Antibacterial activity of some unsymmetrical diorganyltellurium(IV) dichlorides

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Six unsymmetrical diorganyltellurium(IV) dichlorides RR'TeCl₂ (where R= phenacyl-, 1-naphthacyl-, and styrylacyl- and R' = p-methoxyphenyl, p-hydroxyphenyl-, and 3-methyl-4-hydroxyphenyl-) were tested for their antibacterial activity against gram-positive (Bacillus subtilis ATCC 25922) and gram-negative (Escherichia coli ATCC 25922, Pseudomonas aeruginosa ATCC 27853 and Salmonella sp.) bacteria. Antibacterial activity was measured by disk diffusion method. Inhibition zones demonstrated that all the compounds showed good activity against gram-negative strains. Phenacyl (3-methyl-4-hydroxyphenyl) tellurium(IV) dichloride and naphthacyl (3-methyl-4-hydroxyphenyl) tellurium(IV) dichloride showed significant activity against both gram-positive and gram-negative strains. Among the tested compounds, the former exhibited maximum activity against gram-positive bacteria, while the latter against all the bacteria under study and styrylacyl (p-methoxyphenyl) tellurium(IV) dichloride against all the three gram-negative bacteria.

Keywords: Unsymmetrical diorganyltellurium(IV) dichlorides, antibacterial activity, Bacillus subtilis, Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa, Salmonella sp.

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There has been a worldwide increase in the infections caused by the pathogens resistant to multiple microbial agents. Due to the emergence of increasing drug resistance, and also synthetic antibiotics or the substances obtained from medicinal plants showing less or no activity against gram-negative bacteria, there is a need to develop the new classes of synthetic antimicrobials to target pathogens that have no prior exposure and, therefore, no pre-existing resistance to the drug.

In the recent years, organotellurium compounds have attracted considerable attention as antioxidants6,7. The compounds containing 4-(dialkylamino) phenyletelluro group have been found to inhibit human primary cancer cell growth8. Some of the organotellurium compounds also exhibited antibacterial activity9-13. The heterocyclic derivatives of dibenzoyltellurium diiodide showed antibacterial activity against gram-positive (Bacillus subtilis and Staphylococcus aureus), and gram-negative (Escherichia coli and Salmonella typhi) bacteria, however, no activity was found in the parent compounds10. Antimicrobial activity was also reported in some organotellurium and organoselenium compounds, derived from α-bromo-4-methylacetophenone with tellurium analogues showing higher activity than organoselenium compounds11. Complexes of organotellurium trichloride with tetramethylthiourea, benzamidazole, triethylamine, γ-picoline and tri-phenylarsine oxide exhibited antibacterial activity against E. coli and S. typhi, but no activity was found against Pseudo-monas aeruginosa and B. subtilis13. Only the complex with tetramethylthiourea showed some activity against B. subtilis.

Earlier, antibacterial activity of some unsymmetrical diorganyltellurium dichlorides (MeO-PhTeCH₂COCH₃Cl₂ and EtOPhTeCH₂COCH₃Cl₂) and corresponding dicarboxylates was reported14, but only E. coli was found to be more sensitive against these compounds and no activity was determined against P. aeruginosa. Carboxylates showed diminished activity than the parent compounds. In the present paper, antibacterial activity of six acyl (aryl) tellurium(IV) dichlorides was investigated against gram-positive (B. subtilis and S. aureus) and gram-negative (E. coli, P. aeruginosa and Salmonella sp.) bacteria.

Materials and Methods

Tellurium(IV) chloride (Merck, AnaR grade) was used as obtained without further purification. Phenol, o-cresol, anisole and acetophenone were from Sisco Research Laboratories Pvt. Ltd., India. 1-Acetophenone and benzalacetone were of Fluka AG, Switzerland. Solvents were purified and dried by conventional methods15.
Preparation of acyl(aryl)tellurium(IV) dichlorides

Acyl(aryl)tellurium(IV) dichlorides were prepared in two steps. Firstly, \( p \)-anisyl-, \( p \)-hydroxyphenyl- and 3-methyl-4-hydroxyphenyl tellurium trichlorides were prepared by the reaction of TeCl\(_4\) with anisole, phenol and \( o \)-cresol, respectively as described\(^{16-18}\). Thereafter, \( p \)-hydroxyphenyl tellurium trichloride, \( p \)-methoxyphenyl tellurium trichloride and 3-methyl-4-hydroxyphenyl tellurium(IV) trichloride were refluxed with acetophenone, acetonaphthone and benzalacetone, respectively in dry CCl\(_4\), under an atmosphere of dry nitrogen for 8-12 hr until the evolution of HCl ceased\(^{19,20}\). The amount of HCl liberated corresponded to the loss of one equivalent of chlorine per mole of RTeCl\(_3\). Compounds were recrystallized in acetonitrile/benzene and characterized by melting point, elemental analyses, IR and Far-IR spectroscopy.

