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Research Article

SYNTHESIS AND CHARACTERIZATION OF NOVEL ORGANOBISMUTH FOR ANTIMICROBIAL AND ANTITUMOR STUDIES

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ABSTRACT

Objectives: The major objective of this manuscript is to present synthesis and biomedical screening of some organic derivatives of bismuth having general formula (R_3BiL_2) by the method reported and characterized with the help of M.P., elemental, I.R., and NMR spectral analysis along with their antimicrobial and *in vitro* antitumor activity against human breast (MCF-7) and mammary cancer (EVSA-7) cell line.

Methods: All the newly organobismuth having general formula [R_3BiL_2] were synthesised by the method reported especially using oxidative addition and complexation reactions.

Results: It was found that organobismuth compounds have trigonal bipyramidal structure as per their elemental and spectral analysis and show potentiality as antimicrobial and antitumor agents.

Conclusion: The newly synthesized organobismuth(V)substituted carboxylates were fully characterized chemically to ascertain their structure by sophisticated instrumental and spectral analysis resulted as trigonal bipyramidal structure. The compounds were also screened 1st time for antitumor and antimicrobial studies. The observations clearly indicated that organobismuth carboxylates show potent antimicrobial and antitumor activity.

Keywords: Organobismuth, Antimicrobial, Antitumor.

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INTRODUCTION

It is well reported that bismuth compounds have attracted considerable interest due to their biological and medicinal utility [1-5]. They have been utilized from more than 2 centuries in the treatment of gastrointestinal disorders such as dyspepsia, diarrhea, and peptic ulcer [6-9]. Bismuth salts such as colloidal bismuth sub-citrate, bismuth sub-salicylate, and ranitidine bismuth citrate are common agents used for *Helicobacter pylori* eradication therapy and therefore promoted these compounds as antimicrobials [10,11]. The utility of bismuth formulations has motivated many studies into their possible mechanism of action and to the discovery of their biological targets. In search of antiproliferative studies, a variety of organobismuth compounds has been synthesized and tested *in vitro* for their antitumor activity along with their antimicrobial activity [12-15]. The present manuscript describes the synthesis, structural, antimicrobial, and antitumor studies of some novel fluorine-based organic derivatives of bismuth. The compounds were synthesized by the method reported earlier and characterized with the help of M.P., elemental, I.R., and NMR spectral analysis along with their antimicrobial studies, against different pathogenic bacterial and fungal strains and *in vitro* antitumor activity against human breast (MCF-7) and mammary cancer (EVSA-7) cell line and found that compounds have potentiality as antitumor and antimicrobial agents.

METHODS

All the newly organobismuth having general formula [R_3BiL_2] were synthesised by the method reported especially using oxidative addition and complexation reactions.

RESULTS AND DISCUSSION

The synthesis of tris(pentafluorophenyl)bismuth(III)dicarboxylates was performed in laboratory with the help of the following reactions:

$$R_3Bi + Cl_2 \xrightarrow[Et_3N]{\text{Direct Chlorination}} R_3BiCl_2$$

$$R_3BiCl_2 + 2HL \rightarrow R_3BiL_2 + 2Et_3N.HCl$$

Here:
R = (C_6F_5); HL = (Respective carboxylic acids).

All the newly synthesized tris(pentafluorophenyl)bismuth(V) dicarboxylates were crystalline solids, air stable, and soluble in common organic solvents. The compounds were further characterized by their melting points and analytical techniques such as elemental analysis, infrared, and NMR spectroscopy to ascertain their structures and explore their biological properties. The new compounds have sharp melting points and possess trigonal bipyramidal structure as per results obtained by further analysis.

