65 | 5.52 | 10.96 | 8.36[b] | 62.87 | 5.49 | 10.68 | 8.27 |
| 11 | $C_6H_5O$ | N-Pyrrolidino | 65 | 128 | E | $C_{20}H_{21}N_3O_3$ | 68.36 | 6.02 | 11.96 | | 68.78 | 6.29 | 12.30 | |
| | | | | 189 | E | $C_{20}H_{21}N_3O_3 \cdot HCl$ | 61.93 | 5.71 | 10.83 | 9.14 | 61.90 | 5.62 | 10.93 | 9.13 |
| 12 | $C_6H_5O$ | N-Piperidino | 45 | 130 | E | $C_{21}H_{23}N_3O_3$ | 69.02 | 6.34 | 11.50 | | 68.86 | 6.35 | 11.73 | |
| | | | | 170–171 | M–Et | $C_{21}H_{23}N_3O_3 \cdot HCl$ | 62.75 | 6.02 | 10.45 | 8.82 | 62.63 | 6.31 | 10.55 | 9.05 |
| 13 | $C_6H_5O$ | N-Morpholino | 60 | 134 | E | $C_{20}H_{21}N_3O_4$ | 65.38 | 5.76 | 11.11 | | 65.35 | 5.72 | 11.72 | |
| | | | | 208–209 | E | $C_{20}D_{21}N_3O_4 \cdot HCl$ | 59.47 | 5.19 | 10.41 | 8.78 | 59.72 | 5.65 | 10.18 | 8.82 |

[a] E = ethanol, Et = ethyl ether, M = methanol. [b] Analysis for sulfur.

TABLE II

EMBRYONATED EGGS

| No. | MTD,[a] moles/egg | A-PR8 virus[b] Virucidal activity | Virustatic activity | $LD_{50}$, mg/kg ip | Anticonvulsant activity,[c,d] mg/kg Ip | Orally | Antiinflammatory activity,[d] mg/kg |
|---|---|---|---|---|---|---|---|
| 1 | 10 | 0 | 0 | 200[e] | 0 | 0 | 0 |
| 2 | 20 | 0 | 0 | 150[e] | 0 | 0 | 0 |
| 3 | >10 | 0 | 0 | 1000 | 200 | 0 | 0 |
| 4 | 20 | 1 | 0 | 3000 | 300 | 300 | 100 |
| 5 | 10 | 1 | 0 | 2000 | 0 | 300 | 0 |
| 6 | 20 | 0 | 0 | 3000 | 0 | 300 | 0 |
| 7 | 10 | 0 | 0 | 2000 | 0 | 0 | 0 |
| 8 | 20 | 0 | 0 | 3000 | 0 | 0 | 100 |
| 9 | 20 | >2 | 0 | >3000 | 0 | 0 | 100 |
| 10 | 20 | 0 | 0 | >3000 | 0 | 0 | 100 |
| 11 | 25 | >2 | 0 | 150[e] | 0 | 0 | 0 |
| 12 | 2.5 | 1 | 0 | 200[e] | 0 | 0 | 0 |
| 13 | 20 | >2 | 0 | 600[e] | 0 | 0 | 100 |

[a] Maximal tolerated dose. [b] The numbers represent the difference between log $EID_{95}$ of control and log $EID_{50}$ of treated. [c] Dose protecting 70% of animals. [e] The hydrochloride salt was used. [d] 0 = no effect.

0.025 μg/ml of histamine dihydrochloride, on the small intestine of a mouse stimulated by 0.15 μg/ml of acetylcholine, and on the seminal vesicle of a rat stimulated by 1.8 μg/ml of epinephrine hydrochloride according to Leitch, *et al.*[9]

**Effects on Blood Pressure and on Respiration.**—The compounds were tested intravenously on rats anesthetized with urethan. Blood pressure was recorded by means of a mercury manometer connected to a cannulated carotid artery; the pneumotachogram was recorded from the cannulated trachea.

**Antiarrhythmic Activity.**—All compounds were tested intravenously on rats anesthetized with pentobarbital sodium, and their ability to prevent cardiac arrhythmias induced by $CaCl_2$ was determined.

