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SYNTHESIS OF ALKYL CATECHOLS AND EVALUATION OF THEIR ANTIBACTERIAL AND CYTOTOXIC ACTIVITY

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ABSTRACT

A series of potential biologically active mono-, di- and tetra- alkyl catechols were prepared through Friedel- Crafts alkylation of catechol, and evaluated for their antibacterial and cytotoxic activity. The mono-substituted alkyl derivatives showed maximum antibacterial activity in vitro which increased with the increasing length of the alkyl chains. Primary screening results indicated that all the monoalkyl derivatives except 4- (2-octyl) catechol inhibited the growth of *B. bronchoseptica* and maximum zones of inhibition were observed in case of monohexyl catechols (both n- and 2-hexyl) and monobenzyl derivative. In case of Gram-negative organisms growth of *pneumoniae* and *A. cakoaceticus* was inhibited by several derivatives. Mono-3-octyl-, monononyl- and monobenzyl catechols markedly inhibited the growth of *Kl. pneumoniae*. Mono-2-heptyl catechol inhibited the growth of six Gram-negative bacteria. Minimum inhibitory concentration of six most active compounds of the series was determined against Gram-positive and Gram-negative organisms; it ranged from >100 µg/ml to l0 µg/ml. The antibacterial activity of catechol was not significant.

Cytotoxicity test done by brine shrimp assays showed that the order of cytotoxicity decreases in going from mono- to tetra- alkyl catechols, and among the mono- alkyl products, a decrease in order of cytotoxicity was noted in going from mono-methyl catechol (LD_{50}=59) to monopentyl catechol (LD_{50}=173) after which the order of cytotoxicity gradually increased upto the largest alkyl substituent tested i.e. monononyl catechol (LD_{50}=114). Methyl and ethyl catechol, which were almost inactive in respect of their antibacterial activity possessed pronounced cytotoxicity as compared to higher homologues. Catechol itself did not show significant cytotoxicity (LD_{50}=393.27).

Introduction

Catechol (pyrocatechol) and its derivatives possess diverse biological activity such as hyperglycemic (Cavalca *et al*, 1955), thiamine decomposing (Hasegawa *et* al, 1956, Horman *et al,* 1982), antigonadotropic (Gumbinger *et al,* 1981, Winterhoff *et* al., 1988), antimutagenic (Pashin *et al,* 1986) and allelopathic (Moroz *et al.,* 1983) activity and are known to act as antisclerotic agents (Tarasova *et al,* 1966), convulsants (De Ropp *et al,* 1969) and antibiotics (Malama *et al.,* 1974). Catechol also finds its use in the preparations for the treatment of skin wounds, such as burn wounds and herpes. It has further been shown that in Phenolic compounds the order of biological property is dependent on the number of hydroxyl groups and nature of other substituents. Thus, for example, in the series of 4-n-alkyl resorcinols the germicidal activity becomes greater as the alkyl group lengthens from ethyl to propyl to butyl and so on. A similar increase appears in other phenolic compounds (Miller *et al,* 1938). Similarly, when the antimutagenic activity of various di hydroxy aromatic antioxidant compounds, pyrocatechol, hydroquinone and 2, 6-di-tertbutylhydroquinone was studied, it was observed that the most potent antimutagen was 3,5-di-tertbutyl pyrocatechol and that the antimutagenic effects of pyrocatechol and hydroquinones depended upon the position of OH and tertbutyl group (Meyer *et al*, 1982).

Taking into account this back ground, a series of alkyl catechols has been prepared and their cytotoxic and antibacterial activity studied. Friedel-Crafts alkylation of pyrocatechol with alkyl halides ranging from methyl to nonyl and benzyl) using BF3- etherate as a catalyst resulted in a series of alkyl catechols. The reaction product after separation through flash column chromatography furnished three derivatives in each case, namely, mono-, di- and tetra- substituted catechols. The least polar compounds obtained from flash column were tetra-substituted products, the mono-substituted being the most polar compounds. The mono-alkyl derivatives (n-butyl to noctyl) of catechol have been communicated earlier (Miller et at, 1938), whereas di-and tetra-substituted derivatives as well as benzyl and nonyl derivatives (mono-, di-and tetra- substituted) are being reported for the first time.

Materials and Methods

IR and UV spectra were measured on JASCO IRA-1 and Rye- Unicam sp. 800 spectrometers respectively. Mass Specta were recorded on Finnigan Mat-112. The ^{1}H NMR spectra were recorded in $CDCl_3$ on a Bruker AM-300 spectrometer operating at 300 MHz. The chemical shifts are reported in d (ppm) and coupling constants in Hz. Rash column (model Eyela) chromatography (Still *et al*, 1978) was used with silica-gel (E.Merck, 9385) as adsorbent and chloroform and chloroform-methanol (gradually increasing the ratio of methanol) as eluents. Purity of the products was checked on TLC plates coated with silica gel PF_{254} (E.Merck).

Genera/ Procedure for Alkylation of Pyrocatechol

Pyrocatechol (0.1 g) was taken in a 100 ml two-necked flask fitted with a magnetic st[i]rrer. The flask was cooled in an ice bath and alkyl halide (0.001 mole) and BF3-etherate (0.001 mole) were added. The reaction mixture was stirred (0-4°C) for 20 minutes with good cooling. Stirring was continued further for 24 hours at room temperature. Dry ether was added to the reaction mixture which was successively washed with 4% $NaHCO_3$ solution, water and finally with brine solution. The ethereal layer was dried over anhydrous sodium sulphate and freed off the solvent under reduced pressure. The reaction mixture was separated through flash column chromatography with the solvent system chloroform-methanol (9.5:0.5) ultimately furnishing three products tetra-alkyl, di-alkyl and mono-alkyl derivatives of pyrocatechol in the order of polarity.

4-Benzyl catechol [2]: Brown rods: mp 98oC; IR 3400, 1590, 1240, 1020 cm^{-1}; ^{I}HNMR ($CDCI_3$) δ 3.84 (s. 2H, H-1'), 6.62 (dd, 1H, *J* = 8.0, 2.01Hz, H-5), 6.65 (d, 1H, *J* = 2.01 Hz, sH-3), 6.75 (d, 1H, J = 8.0 Hz, H-6), 7.15 (d, 2H, J= 7.50 Hz, H-3', H-7'), 7.17 (dd, 1H, *J* = 7.40, 7.25 Hz, H-5'), 7.26 (dd, 2H, *J* = 7.50, 7.40 Hz, H-4', H-6'); HRMS m/z 200.0837 (M^+) $C_{13}H_{12}O_2$ requires 200.0842.