IR and NMR spectral analysis

The IR spectra of new tris(pentafluorophenyl)bismuth(V)dicarboxylates were recorded in PerkinElmer spectrophotometer in 4000-200/cm range. The IR spectra of these compounds show absorption bands due to pentafluorophenyl groups. The absorption frequencies have been fully assigned. The Bi-C vibration in case of pentafluorophenyl derivatives corresponding to the "y" mode appears in the range of 440–460/cm. The IR data suggested a monodentate coordination mode of the carboxylate ligands. The ^{1}H-NMR spectra of the representative tris(pentafluorophenyl)bismuth(V)dicarboxylates showed a multiplet in the range of δ7.82–8.12 ppm which could be assigned to aromatic protons. The ^{19}F-NMR spectra of the compound were carried out at room temperature and the compounds showed peaks appearing in the approximate range consistent with the presence of fluorophenyl groups. Thus, on the basis of above discussions, the newly synthesized compounds assigned a trigonal bipyramidal structure.

Here,
R = (C_6F_5); L = Respective carboxylate as ligands.

Antibacterial activity

Antibacterial activity of these compounds was studied against three human pathogenic bacteria, namely, *Pseudomonas aeruginosa*, *Staphylococcus aureus,* and *Klebsiella pneumonia*, using 10 mg/ml conc. of the test compounds. It was found that compounds show moderate to higher activity against *P. aeruginosa*, *S. aureus,* and *K. pneumonia*. It was found that the respective compounds may damage the cell wall of bacteria by reacting with peptides of cell wall of bacteria.