Coronary vasodilator activity was determined by perfusing isolated rabbit heart by Langendorff's method as modified by Setnikar.[10] Antitussive activity was tested administering the substance to mice in which cough was provoked by inhalation of nebulized $H_2SO_4$. For anticonvulsant activity, the compounds were given orally and intraperitoneally to groups of 10 mice and, after 60 and 30 min, respectively, the animals were subjected to electroshock. To evaluate antiinflammatory activity, the compounds were injected subcutaneously and their effects on rat's paw edema induced by local injection of a 3% formalin solution and measured by Courvoisier and Duerots's method[11] was tested. Active compounds provoked a statistically significant diminution of edema over 3 hr and were then tested also by the Randall and Selitto's method.[12]

(9) J. L. Leitch, C. S. Liebig, and T. J. Haley, *Brit. J. Pharmacol.*, **9**, 236 (1954).

(10) I. Setnikar, *Farmaco* (Pavia), *Ed. Sci.*, **11**, 750 (1956).

(11) S. Courvoisier and R. Duerot, *Arch. Intern. Pharmacodyn.*, **102**, 33 (1955).

(12) L. O. Randall and J. J. Selitto, *ibid.*, **111**, 409 (1957).

## Potential Antimicrobial Agents. Bromo Compounds of Eugenol

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The knowledge that the bactericidal and antiseptic activity of phenols is enhanced by the introduction of halogen atoms[2a] prompted us to prepare some new bromo compounds of eugenol (I).

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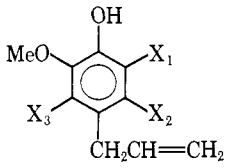
(2) (a) C. M. Suter, *Chem. Rev.*, **28**, 269 (1941); (b) G. L. Jenkins, W. H. Harding, K. E. Hamlin, and J. B. Data, "The Chemistry of Organic Medicinal Products," John Wiley and Sons, Inc., New York, N. Y., 1957, p 57 ff.

TABLE I
DATA OF BROMO COMPOUNDS OF EUGENOL

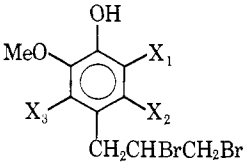
| Compd | Bp (mm) or mp, °C | Recrystn solvent | Yield, % | Formula | Calcd, % C | Calcd, % H | Calcd, % Br | Found, % C | Found, % H | Found, % Br |
|---|---|---|---|---|---|---|---|---|---|---|
| II[a] | 61 | Aq EtOH | 71 | ... | ... | ... | ... | ... | ... | ... |
| IIa | 123–124 | EtOH–$Me_2CO$ | .. | $C_{17}H_{14}Br_2O_3$ | 47.92 | 3.31 | 37.51 | 47.79 | 3.36 | 37.55 |
| III[a] | 119–120 | Aq EtOH | 85 | ... | ... | ... | ... | ... | ... | ... |
| IIIa[b] | 117 | EtOH–$Me_2CO$ | .. | ... | ... | ... | ... | ... | ... | ... |
| VII | 186–188 (0.1) | ... | 73 | $C_{10}H_{12}Br_2O_2$ | 37.07 | 3.74 | 49.33 | 36.93 | 3.73 | 49.17 |
| VIII | 165–167 (0.8) | ... | 32 | $C_{10}H_{11}Br_3O_2$ | 29.81 | 2.75 | 59.53 | 29.80 | 2.65 | 59.36 |
| IX | 126–127 (0.3) | ... | 26 | $C_{10}H_{11}BrO_2$ | 49.40 | 4.56 | 32.87 | 49.53 | 4.49 | 32.60 |
| IXa | 92 | Aq EtOH | .. | $C_{17}H_{15}BrO_3$ | 58.80 | 4.36 | 23.02 | 58.92 | 4.27 | 22.84 |
| X | 97 | Acetic acid | 72 | $C_{17}H_{13}Br_3O_3$ | 40.27 | 2.98 | 47.30 | 40.11 | 3.16 | 47.11 |
| XI | 149–151 (0.3) | ... | 54 | $C_{10}H_{11}BrO_2$ | 49.40 | 4.56 | 32.87 | 49.32 | 4.41 | 32.73 |
| XIa | 68 | Aq EtOH | .. | $C_{17}H_{15}BrO_3$ | 58.80 | 4.36 | 23.03 | 58.80 | 4.39 | 22.86 |

[a] See ref 3. [b] E. von Boyen [*Ber.*, **21**, 1393 (1888)] reported mp 113°.