4,5-Dihenzyl catechol [3]: Brown rods: mp 88°C; IR 3410, 1590, 1120, 1015 cm^{-1}; ^{I}H-NMR ($CDCI_3$) δ 3.81 (s, 411, $2xCH_2$), 6.59 (s, 2H, H-3, H-6), 7.04 (d, 2H, *J* = 8.10 Hz, H-3',H -7'/H-3",H-7"), 7.05 (d, 2H, *J* = 8.10 Hz,H- 3', H-7/ H-3", H-7"), 7.14 (dd, 1H, *J* = 7.30, 7.25 Hz, H-5'/H-5"), 7.15 (dd, 1H, J = 7.30, 7.25 Hz, H-5/ H-5"), 7.24 (dd, 2H, *J* = 8.10, 7.25 Hz, H-4', H-6'/ H-4", H-6'), 7.25 (dd, 2H, J = 8.10, 6.90 Hz,H-4',H-6'/ H-4",H-6"); HRMS m/z 290.1306 (M^+) $C_{20}H_{18}O_2$ requires 290.1315.

3,4,5,6-Tetrabenzyl catechol [4]: Brown rods: mp 7I°C ; IR 3390, 1595, 1100, 1010 cm^{-1}; ^{1}H-NMR ($CDCI_3$) δ 3.90-3.95 (s, 8H, 4xCH2), 6.95-7.28 (m, 20 H, aromatic); HRMS m/z 470.2245 (M^+) $C_{34}H_{30}O_2$ requires 470.2276.

4-Nonyl catechol [5]: Yellow needles: mp 92°C; IR 3400, 2950- 2850, 1590, 1270 cm^{-1} ; ^{I}H-NMR ($CDCI_3$) δ 1.17 (t, 3H, *J=7.65* Hz,CH_3), 1.59-1.62 (m, 14H,$7xCH_2$), 2.51 (t, 2H, J= 7.56 Hz, Ar-CH_2), 6.63 (dd, 1H, 1=8.04, 2.02 Hz, H-5), 6.71 (d, 1H, J=2.02 Hz, H-3), 6.76 (d, 1H, J=8.04 Hz,H-6): HRMS m/z 236.1801 (M^+) $C_{15}H_{24}O_2$ requires 236.1762.

4,5-Dinonyl catechol [6]: Yellow needles: mp 84°C; IR 3500, 2900- 2850, 1590, 1280 cm^{-1}; ^{1}H-NMR ($CDCl_3$) δ 1.06 (t, 3H,J=756 Hz, CH_3), 1.17 (t, 3H, *J* = 7.56 Hz, CH_3), 1.58-1.63 (m, 28H,$14xCH_2$), 2.65 (t, 2H, J=7.39 Hz, Ar-$\underline{CH_2}$), 2.67 (t, 2H, J=7.70 Hz, Ar-CH_2), 6.72 (s, 2H, H-3, H-6); HRMS m/z 362.3184 (M+) $C_{24}H_{42}O_2$ requires 362.3219.

3,4,5,6-Tetranonyl catechol [7]: Yellow needles: mp 76°C; IR 3450, 2900-

2825, 1595, 1275 cm^{-1}; 1H-NMR ($CDCl_3$) δ 1.15-1.18 (m, 12H, 4xCH_3), 1.60-1.62 (m, 56H, 28xCH_2), 2.49-2.68 (m, 8H, 4xAr-$\underline{CH_2}$); HRMS m/z 614.2284 (M^+) $C_{42}H_{78}O_2$ re-quires 614.2373.

4-(2-Octyl) catechol [8]: Brown rods: mp 72°C; IR 3400, 2900- 2800, 1595, 1265 cm^{-1} ^{1}H-NMR ($CDCl_3$) δ 0.73 (t, 3H, *J*= 7.36 Hz,CH_3), 0.90 (d, 3H, *J* = 7.33 Hz,CH_3), 1.45-1.60 (m,10H,5xCH_2), 3.62 (m, 1H,CH), 6.55 (dd, 1H, *J* = 8.05, 1.98 Hz, H-5), 6.65 (d,1H, *J* = 1.98 Hz, H-3), 6.76 (d, 1H, *J* = 8.05 Hz, H-6); HRMS m/z 222.1619 (M^+) $C_{14}H_{22}O_2$ requires 222.1615.

4,5-Di-(2-octyl) catechol [9]: Brown rods: mp 65°C; IR 3440, 2900-2850, 1590, 1275 cm^{-1}; ^{1}H-NMR ($CDCI_3$) δ 0.75 (t, 6H, *J* = 7.10 Hz, 2xCH_3), 0.92 (d, 6H, *J* = 6.95 Hz,2xCH_3), 1.49-1.61 (m,20H,10xCH_2), 2.97 (m, 2H, 2xCH), 6.72 (s,2H, H-3,H-6); HRMS m/z 334.2877 (M^+) $C_{22}H_{38}O_2$ requires 334.2873.

3,4,5,6-Tetra-(2-octyl) catechol [10]: Brown rods: mp 62°C; IR 3450, 2900·2850, 1595, 1270 cm^{-1}; ^{1}H-NMR ($CDCI_3$) δ 0.79-0.88 (m, 24H, 8xCH_3), 1.45-1.59 (m,40H, 20xCHx), 2.95 (m, 4H,4xCH); HRMS m/z 559.3127 (M^+ +1) $C_{38}H_{71}O_2$ requires 559.3118.

4-(3.Octyl) catechol [11]: Brown rods: mp 102°C; IR 3400, 2910-2800, 1590, 1270 cm^{-1}; ^{1}H-NMR ($CDC1_3$) δ 0.60, 0.77 (each t, 3H, *J* = 7.03 and 7.34 Hz, 2xCH_3), 1.46-1.58 (m, 10H, SxCH_2), 2.96 (m, 1H,CH), 6.64 (dd, 1H, *J* =8.21,1.89 H_z H-5), 6.67 (d, 1H, *J* = 1.89 Hz, H-3), 6.75 (d, 1H, *J* = 8.21 Hz, H-6); HRMS m/z 222.1617 (M^+) $C_{l4}H_{22}O_2$ requires 222.1624.

4,S-Di-(3-octyl) catechol [12]: Brown rods: mp 97°C; IR 3400, 2910- 2800, 1590, 1270 cm^{-1}; ^{l}H-NMR ($CDCI_3$) δ 0.80-0.85 (m, 12H, 4xCH_3), 1.47-1.59(m,20H, 10xCH_2), 2.90-3.00(m, 2H.2 xCH), 6.69 (s, 2H, H-3, H-6); HRMS, m/z 334.2871 (M^+) $C_{22}H_{38}O_2$ requires 334.2793.