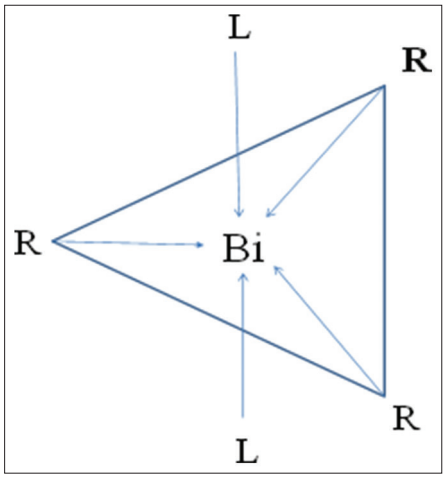

Fig. 1: Suggested structure of triorganobismuth(V) dicarboxylates

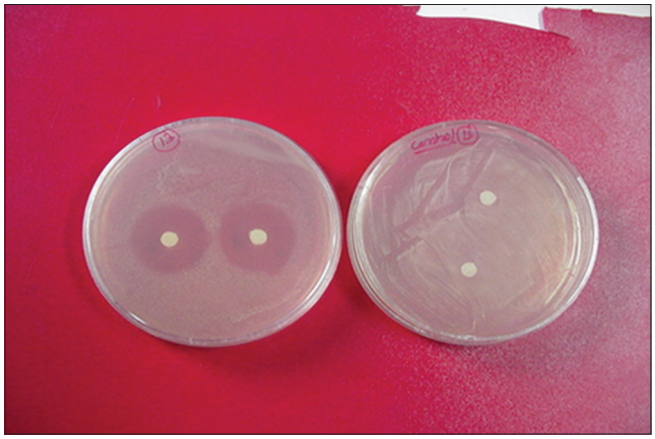

Fig. 2: Antibacterial activity of $(C_6F_5)_3Bi(OOCC_6H_4N(C_2H_5)_2)_2$

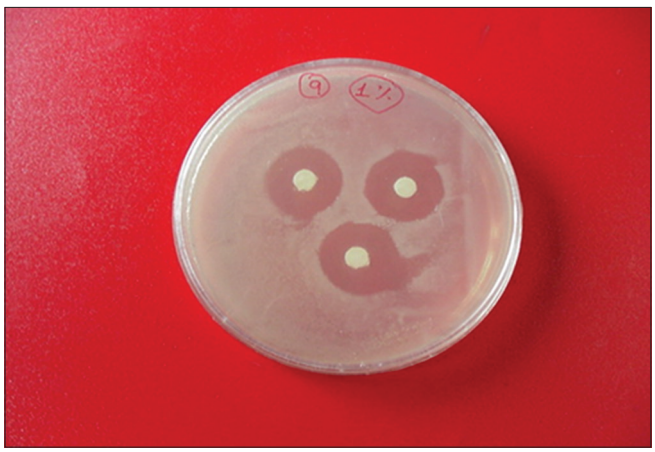

Fig. 3: Antifungal activity of $[(C_6F_5)_3Bi(OOCC_6H_3(OH)OCH_3]_2$

Antifungal activity

Antifungal activity of these compounds was tested against two fungal strains, namely, *Aspergillus flavus* and *Aspergillus niger* at different concentrations, namely, 10 mg/ml, 20 mg/ml, 50 mg/ml, and 100 mg/ml of the test compounds. At 10 mg/ml conc., the compounds show better inhibition (%) against *A. flavus* and *A. niger*. At 20 mg/ml concentration of test compounds, the compounds show higher percentage inhibition while at 50 mg/ml and 100 mg/ml concentration, approximately all the compounds show higher percentage of inhibition against fungal strains.

***In vitro* antitumor activity**

The compounds show moderate to high activity against tumor cell lines. It was found that these compounds are in +3 oxidation state and the slight variation in their activity is due to the presence of different carboxylate group as ligand. The compounds generally interact with the receptor site of multienzyme complex responsible for the cytostatic and cytotoxic conditions. It was reported that compounds in +3 oxidation state can easily bind with the receptor site. It may be noted that the organobismuth compound generally binds with nitrogen 7 position of purine bases in DNA molecule and forms complexes with DNA strands affecting replication and transcription of DNA molecule and stops the cell division along with protein synthesis.

Experimental

The fluorine-based triorganobismuth(V)dichloride was synthesized by the methods reported earlier [16]. The ligands were recrystallized before use while the reactions were performed under inert/nitrogen atmosphere. Preparation of representative organobismuth compounds is discussed below.

Reaction of $(C_6F_5)_3BiCl_2$ with $(HOOC.C_6H_4.NO_2)$

In an oxygen-free nitrogen atmosphere, solution of tris(pentafluorophenyl)bismuth(V) dichloride (1 mmol) in benzene and 2-nitrobenzoic acid (2 mmol) in same solvent was stirred together in the presence of triethylamine at room temperature for 6 h. The off-white color $Et_3N.HCl$ was formed (M.P. = 240°C), which was filtered off and the filtrate on evaporation in vacuum gives an off-white color crystalline solid which was further recrystallized in petroleum ether.

Reaction of $(C_6F_5)_3BiCl_2$ with $(HOOC.C_6H_4.NO_2)$

In an inert atmosphere, solution of tris(pentafluorophenyl)bismuth(V) dichloride (1 mmol) in benzene and 4-nitrobenzoic acid (2 mmol) in same solvent was stirred together in the presence of triethylamine at room temperature for 6 h. The off-white color $Et_3N.HCl$ was formed (M.P. = 240°C), which was filtered off and the filtrate on evaporation in vacuum gives an off-white color crystalline solid which was further recrystallized in petroleum ether.

Reaction of $(C_6F_5)_3BiCl_2$ with $(HOOC.C_6H_4.Cl)$

In an oxygen-free nitrogen atmosphere, solution of tris(pentafluorophenyl)bismuth(V) dichloride (1 mmol) in benzene and 2-chlorobenzoic acid (2 mmol) in same solvent was stirred together in the presence of triethylamine at room temperature for 6 h. The off-white color $Et_3N.HCl$ was formed (M.P. = 240°C), which was filtered off and the filtrate on evaporation in vacuum gives an off-white color crystalline solid which was further recrystallized in petroleum ether.

Reaction of $(C_6F_5)_3BiCl_2$ with $(HOOC.C_6H_4.Cl)$

In an oxygen-free nitrogen atmosphere, solution of tris(pentafluorophenyl)bismuth(V) dichloride (1 mmol) in benzene and 4-chlorobenzoic acid (2 mmol) in same solvent was stirred together in the presence of triethylamine at room temperature for