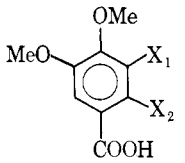
In 1885, Chasanowitz and Hell[3] reported the preparation of a dibromoeugenol and a dibromoeugenol dibromide. The positions occupied by the two nuclear bromine atoms in these compounds were assumed,[4] without sufficient evidence, to be 2 and 5, until Raiford and Perry[5] furnished incontrovertible data to show that these compounds are really 2,3-dibromoeugenol (II) and 2,3-dibromoeugenol dibromide (III), respectively. In 1890, Woy[6] prepared eugenol dibromide benzoate (IV) through bromination of eugenol benzoate (Ia). The preparations of 2,3,5-tribromoeugenol (V) and 2,3,5-tribromoeugenol dibromide (VI) were described by Hell[7] in 1895.




I, $X_1 = X_2 = X_3 = H$
Ia, $X_1 = X_2 = X_3 = H$; benzoate
II, $X_1 = X_2 = Br$; $X_3 = H$
IIa, $X_1 = X_2 = Br$; $X_3 = H$; benzoate
V, $X_1 = X_2 = X_3 = Br$
IX, $X_1 = Br$; $X_2 = X_3 = H$
IXa, $X_1 = Br$; $X_2 = X_3 = H$; benzoate
XI, $X_1 = X_3 = H$; $X_2 = Br$
XIa, $X_1 = X_3 = H$; $X_2 = Br$; benzoate




III, $X_1 = X_2 = Br$; $X_3 = H$
IIIa, $X_1 = X_2 = Br$; $X_3 = H$; benzoate
IV, $X_1 = X_2 = X_3 = H$; benzoate
VI, $X_1 = X_2 = X_3 = Br$
VII, $X_1 = X_2 = X_3 = H$
VIII, $X_1 = Br$; $X_2 = X_3 = H$
X, $X_1 = X_3 = H$; $X_2 = Br$; benzoate




XII, $X_1 = Br$; $X_2 = H$
XIII, $X_1 = H$; $X_2 = Br$
XIV, $X_1 = X_2 = Br$

In this paper is described the preparation of the following new bromo compounds of eugenol: eugenol dibromide (VII), 2-bromoeugenol dibromide (VIII), 2-bromoeugenol (IX), 3-bromoeugenol dibromide benzoate (X), 3-bromoeugenol (XI), and 2,3-dibromoeugenol benzoate (IIa). Furthermore, new evidence has been provided to confirm the structures of 2,3-dibromoeugenol (II) and 2,3-dibromoeugenol dibromide (III).

**Bromination of eugenol** was conducted with 1, 2, and 3 moles and excess bromine/mole of eugenol. With equimolar proportions of bromine, 2-bromoeugenol dibromide (VIII) was obtained. The position of the nuclear bromine atom was fixed by converting the reaction product to 5-bromoveratric acid (XII), through side-chain debromination, methylation of the phenolic OH group, and oxidation of the allyl side chain. On debromination with zinc and alcohol, 2-bromoeugenol dibromide (VIII) produced 2-bromoeugenol (IX). When 2 moles of bromine was used for bromination, the reaction product could neither be induced to solidify nor be distilled *in vacuo* without decomposition. With 3 moles and more of bromine, 2,3-dibromoeugenol dibromide (III) was obtained.

**Bromination of eugenol benzoate (Ia)** with 1 mole of bromine yielded the reported eugenol dibromide benzoate (IV). On hydrolysis of the benzoate (IV) with 65% $H_2SO_4$, eugenol dibromide (VII) was formed. With 2 moles and more of bromine, eugenol benzoate formed 3-bromoeugenol dibromide benzoate (X). The position of the nuclear bromine atom was determined by converting X to 6-bromoveratric acid (XIII). The corresponding phenol could not be obtained, as the product of hydrolysis decomposed when distilled *in vacuo*. When the crude hydrolyzed product, however, was debrominated with zinc and alcohol and then distilled, an oil was obtained which was found to be 3-bromoeugenol (XI). This compound is particularly interesting in view of the observation that in the one known example of a phenol containing a halogen atom *meta* to the hydroxyl group, 3-halophenol, the bactericidal value is much higher than for the other isomers.[8]

**Bromination of 3-Bromoeugenol Dibromide.**—When crude 3-bromoeugenol dibromide benzoate (X) was debenzoylated and then brominated, there was obtained 2,3-dibromoeugenol dibromide (III). Debromination of III using zinc and alcohol gave 2,3-dibromoeugenol (II). Structural proof of these compounds was obtained by conversion of III to 5,6-dibromoveratric acid (XIV). The above reactions provide additional evidence in support of Raiford and Perry's work[5] on the structures of 2,3-dibromoeugenol dibromide and 2,3-dibromoeugenol. A Schotten–Bau-