3,4,5,6-Tetra-(3-octyl) catechol [13]: Yellow rods: mp 95°C; IR 3450, 2900-2800, 1595, 1280 cm^{-1}; ^{1}H-NMR ($CDCI_3$) δ 0.71-0.85 (m, 24H, 8xCH_3), 1.50-1.62 (m,40H,20xCH_2), 2.76-3.01 (m, 4H,4xCH); HRMS m/z 558.1241 (M^+) $C_{38}H_{70}O_2$ re-quires 558.1230.

4-Heptyl catechol [14]: Yellow needles: mp 87°C; IR 3400, 2910-2800, 1595, 1270, 1160 $cm^{-1;}$ ^{1}H-NMR ($CDCI_3$) δ 1.18 (t, 3H, *J* = 7.62 Hz,CH_3), 1.57-

1.62 (m, 10H,5xCH_2), 2.53 (t,2H, *J* = 7.50 Hz,Ar-CH_2), 6.62 (dd, 1H, *J* = 8.05, 1.89 Hz, H-5), 6.71 (d, 1H, *J* = 1.89 Hz,H-3), 6.76 (d, 1H, *J* = 8.05 Hz,H-6); HRMS m/*z* 208.1463 (M +) $C_{13}H_{20}O_2$ requires 208.1504.

4,5-Diheptyl catechol [15]: Yellow needles: mp 92°C; IR 3350, 2900-2850, 1598, 1280, 1165 cm^{-1}; ^{1}H-NMR ($CDCI_3$) δ 1.24 (t, 6H, *J* = 7.53 Hz, 2xCH_3), 1.49-1.55 (m, 20H,lOxCH_2), 2.64 (t, 4H, *J* = 7.51 Hz,2xAr-CH_2), 6.72 (s, 2H, H-3, H-6); HRMS m/z 306.2558 (M^+) $C_{20}H_{34}0_2$ requires 306.3041.

3,4,5,6-Tetraheptyl catechol [16]: Yellow needles: mp 88°C; 1R 3350, 2900-2850, 1590, 1300, 1165 cm^{-1}, ^{1}H-NMR ($CDCI_3$) δ 0.741.85 (m,12 H, 4xCH_3), 1.58-1-62 (m, 40 H, 20xCH_2), 2.54-2.57 (m, 8H,4xAr-CH_{12}); HRMS m/z 502.1449 (M^t) $C_{34}H_{62}O_2$ requires 502.1503.

4-(2-Heptyl) catechol [17]: Brown rods: mp 78°C; IR 3500, 2900- 2850, 1595, 1260, 1020 cm^{-1}, ^{1}H-NMR ($CDCI_3$) δ 0.73 (t, 3H, *J* = 7.38 Hz,CH3), 0.83 (d, 1 H, *J* = 7.08 Hz,CH_3), 1.51-1.64 (m, 8H,4xCH_2), 2.25 (m, 1H,CH), 6.65 (dd, 1H, *J* = 8.06, 1.98 Hz, H-5), 6.65 (d, 1H, *J* = 1.98 Hz,H-3), 6.76 (d, 1H, *J* = 8.06 Hz, H-6); HRMS m/z 208.1509 (M +) $C_{13}H_{20}O_2$ requires 208.1512.

4,5-Di-(2-heptyl) catechol [18]: Brown rods: mp 87°C; IR 3510, 2900-2850, 1590, 1275, 1040 cm^{-1}, ^{1}H-NMR ($CDCI_3$) δ 0.79 (t, 3H, *J* = 7.25 Hz,CH_3), 0.81 (t, 3H, *J* = 8.02 Hz,CH_3), 0.82 (d, 3H, *J* = 7.12 Hz,CH_3), 0.84 (d, 3H, *J* = 7.07 Hz,CH_3), 1.58-1.67 (m, 16 H,8xCH_2), 2.23 (m, 1H, CH), 2.25 (m, 1H,CH), 6.47 (s, 2H,H-3,H-6); HRMS m/z 306.2017 (M^+) $C_{20}H_{34}O_2$ requires 306.2563.

3,4,5,6-Tetra-(2-heptyl) catechol [19]: Brown rods: mp 94°C; IR 3525, 2910-2850, 1598, 1250, 1025 cm^{-1} ; ^{1}H-NMR ($CDCI_3$) δ 0.75-0.84 (m, 24H, 8xCH_3), 1.57-1.63 (m, 32 H, 16xCH_2), 2.74-2.98 (m, 4H, 4xCH); HRMS m/*z* 502.4513 (M^+) $C_{34}H_{62}O_2$ re-quires 502.4624.

4-Hexyl catechol [20]: Yellow plates: mp 61°C; 1R 3450, 2950-2850, 1595, 1200, 990 cm^{-1}; ^{1}H-NMR ($CDCI_3$) δ 1.16 (t, 314, *J* = 7.60 Hz, CH_3), 1.53-1.70(m,8H, 4xCH_2), 2.53 (t, 2H, *J* = 7.75 Hz, Ar-CH_2), 6.63 (dd, 1H, *J* = 8.04, 2.01 Hz, H-5), 6.71 (d, 1H, *J* = 2.01 Hz,H-3), 6.76 (d, 1H, *J* = 8.04 Hz, H-6); HRMS m/z 194.1297 (M^+) $C_{12}H_{18}O_2$ requires 194.1309.

4,5-Dihexyl catechol [21]: Yellow plates: mp 56°C; IR 3450, 2950- 2800, 1590, 1230, 1060 cm^{-1}; ^{1}H-NMR ($CDCI_3$) δ 0.78 (t, 3H, *J* = 7.45 Hz,CH_3), 0.85 (t, 3H, *J* =-7.08 Hz,CH_3), 1.54-1.71(m,16H,8xCH_2), 2.52-2.54 (m, 4H,2xAr-CH_2), 6.72 (s, 2H, H-3, H-6); HRMS m/z 278.2245 (M^+) $C_{18}H_{30}O_2$ requires 278.2216.

3,4,5,6-Tetrahexyl catechol [22]: Yellow plates: mp 68°C; IR 3450, 2950-2850, 1595, 1230, 1070 cm^{-1}; ^{1}H-NMR ($CDCI_3$) δ 0.82-0.85 (m, 12H, 4xCH_3), 1.55-1.72 (m,32H, 16xCH_2), 2.52-2.53 (m, 8H, 4xAr-CH_2); HRMS m/z 446.4123 (M^+) $C_{30}H_{54}O_2$ requires 446. 4119.