The acyl(aryl)tellurium(IV) dichlorides (Fig. 1) prepared were as follows: Phenacyl (\( p \)-hydroxyphenyl) tellurium(IV) dichloride (1), phenacyl (3-methyl-4-hydroxy-phenyl) tellurium(IV) dichloride (2), naphthacyl (\( p \)-hydroxyphenyl) tellurium(IV) dichloride (3), naphthacyl (\( p \)-methoxyphenyl) tellurium(IV) dichloride (4), naphthacyl (3-methyl-4-hydroxy-phenyl) tellurium(IV) dichloride (5) and styrylacyl (\( p \)-methoxyphenyl) tellurium(IV) dichloride (6).

Antibacterial activity

Antibacterial activity of compounds was determined against gram-positive \( B. subtilis \) ATCC 6633 and \( S. aureus \) ATCC 25923 and gram-negative \( E. coli \) ATCC 25922, \( P. aeruginosa \) ATCC 27853 and \( Salmonella \) sp. using the paper disk method on Luria-Bertani (LB) agar plates according to the National Committee for Clinical Laboratory Standards (NCCLS)\(^{21}\). The test compounds were dissolved in DMSO and two different concentrations (1000 and 250 \( \mu \)g/mL) were used in disk diffusion assay. The micro-organisms were grown on LB agar plates. DMSO was taken as control in one of the disks. Filter paper disks were soaked with test compounds solution (in DMSO) and then placed onto the inoculated agar surface. After keeping at room temperature for 30 min, they were incubated at 37\(^\circ\)C for 27 hr. The results were expressed in terms of the diameter of inhibition zones. No inhibition zone was shown by control disk and the values were average of three separate experiments.

Results and Discussion

The antibacterial activity of different acyl(aryl)tellurium (IV) dichlorides against the various organisms is given in Table 1. Both phenacyl (3-methyl-4-hydroxyphenyl) tellurium(IV) dichloride (2) and naphthacyl (3-methyl-4-hydroxy-phenyl) tellurium(IV) dichloride (5) showed significant activity against both gram-positive and gram-negative pathogens. Among the tested compounds, the former exhibited maximum activity against gram-positive bacteria, while the latter against all the bacteria under study. Both of these compounds contain \( o \)-cresol as one of the aryl groups, but differ in the acyl group. Naphthacyl (\( p \)-methoxyphenyl) tellurium(IV) di-chloride (4) and styrylacyl (\( p \)-methoxyphenyl) tellurium(IV) dichloride (6) exhibited good activity against all gram-negative bacteria; they showed maximum activity against \( P. aeruginosa \). Phenacyl (\( p \)-hydroxyphenyl) tellurium(IV) dichloride (1) and naphthacyl (\( p \)-hydroxyphenyl) tellurium(IV) di-chloride (3) showed fair activity against both gram-negative and gram-positive bacteria, but were inactive against \( S. aureus \).

Interestingly, all the compounds showed good activity against gram-negative bacteria. Earlier, it was reported\(^{14}\) that compounds containing tellurium attached to an aliphatic carbon possessed better activity than bonded to an aromatic carbon. However, in the present study, compounds having more unsaturation were found to show higher activity against gram-negative bacteria.

The structural differences in the membranes of gram-positive and gram-negative bacteria cause...
permeability differences and this might explain the ineffectiveness of most of the other synthetic and natural antimicrobials against \(E. \text{coli}\) and \(P. \text{aeruginosa}\). The outer membrane in these bacteria consists of a characteristic lipopolysaccharide-lipoprotein complex and is inaccessible to most of the antibiotics including penicillin and other compounds such as oligo-3-aminopyridine\(^4\), etc. The organotellurium compounds used in the present study might have crossed the outer membrane of these strains, however, the exact mechanism of the antibacterial action is not clear. Further, the toxicity study is needed for utilizing them as antimicrobial agents.

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**References**


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