(3) L. Chasanowitz and C. Hell, *Ber.*, **18**, 823 (1885).
(4) (a) Th. Zincke and O. Hahn., *Ann.*, **329**, 4 (1903); (b) F. K. Beilstein, "Handbuch der Organischen Chemie," Vol. VI, J. Springer, Berlin, 1923, p 923; (c) I. Heilbron and H. M. Bunbury, "Dictionary of Organic Compounds," Vol. II, Eyre and Spottiswoode, London, 1953, p 86.
(5) L. C. Raiford and R. P. Perry, *J. Org. Chem.*, **7**, 354 (1942).
(6) E. F. R. Woy, *Ber.*, **23 Ref.**, 204 (1890).
(7) C. Hell, *ibid.*, **28**, 2083 (1895).
(8) M. Klarmann, *J. Bacteriol.*, **17**, 440 (1929).

TABLE II

ANTIMICROBIAL ACTIVITY[a] OF BROMO COMPOUNDS OF EUGENOL

| | | Antibacterial | | | | | | | | | Antituberculous | | | Antifungal | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Compd tested | pH | *Micrococcus pyogenes var aureus* | *Bacillus subtilis* | *Escherichia coli* | *Salmonella typhosa* | *Vibrio cholerae* | *Shigella dysenteriae* | *Diplococcus pneumoniae* | *Streptococcus pyogenes* | *Corynebacterium diphtheriae* | *Mycobacterium phlei* | *Mycobacterium 607* | *Microsporum gypseum* | *Trichophyton mentagrophytes* | *Candida albicans* | *Helminthosporium sativum* |
| I | 4.9 | ++ | ++ | ++ | ++ | ++ | ++ | ++ | −− | +− | −− | −+ | +− | ++ | ++ | +− |
| | 7.0 | ++ | ++ | ++ | ++ | ++ | ±− | −+ | ±± | −+ | ±− | ++ | ++ | −+ | ++ | +− |
| IX | 5.2 | ++ | ++ | ++ | ++ | ++ | ++ | −+ | +± | +− | +− | ++ | ++ | −+ | ++ | +− |
| | 7.0 | ++ | ++ | ++ | ++ | ++ | −− | ±± | +− | ++ | ++ | ++ | ++ | −± | ±− | ±+ |
| XI | 5.5 | ++ | ++ | ++ | ++ | ++ | ++ | +− | −+ | ++ | ++ | ++ | ++ | −+ | −− | −+ |
| | 7.0 | ++ | ++ | ++ | ++ | +± | ++ | ++ | ++ | −+ | −+ | ++ | ++ | ++ | ++ | ++ |
| II | 5.5 | ++ | ++ | ++ | +− | ±− | ++ | ++ | ±+ | ++ | ++ | ++ | ++ | ++ | ++ | ++ |
| | 7.0 | ++ | ++ | ++ | ++ | ±− | ++ | ±− | ±+ | −+ | ++ | +− | ++ | ++ | ±± | ±+ |
| VII | 4.9 | ± | ± | + | + | + | + | ± | ± | + | ±± | +− | − | − | − | − |
| | 7.0 | + | ± | + | + | ± | + | ± | + | ± | ++ | ±− | − | − | − | − |
| VIII | 4.0 | ++ | ±± | ++ | ±+ | ±+ | ++ | ±± | ±− | −− | −− | ±± | ±± | ±± | ±− | −± |
| | 7.0 | ±± | ±± | ++ | ++ | ++ | ++ | ±+ | ±± | −− | −− | ++ | ++ | ++ | ±± | ±+ |
| III | 5.8 | + | + | − | − | ± | − | + | + | + | ++ | +− | + | ++ | − | ± |
| | 7.0 | ± | + | − | − | − | − | − | + | + | ++ | +− | ± | ++ | − | ± |
| Ia | 5.5 | − | − | − | − | − | − | − | − | − | ±+ | ++ | ± | ± | − | − |
| | 7.0 | − | − | − | − | − | − | − | − | − | ++ | ++ | ± | ± | − | − |
| IIa | 5.5 | ± | ± | ± | ± | + | ± | − | − | − | − | + | ± | ± | − | − |
| | 7.0 | ± | ± | ± | ± | + | ± | − | − | − | ± | + | ± | ± | − | − |
| IV | 5.5 | − | − | − | − | − | − | − | − | − | ± | + | − | − | − | − |
| | 7.0 | − | − | − | − | − | − | − | − | − | + | + | − | − | − | − |
| X | 5.5 | − | − | − | − | − | − | − | − | − | + | + | − | − | − | − |
| | 7.0 | − | − | − | − | − | − | − | − | − | + | + | − | − | − | − |
| IIIa | 5.8 | − | − | − | − | − | − | − | − | − | + | ± | − | − | − | − |
| | 7.0 | − | − | − | − | − | − | − | − | − | + | + | − | − | − | − |