4-(2-Hexyl) catechol [23]: Colour-less needles: mp 84°C; IR 3450, 2950-2850, 1590, 12.00, 995 $cm^{-1'}$; ^{1}H-NMR ($CDCI_3$) δ 1173 (t, 3H, *J* = 7.37 Hz,CH_3), 1.17 (d, 3H, *J* = 6.92 Hz,CH_3), 1.50-1.62 (m, 6H, 3xCH_2), 2.53 (m, 1H,CH), 6.59 (dd, 1H, *J* = 8.01, 2.04 Hz, H-5), 6.64 (d,1H, *J* = 2.04 Hz, H-3), 6.75 (d, 1H, *J* = 8.01 Hz, H-6); HRMS m/z 194.1306 (M^+) $C_{12}H_{18}O_2$ requires 194.1299.

4,5-Di-(2-hexyl) catechol [24]: Colour-less needles: mp 79°C; IR 3500, 2900-2850, 1595, 1210, 995 cm^{-1}; ^{1}H-NMR ($CDCI_3$) δ 0.81-0.87 (m, 6H,2xCH3), 1.21-1.22 (m, 6H, 2xCH_3),1.50-1.65(m,12H,6xCH_2), 2.81-2.84 (m, 2H, 2xCH), 6.69 (s, 211, H-3, H-6); HRMS In /z 278.2245 (M^+) $C_{18}H_{30}O_2$ requires 278.2267. .

3,4,5,6-Tetra-(2-hexyl) catechol [25]: Colour-less needles: mp 77°C ; IR 3440, 2900-2800, 1590, 1220, 1000 cm^{-1}; ^{1}H-NMR ($CDCl_3$) δ 0.78-0.89 (m, 12H, 4xCH_3), 1.20-1.22 (m, 12H, 4xCH_3), 1.56-1.65(m,24H,12xCH_2), 280- 2.84 (m, 41-1, 4xCH); HRMS m/z 446.4123 (M^+) $C_{30}H_{54}O_2$ requires 446.4319.

4-(3-Hexyl) catechol [26]: Brown plates: mp 67°C; IR 3500, 2950- 2850, 1595, 1265, 1100 cni^{-1}; ^{1}H-NMR ($CDCI_3$) δ 0.72 (t, 3H, *J* = 7.35 Hz,CH_3), 0.83 (t, 3H, *J* =-7.05 Hz,CH_3), 2.54 (m, 1H,CH), 6.59 (dd, 1H, *J* = 8.01, 2.00 Hz,H-5), 6.68 (d, 1H, *J* = 2.00 Hz,H-3), 6.75 (d, 1H, *J* = 8.10 Hz,H-6); HRMS rn/z 194.1306 (M^+) $C_{12}H_{18}O_2$ requires 194.1309.

4,5-Di-(3-hexyl) catechol [27]: Brown plates: mp 63°C; IR 3550, 2950-2870,1590, 1270, 1010 cm^{-1}; ^{1}H-NMR ($CDCI_3$) δ 0.70-0.83 (m, 12H, 4xCH_3), 1.57-1.62 (m, 12H, 6xCH_2), 249 (m, 1H,CH), 2.52 On, 1H,CH), 6.67 (s, 2H, H-3, H-6); HRMS m/z 278.2245 (M^+) $C_{18}H_{30}O_2$ requires 278.2268.

3,4,5,6-Tetra-(3-hexyl) catechol [28]: Brown plates: mp 55°C; IR 3510, 2950-2800,1590, 1270, 1010 cm^{-1}; ^{1}H-NMR ($CDCI_3$) δ 0.69-0.83 (m, 24H, 8xCH_3), 1.54-1.62 (m, 24H,12xCH_2), 2.24-2.94 (m, 4H, 4xCH); HRMS m/z 446.4123 (M^+) $C_{30}H_{54}O_2$ re-quires 446.4119.

4-Pentyl catechol [29]: Yellow plates: mp 88°C; IR 3510, 2900-2850, 1590, 1300-1160 cm^{-l}; ^{1}H-NMR ($CDCI_3$) δ 1.17 (t, 3H, *J* = 7.60 Hz, CH_3), 1.57-1.64 (m, 611, 3xCH_2), 2.53 (t, 2H, *J* = 7.58 Hz, Ar-CH_2), 6.62 (dd, 1H, *J* = 8.05, 2.01 Hz,H-5), 6.71 (d, 1H, *J* = 2.01 Hz, H-3), 6.76 (d, 1H, *J* = 8.05 Hz, 16-6); HRMS m/z 180.1150 (M^+) $C_{11}H_{16}O_2$ requires 180.1091.

4,5-Dipentyl catechol [30]: Yellow plates: mp 86°C; IR 3450, 2910-2850,

1595, 1295-1160 cm^{-1}; ^{1}H-NMR ($CDCl_3$) δ 1.22 (t, 6H, *J* = 7.57 Hz, 2xCH_3), 1.56-1.60 (m, 12H, 6xCH_2), 2.63 (t, 4H, 7.59 Hz, 2xAr-CB_2), 6.72 (s, 2H,H-3, HL); HRMS m/z 250.1932 (M^+) $C_{16}H_{26}O_2$ requ^{i}res 250.2001.

3,4,5,6-Tetrapeotyl catechol [31]: Yellow plates: mp 91°C; IR 3400, 2900-2825, 1590,1280-1165 cm^{-1}; ^{1}H-NMR (CDCl3) δ 1.17 (t, 6H, *J* = 7.87 Hz, 2xCH_3), 1.21 (t, 6H, J = 7.55 Hz, 2xCH_3),156.1.67 (m, 24H, 12xCH_2), 233-2.57 (m, 8H, 4xAr-CH_2); HRMS m/z 390.3097 (M^+) $C_{26}H_{46}O_2$ requires 390.2998.

4-Butyl catechol [32]: Yellow needles: mp 57°C; IR 3500, 2900-2800, 1595, 1265, 1020 cm^{-1}; ^{1}H-NMR ($CDC1_3$) δ 1.17 (t, 3H, *J* = 7.60 Hz,CH_3), 1.54-1.60 (m, 4H, 2xCH_2), 251 (t, 2H, *J* = 736 Hz, Ar-CH_2), 6.62 (dd, 114, *J* = 8.05, 2.00 Hz,H-5), 6.71 (d, 1H, l = 200 Hz,H-3), 6.76 (d, 1H, *J* = 8.05 Hz, H-6); HRMS m/z 166.0993 (M^+) $C_{10}H_{14}O_2$ requires 166.0983.

45-Dibutyl catechol [33]: Yellow needles: mp 87°C; 1R 3450, 2900- 2800, 1595, 1280, 1160 cm^{-1}; ^{1}H-NMR ($CDC_{(3)}$ δ 1.22 (t, 3H, J = 7.58 Hz,CH_3), 1.24 (t, 3H, J = 7.52 Hz,,CH_3),155-1.60 (m, 8H, 4xCH_2), 250(m, 4H, 2xAr-CH_2), 6.72 (s, 2H, H-3, H-6; HRMS m/z 223.1697 (M^++1) $C_{14}H_{23}O_2$ requires 223.1701.

3,4,5,6-Tetrabutyl catechol [34]: Yellow needles: mp 94°C; IR 3450, 2900-2800, 1595, 1280, 1160 cm^{-1}; ^{1}H-NMR ($CDCI_3$) δ 0.79-0.86 (m, 12H, 4xCH_3), 1.55-1.63 (m, 16H, 8xCH_2), 2.29-2.50 (m, 8H, 4xAr-CH_2); HRMS m/z 334.2871 (M^+) $C_{22}H_{38}O_2$ re-qu^{i}res 334.2872.

4-Propyl catechol [35]: Brown plates: mp 74°C; 1R 3450, 2900-2850, 1590, 1265-1160 cm^{-1}; ^{1}H-NMR ($CDCI_3$) δ 1.16 (t, 314, J = 7.63 Hz, CH_3), 1.62-1.64 (m, 2H,CH_2), 2.49 (t, 2H, J = 7.60 Hz, Ar-CH_2), 6.62 (dd, 1H, J = 8.04, 1.99 Hz, H-5), 6.71 (d, 1H, J = 1.99 Hz, H-3), 6.76 (d, 1H, J = 804 Hz, H-6); HRMS m/z 152.0893 (M^+) $C_9H_{12}O_2$ requires 152.0901.

4,5-Dlpropyl catechol [36]: Brown plates: mp 79°C; IR 3425, 2925- 2850, 1595, 1280-1165 cm^{-1}; ^{1}H-NMR ($CDC1_3$) δ 1.17 (t, 3H, J = 6.21 Hz,CH_3), 1.19 (t, 3H, J = 731 Hz,CH_3), 1.57-1.62 (m, 4H, 2xCH_2), 2.46 (t, 2H, J = 7.18 Hz, Ar-CH_2), 2.61 (t, 2H, J = 7.62 Hz, Ar-CH_2), 6.73 (s, 2H, H-3, H-6); HRMS ink 194.1401 (M^+) $C_{12}H_{18}O_2$ requires 194.1356.

3,4,5,6-Tetrap--ropyl catechol [37]: Brown plates: mp 60°C; IR 3400, 2900-2850,1595, 1295-1165 cm^{-t}; ^{1}H-NMR ($CDCI_3$) δ 1.10 (t, 6H, J = 7.29 Hz, 2xCH_3), 1.18 (t, 6H, J = 7.36 Hz, 2xCH_3), 1.58-1.63 (m, 8H, 4xCH_2), 2.44-2.55 (m, 8H, 4xAr-CH_2); HRMS m/z 278.2290 (M^+) $C_{l8}H_{30}O_2$ requires 278.2215.

4-Ethyl catechol [38]: Brown rods: nip 58°C; IR 3550, 2950-2800,1595,1280-1140, 990 cm^{-1}; ^{1H}-NMR ($CDCI_3$) δ 1.21 (t, 3H, *J* = 7.37

Hz,CH_3), 2.53 (q, 2H, *J* = 7.52 Hz, Ar-CH_2]z), 6.62 (dd, 1H, *J* = 8.05.1.89 Hz, H-5), 6.71 (d, 1H, *J* = 1.89 Hz, H-3), 6.77 (d, 1H, *J* = 8.05 Hz, H-6); HRMS m/z 138.0680 (M^e) $C_8H_{10}O_2$ requires 138.0745.

4-Methyl catechol [39]: Brown rods: mp 66°C; IR 3500, 2900-2850, 1595, 1240, 1020 cm^{-1}; ^{1}H-NMR ($CDCI_3$) δ 2.51 (s, 3H,CH_3), 6.61 (dd, 1H, J = 8.04, 2.05 Hz, H-5), 6.71 (d, 1H, *J* = 2.05 Hz, H-3), 6.77 (d, 1H, *J* = 8.04 Hz, H-6); HRMS m/z 124.0499 (M^+) $C_7H_8O_2$ requires 124.0531.

Biological Results and Discussion

Antibacterial Activity

Compounds [**1-39**] were evaluated for their antibacterial activity against 12 Gram-positive and 16 Gram-negative bacteria and on the basis of the primary screening results, their activity in relation to structure was established. It was found that the substitution of hydrogen in catechol with alkyl groups generally increased the activity and the order of increase depended on the length of the alkyl substituents. With the Gram- positive bacteria an increase in activity was noted with increasing length of the alkyl chain. Among the straight chain monoalkyl derivatives, monononyl catechol inhibited the growth of a maximum number of bacteria whereas in case of Gram-negative organisms mono-2-heptyl catechol was found to be the most active. On the other hand, substitution of one benzyl group showed a pronounced activity against Gram-positive bacteria, specially *C. diptlteriae Cxerosis, St.* pyngenes S. curette *S. eider*-midis and *B. bronchoseptica* The same derivative inhibited the growth of only two Gram-negative bacteria *Kl. pneumoni* and *Sh. flexneri.* The data further show that introduction of one benzyl group reduced the activity against Gram-negative bacteria while the same moiety enhanced the activity against Gram-positive bacteria. The second benzyl group reduces the activity against both Gram-positive and Gram-negative bacteria (Table I).

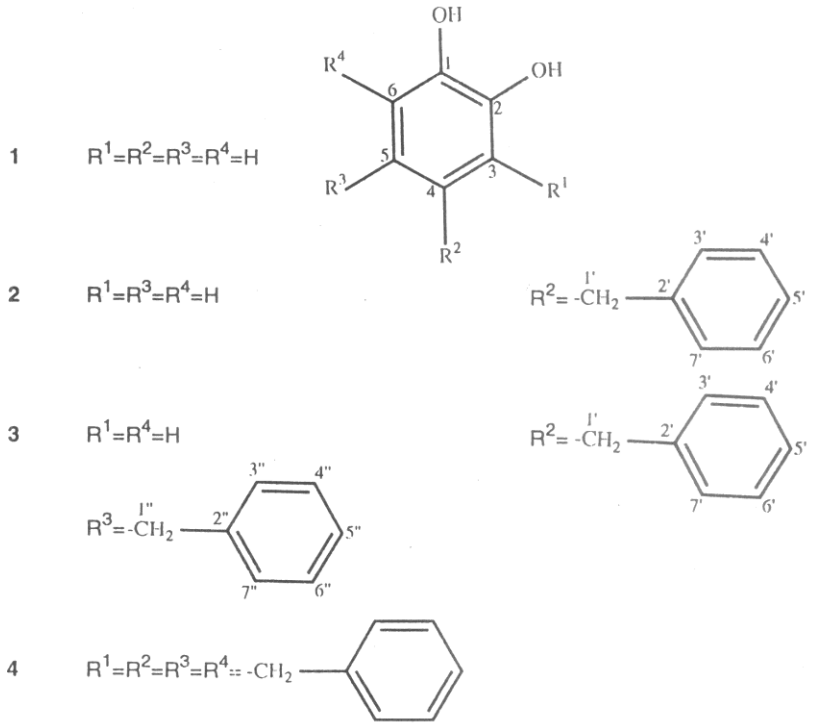
Minimum inhibitory concentration of six compounds was determined against 10 Gram-positive and 8 Gram-negative bacteria. 4,5-di-(2-heptyl)-catechol was found most effective against a number of Gram-positive organisms and its MIC ranged from >100 μg/ml to 10 μg/ml, while the MIC of other compounds was found >103 μg/ml, (Table II).