[a] The concentration of the compound in the ditch was 10%. The tests for each compound were conducted at the normal pH of the compound and also at pH 7 by using a buffered solution. The activity is shown by: −, confluent growth across the ditch, *i.e.*, no inhibition; ±, sparse growth across the ditch, *i.e.*, slight inhibition; +, growth up to either side of the ditch, *i.e.*, moderate inhibition; ++, absence of growth across the ditch and ending some distance beyond the ditch on either side, *i.e.*, marked inhibition.

niam benzoylation of 2,3-dibromoeugenol (II) produced the corresponding benzoate (IIa) and bromination of the benzoate yielded 2,3-dibromoeugenol dibromide benzoate (IIIa).

Table I summarizes data of these compounds. The bromo compounds of eugenol were tested against a wide range of microorganisms by the ditch-plate technique[9] and have shown marked and, in some cases, specific activity. Results of these tests are summarized in Table II.

### Experimental Section[10]

**Bromination. General Method.**—A solution of the requisite amount of bromine in 100 ml of acetic acid was added dropwise to a well-stirred, cooled solution of 0.1 mole of the compound to be brominated in 100 ml of acetic acid. The reaction mixture was allowed to stand for 1 hr after the addition of bromine was completed. If any solid product separated, it was filtered and recrystallized. The filtrate was diluted with water, filtered if necessary, and extracted with three 100-ml portions of ether. The ether extract was washed with water and dried ($Na_2SO_4$). The ether was evaporated and the residual oil was distilled *in vacuo*.

**Side-Chain Debromination. General Method.**—A solution of 5 g of the dibromide in 100 ml of ethanol was heated with 10 g of granulated zinc at 70–80° for 2 hr. The reaction mixture was then filtered, the filtrate was diluted with water, and the oil that separated was extracted with three 100-ml portions of ether. The ether extract was dried ($Na_2SO_4$). The ether was evaporated to give a residual oil which was distilled *in vacuo*.

**Hydrolysis of Eugenol Dibromide Benzoates. General Method.**—To a solution of 0.01 mole of the dibromide benzoate in acetic acid was added 3 ml of 65% $H_2SO_4$. Sufficient acetic acid was added to redissolve any solid that was precipitated on addition of the $H_2SO_4$. The mixture was refluxed gently on a steam bath until a test portion showed that the benzoate was completely hydrolyzed. After cooling and diluting with water, the reaction mixture was extracted with ether. The ether was evaporated and the residual liquid was digested repeatedly with hot water to remove all the benzoic acid. The oil was again taken up in ether. After drying the extract ($MgSO_4$), the ether was evaporated and the residual oil was distilled *in vacuo*.

**Conversion of Bromoeugenols to Bromoveratric Acids. General Method.**—The phenol (2.0 ml) from which the side-chain bromine atoms had been removed was dissolved in 20% NaOH solution. To this solution, sufficiently cooled, was added dropwise 5 ml of dimethyl sulfate. The reaction mixture was then refluxed for 0.5 hr. After cooling and diluting with water, it was extracted with ether. The ether extract was washed with dilute $H_2SO_4$ and then with water until the washings were neutral to litmus. The ether was evaporated and the residual oil was refluxed for 1 hr with alkaline $KMnO_4$. The reaction mixture was acidified ($H_2SO_4$) and excess $KMnO_4$ was reduced with sodium bisulfite. The solid obtained was filtered and recrystallized from aqueous ethanol or from ligroin (bp 100–120°).

**Acknowledgment.**—The authors wish to express their gratitude to Rev. J. M. Corbella, Director of this department, for the facilities offerred and to Miss Myrna Chaves for the antimicrobial data.

(9) A. Fleming, *Brit. J. Exptl. Pathol.*, **10**, 226 (1929).

(10) Melting points were observed in capillary tubes and are corrected.

## Arylazo Derivatives of Pyridoxine

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Pyridoxine couples readily at pH 8 with aryldiazonium chlorides to give good yields of 6-substituted derivatives (I, Table I). The coupling of pyridoxine with diazonium salts has been recorded as a color