Cytotoxicity Test

The cytotoxicity test for compounds [**1-39**] was performed by brine shrimp assays (Meyer *et al,* 1982). Generally the monoalkyl derivatives of pyrocatechol possess maximum toxicity as compared to di-and tetra-substituted derivatives. Among the mono-substituted compounds activity decreased with increasing length of the alkyl side chain upto the pentyl derivatives, after which

the order of cytotoxicity gradually increased upto the largest alkyl substituent tested i.e. monononyl catechol. As compared to other straight chain derivatives, monobenryl catechol and mono-(2-octyl)catechol showed highest LD_{50} values i.e. 62.27 and 54.92 µg/ml respectively. Thus mono-(2-octyl)catechol was found to possess maximum cytotoxicity as compared to other monoalkyl catechols. In the case of dialkyl catechols the activity observed was less than that of monoalkyl catechols. However, among these, maximum cytotoxicity was exhibited by di-(2-octyl)catechol with LD_{50}=56.66 µg/ml. Dibutyl catechol with LD_{50}= 667.76 µg/ml was found to be least active among the dialkylcatechols.

In most of the tetraalkyl catechols the activity was not remarkable. The complete results are reported in Table III.



5	$R^1=R^3=R^4=H$	$R^2=-CH_2-(CH_2)_7-CH_3$
6	$R^1=R^4=H$	$R^2=R^3=-CH_2-(CH_2)_7-CH_3$
7	$R^1=R^2=R^3=R^4=-CH_2-(CH_2)_7-CH_3$	
8	$R^1=R^3=R^4=H$	$R^2=-\underset{\displaystyle CH_3}{\underset{\vert}{CH}}-(CH_2)_5-CH_3$
9	$R^1=R^4=H$	$R^2=R^3=-\underset{\displaystyle CH_3}{\underset{\vert}{CH}}-(CH_2)_5-CH_3$
10	$R^1=R^2=R^3=R^4=-\underset{\displaystyle CH_3}{\underset{\vert}{CH}}-(CH_2)_5-CH_3$	
11	$R^1=R^3=R^4=H$	$R^2=-\underset{\displaystyle CH_2\text{-}CH_3}{\underset{\vert}{CH}}-(CH_2)_4-CH_3$
12	$R^1=R^4=H$	$R^2=R^3=-\underset{\displaystyle CH_2\text{-}CH_3}{\underset{\vert}{CH}}-(CH_2)_4-CH_3$
13	$R^1=R^2=R^3=R^4=-\underset{\displaystyle CH_2\text{-}CH_3}{\underset{\vert}{CH}}-(CH_2)_4-CH_3$	
14	$R^1=R^3=R^4=H$	$R^2=-CH_2-(CH_2)_5-CH_3$
15	$R^1=R^4=H$	$R^2=R^3=-CH_2-(CH_2)_5-CH_3$
16	$R^1=R^2=R^3=R^4=-CH_2-(CH_2)_5-CH_3$	
17	$R^1=R^3=R^4=H$	$R^2=-\underset{\displaystyle CH_3}{\underset{\vert}{CH}}-(CH_2)_4-CH_3$
18	$R^1=R^4=H$	$R^2=R^3=-\underset{\displaystyle CH_3}{\underset{\vert}{CH}}-(CH_2)_4-CH_3$
19.	$R^1=R^2=R^3=R^4=-\underset{\displaystyle CH_3}{\underset{\vert}{CH}}-(CH_2)_4-CH_3$	
20.	$R^1=R^3=R^4=H$	$R^2=-CH_2-(CH_2)_4-CH_3$
21	$R^1=R^4=H$	$R^2=R^3=-CH_2-(CH_2)_4-CH_3$
22	$R^1=R^2=R^3=R^4=-CH_2-(CH_2)_4-CH_3$	
23	$R^1=R^3=R^4=H$	$R^2=-\underset{\displaystyle CH_3}{\underset{\vert}{CH}}-(CH_2)_3-CH_3$

24	$R^1=R^4=H$	$R^2= R^3=-\overset{CH_3}{\overset{\vert}{C}}H\text{-}(CH_2)_3\text{-}CH_3$
25	$R^1=R^2=R^3=R^4=-\overset{CH_3}{\overset{\vert}{C}}H\text{-}(CH_2)_3\text{-}CH_3$	
26	$R^1=R^3=R^4=H$	$R^2=-\overset{CH_2\text{-}CH_3}{\overset{\vert}{C}}H\text{-}(CH_2)_2\text{-}CH_3$
27	$R^1=R^4=H$	$R^2= R^3=-\overset{CH_2\text{-}CH_3}{\overset{\vert}{C}}H\text{-}(CH_2)_2\text{-}CH_3$
28	$R^1= R^2=R^3=R^4=-\overset{CH_2\text{-}CH_3}{\overset{\vert}{C}}H\text{-}(CH_2)_2\text{-}CH_3$	
29	$R^1=R^3=R^4=H$	$R^2=-CH_2\text{-}(CH_2)_3\text{-}CH_3$
30	$R^1=R^4=H$	$R^2=R^3=-CH_2\text{-}(CH_2)_3\text{-}CH_3$
31	$R^1=R^2=R^3=R^4=-CH_2\text{-}(CH_2)_3\text{-}CH_3$	
32	$R^1=R^3=R^4=H$	$R^2=-CH_2\text{-}(CH_2)_2\text{-}CH_3$
33	$R^1=R^4=H$	$R^2= R^3=-CH_2\text{-}(CH_2)_2\text{-}CH_3$
34	$R^1=R^2=R^3=R^4=-CH_2\text{-}(CH_2)_2\text{-}CH_3$	
35	$R^1=R^3=R^4=H$	$R^2=-CH_2\text{-}CH_2\text{-}CH_3$
36	$R^1=R^4=H$	$R^2= R^3=-CH_2\text{-}CH_2\text{-}CH_3$
37	$R^1=R^2=R^3=R^4=-CH_2\text{-}CH_2\text{-}CH_3$	
38	$R^1=R^3=R^4=H$	$R^2=-CH_2\text{-}CH_3$
39	$R^1=R^3=R^4=H$	$R^2=-CH_3$

Table-1. Screening of Catechol and its Derivatives for Anti-Bacterial Activity *in vitro* (Zones of inhibitions in millimeters of compounds) (**1-13**).

Compound Number	1	2	3	4	5	6	7	8	9	10	11	12	13
GRAM NEGATIVE													
Salmonella typhi	0	0	0	0	0	0	0	0	0	0	0	0	0
Salmonella typhi Para A	0	10	0	1 0	14	10	10	0	0	0	0	10	0
Salmonella typhi Para B	0	-	-	-	-	-	-	-	-	-	-	-	-
Salmonella typhimurium	0	0	0	0	0	0	0	0	0	0	0	0	0
Salmonella gallinarium	0	10	0	0	10	0	0	0	0	0	0	0	0
Salmonella pullorum	10	10	0	0	0	0	0	0	0	0	0	0	0
Shigella dysenteriae	12	0	0	0	0	0	0	0	0	0	0	0	0
Shigela flexneri	16	22	0	18	22	14	10	0	0	22	0	0	0
Shigella sonnei	6	-	-	-	-	-	-	-	-	-	-	-	-
Shigella boydii	8	-	-	-	-	-	-	-	-	-	-	-	-
Entamoeba coli	0	-	-	-	-	-	-	-	-	-	-	-	-
Enterobacter aerogenes	11	0	0	0	0	0	0	0	0	0	0	0	0
Enterobacter cloacae	12	-	-	-	-	-	-	-	-	-	-	-	-
Klebsiella pneumoniae	16	42	20	20	30	30	24	0	18	0	28	18	10
Klebsiella ozaenae	18	10	10	15	16	12	12	-	0	0	0	28	19
Pseudomonas aeruginosa	8	-	-	-	-	-	-	-	-	-	-	-	-
Vibrio cholerae	10	-	-	-	-	-	-	-	-	-	-	-	-
Vibrio parahaemolyticus	11	-	-	-	-	-	-	-	-	-	-	-	-
Proteus vulgaris	16	-	-	-	-	-	-	-	-	-	-	-	-
Proteus mirabilis	12	-	-	-	-	-	-	-	-	-	-	-	-
Serratia.marescens	18	0	0	0	0	0	0	0	0	0	0	0	0
Aeromonas hydrophila	8	0	0	0	0	0	20	10	0	0	0	0	0
Acinetobacter calcoaceticus	18	0	0	0	0	0	0	0	0	0	0	0	0
Citrobacter freundii	8	0	0	0	0	0	0	0	0	0	0	0	0
GRAM POSITIVE													
Corynebacterium diphtheriae	11	32	12	28	36	20	12	0	11	0	14	0	0
Corynebacterium hoffmanii	12	21	13	14	20	16	15	0	0	0	10	0	0
Corynebacterium xerosis	9	28	0	26	16	12	16	0	10	0	0	10	9
Streptococcus pyogenes	12	32	14	30	28	20	16	0	13	20	21	6	0
Streptococcus faecalis	15	25	10	12	16	13	10	0	16	20	20	0	0
Staphylococcus aureus	16	30	14	22	22	18	20	0	0	0	14	0	6
Staphylococcus epidermidis	18	34	14	25	28	16	18	0	0	0	18	0	0
Bacillus subtilis	12	22	14	14	22	16	15	0	0	0	12	10	0
Bacillus anthracis	14	-	-	-	-	-	-	-	-	-	-	-	-
Bordetella bronchoseptica	12	31	14	20	22	15	14	0	0	0	22	0	0

- Activity not studied

Table 1. Screening of Catechol and its Derivatives for Anti-Bacterial Activity *in vitro* (Zones of inhibitions in millimeters of compounds) (**14-26**).

Compound Number	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**
GRAM NEGATIVE													
Salmonella typhi Para A	18	0	0	18	14	14	14	0	10	0	0	0	18
Salmonella typhi Para B	0	0	0	0	0	0	0	0	0	0	0	0	0
Salmonella typhimurium	0	0	0	0	0	0	0	0	0	0	0	0	0
Salmonella pullorum	0	0	0	14	16	0	0	0	0	0	0	0	0
Shigella sonnei	-	-	-	-	-	-	-	-	-	-	0	0	0
Entamoeba coli	0	0	0	0	16	0	0	0	0	0	0	0	0
Enterobacter cloacae	18	12	0	20	36	12	0	0	0	0	12	0	0
Klebsiella ozaenae	12	12	12	24	22	14	10	0	18	14	14	0	0
Pseudomonas aeruginosa	0	0	0	0	0	0	0	0	0	0	0	0	0
Proteus vulgaris	18	12	0	20	36	12	11	0	0	14	24	0	18
Serratia marescens	14	0	0	24	20	0	-	0	0	0	0	0	18
Aeromonas hydrophila	0	0	0	0	0	0	0	0	0	0	0	0	0
Acinetobacter calcoaceticus	20	18	18	18	20	20	20	0	10	0	20	0	18
GRAM POSITIVE													
Corynebacterium diphtheriae	16	18	10	30	20	12	0	0	0	14	12	0	0
Corynebacterium hoffmanii	10	0	0	14	20	0	0	0	0	0	0	0	0
Crynebacterium xerosis	20	20	12	20	20	18	18	16	0	20	20	0	16
Streptococcus pyogenes	0	0	0	0	0	0	0	0	0	0	0	0	0
Streptococcus faecalis	0	0	0	0	0	0	0	0	0	0	0	0	0
Staphylococcus aureus	14	12	10	20	0	0	14	0	0	16	20	0	14
Staphylococus epidermidis	22	12	0	22	20	12	20	12	0	24	20	0	18
Bacillus subtilis	18	13	13	18	18	0	12	0	0	15	13	0	0
Bacillus anthracis	20	0	0	28	20	0	18	0	0	17	17	0	15
Bordetella bronchoseptica	20	20	24	24	24	30	30	0	16	18	20	0	28
Listeria monocytogenes	0	0	0	0	0	0	0	0	0	0	0	0	0
Listeria ivanovii	0	0	0	0	0	0	0	0	0	0	0	0	0

- Activity not studied

Table 1. Screening of Catechol and its Derivatives for Anti-Bacterial Activity *in vitro* (Zones of inhibitions in milimeters of compounds) (**27-39**)

Compound Number	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**
GRAM NEGATIVE													
Salmonella typhi	-	-	0	0	0	0	0	0	0	0	0	0	0
Salmonella typhi Para A	12	10	0	0	0	0	0	0	0	0	0	0	0
Salmonella typhi Para B	0	0	0	0	0	0	0	0	0	0	0	0	0
Salmonela typhimurium	0	0	0	0	0	0	0	0	0	0	0	0	0
Salmonella gallinarium	-	-	0	0	0	0	0	0	0	0	0	0	0
Salmonela pullorum	0	0	0	0	0	0	0	0	0	0	0	0	0
Shigella dysenteriae	-	-	0	0	0	0	0	0	0	0	0	0	0
Shigella flexneri	-	-	0	0	0	0	0	0	0	0	0	0	0
Shigella sonnei	0	0	20	16	13	17	14	10	19	14	13	11	16
Shigella boydii	-	-	0	0	0	0	0	0	0	0	0	0	0
Entamoeba coli	0	0	0	0	0	0	0	0	0	0	0	0	0
Enterobacter aerogenes	-	-	0	0	0	0	0	0	0	0	0	0	0
Enterobacter cloacae	0	0	0	0	0	0	0	0	0	0	0	0	0
Klebsiella pneumoniae	-	-	0	0	0	0	0	0	0	0	0	0	0
Klebsiella ozaenae	0	0	15	16	10	16	14	12	16	11	14	12	12
Pseudomonas aeruginosa	0	-	0	0	0	0	0	0	0	0	0	0	0
Vibrio cholerae	-	-	0	0	0	0	0	0	0	0	0	0	0
Vibrio parahaemolytics	-	-	0	0	0	0	0	0	0	0	0	0	0
Proteus vulgaris	0	0	0	0	0	0	0	0	0	0	0	0	0
Proteus mirabilis	-	-	0	0	0	0	0	0	0	0	0	0	0
Serratia marescens	0	0	0	0	0	0	0	0	0	0	0	0	0
Aeromonas hydrophila	0	0	0	0	0	0	0	0	0	0	0	0	0
Acinetobacter calcoacetics	10	24	16	18	11	17	17	16	18	13	15	14	15
Citrobacter freundii	-	-	15	16	12	15	16	15	18	15	14	14	12
GRAM POSITIVE													
Corynebacterium diphtheriae	0	12	11	13	10	9	12	10	10	10	11	10	11
Corynebacterium hoffmanii	0	0	12	15	10	12	12	12	14	12	11	11	11
Corynebacterium xerosis	0	10	9	12	9	12	13	10	12	10	9	9	10
Streptococcus pyogenes	0	0	0	0	0	0	0	0	0	0	0	0	0
Streptococcus faecalis	0	0	11	13	9	12	11	10	10	10	1	11	10
Staphylococcus aureus	0	0	13	12	10	12	12	13	12	12	16	12	10
Staphylococus epidermidis	16	0	18	21	10	17	22	16	21	17	16	14	15
Bacillus subtilis	0	0	16	16	11	15	15	14	18	12	16	12	14
Bacillus nthracis	0	0	0	0	0	0	0	0	0	0	0	0	0
Bordetella bronchoseptica	0	20	19	17	14	18	18	15	17	16	18	15	16
Listeria monocytogenes	0	0	0	0	0	0	0	0	0	0	0	0	0
Listeria ivanovii	0	0	0	0	0	0	0	0	0	0	0	0	0

-Activity not studied

Table 2. Minimum Inhibitory Concentration of Catechol and its Derivatives (µg/ml) of compounds (**1,2,5,17,18,20**).

Compound Number	**1**	**2**	**5**	**17**	**18**	**20**
GRAM NEGATIVE						
Salmonella typhi Para A	>100	-	-	>100	-	-
Shigella flexneri	>100	>100	>100	-	-	-
Enterobacter cloacae	>100	-	-	>100	>100	-
Klebsiella pneumoniae	>100	>100	>100	-	-	-
Klebsiella ozaenae	>100	-	-	100	25	-
Proteus vulgaris	>100	-	-	>100	>100	-
Serratia marescens	>100	-	-	>100	>100	-
Acinetobacter calcoaceticus	>100	-	-	25	10	>100
GRAM POSITIVE						
Corynebacterium diphtheriae	>100	>100	>100	100	10	-
Corynebacterium hoffmanii	>100	>100	100	>100	25	-
Corynebacterium xerosis	>100	>100	-	>100	10	>100
Streptococcus pyogenes	>100	>100	100	25	10	-
Streptococcus faecalis	>100	>100	-	>100	10	-
Staphylococcus aureus	>100	>100	>100	>100	100	-
Staphylococcus epidermidis	>100	-	100	-	-	>100
Bacillus subtilis	>100	>100	50	50	10	-
Bacilus anthracis	>100	-	-	10	10	100
Bordetella bronchoseptica	>100	>100	100	25	10	-

- Activity not studied

Compound No.	Compound Name	LD_{50} g/ml
14	4-Heptyl catechol	151.59
15	4,5-Diheptyl catechol	149.12
16	3,4,5,6-Tetraheptyl catechol	> 1000
17	4-(2-Heptyp) catechol	122.19
18	4,5-Di-(2-heptyl) catechol	> 1000
19	3,4,5,6-Tetra-(2-heptyl) catechol	> 1000
20	4-Hexyl catechol	113.91
21	4,5-Dihexyl catechol	203.29
22	3,4,5,6-Tetrahexyl catechol	> 1000
23	4-(2-Hexyl) catechol	115.31
24	4,5-Di-(2-hexyl) catechol	415.50
25	3,4,5,6-Tetra-(2-hexyl) catechol	> 1000
26	4-(3-Hexyl) catechol	446.37
27	4,5-Di-(3-hexyl) catechol	> 1000
28	3,4,5,6-Tetra-(3-hexyl) catechol	> 1000
29	4-Pentyl catechol	173.00
30	4,5-Dipentyl catechol	464.33
31	3,4,5,6-Tetrapentyl catechol	> 1000
32	4-Butyl catechol	122.61
33	4,5-Dibutyl catechol	667.76
34	3,4,5,6-Tetrabutyl catechol	> 1000
35	4-Propyl catechol	117.72
36	4,5-Dipropyl catechol	264.30
37	3,4,5,6-Tetrapropyl catechol	> 1000
38	4-Ethyl catechol	88.56
39	4-Methyl catechol	59.94

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