

# SYNTHESIS AND CHARACTERIZATION OF SOME NOVEL ORGANOANTIMONY DERIVATIVES OF 2-MERCAPTOBENZIMIDAZOLE FOR BIOMEDICINAL EFFICACY

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## Abstract

The present invention deals the synthesis of some novel 2-mercaptobenzimidazole derivative of antimony through modified method followed by their characterization through sophisticated instrumentation and spectral analysis. The synthesized compounds were also screened for their antimicrobial activity against pathogenic strains of bacteria and fungi at different concentrations to find out their efficacy against Antimicrobial Resistance (AMR). The series of compounds were also tested In-vitro for antitumor activity against human breast adenocarcinoma cell line (MCF-7) and mammary cancer Cell lines (EVSA-7). It was found that these compounds show remarkable antimicrobial and antitumor activity and shows effective against Antimicrobial Resistance with different Structure-Activity Relationship.

**Key words:** organoantimony, 2-mercaptobenzimidazole, Antimicrobial, Antitumor, AMR

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## Introduction

The importance of metal based drugs lies in the fact that they are essential components for various physico-chemical processes occurring in living system [1]. The spectrum of the metal based drugs has been expanded as metals can do better due to generation of reactive oxygen species, which help in the treatment of cancer and other acute diseases [2]. The chemistry of main-group elements has seen remarkable advances in organic synthesis and catalysis, redefining the boundaries of redox and acid-base reactivity traditionally dominated by transition metals [3]. The last decades have witnessed major discoveries in the chemistry of main-group elements. Among these developments, organoantimony chemistry has remained largely overlooked. Much of the synthetic chemistry of antimony starts with antimony halides ( $\text{SbX}_3$  and  $\text{SbX}_5$ ), which can be used to design the targeted structure around the Sb center. Organoantimony (III) derivatives ( $\text{SbAr}_3$ ) are most commonly synthesized *via* nucleophilic substitution of stibine halides ( $\text{SbX}_3$ ) with organolithium or Grignard reagents, affording stable and isolable species used as precursors in further functionalization or oxidation reactions [4]. In recent years benzimidazole derivatives have attracted considerable interest because of their therapeutic and pharmacological properties. It is well known that benzimidazole derivatives possess antimicrobial, analgesic and anti-inflammatory activities, as well as proved to have activities against HIV and cancer [5]. 2-mercaptobenzimidazole, one of the most important derivatives of benzimidazole exhibited a wide variety

of interesting biological activities such as antimicrobial, antihistamine, neurotropic and analgesic activities [6]. These observations have been guiding for the development of new 2-mercaptobenzimidazole derivatives that possess varied biological activities. The present manuscript deals the synthesis of some novel 2-mercaptobenzimidazole derivative of antimony and their further characterization for biomedical studies.

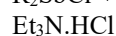
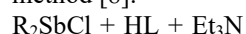
## Experimental

### Synthesis of 2-mercaptobenzimidazole:

A mixture of o-phenylenediamine (0.01mole), potassium hydroxide (0.01mole) and carbon disulfide (0.01mole), 100 ml of methanol and 15ml of water in a 500ml round bottom flask and heated under reflux for 3hours. The reaction mixture was then filtered. The filtrate was heated to 60-70°C then 100 ml water was added followed by acidification with dilute acetic acid with stirring. The mixture was then placed in the refrigerator for crystallization. The product was collected after filtration and dried. The product was recrystallized with ethanol [7].

### Complexation Reaction:

The organoantimony (III) complex of 2-mercaptobenzimidazole were synthesized by refluxing the stoichiometric amount of the 2-mercaptobenzimidazole with corresponding organoantimony (III) chloride in presence of triethylamine as an HCl acceptor, at ambient temperature in a nitrogen environment using reported method [8].



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RSbCl<sub>2</sub> + 2HL + 2Et<sub>3</sub>N  
2Et<sub>3</sub>N.HCl  
RSbCl<sub>2</sub> + HL + Et<sub>3</sub>N  
Et<sub>3</sub>N.HCl

R: (C<sub>6</sub>H<sub>5</sub>); (C<sub>6</sub>F<sub>5</sub>); (p-FC<sub>6</sub>H<sub>4</sub>); HL: 2-mercaptobenzimidazole

## Antibacterial Activity:

Antibacterial activity of the synthesized organotin compound was carried out by disc diffusion method [9] using ampicillin as standard. The filter paper (Whatman No.1) sterile disc of 5 mm diameter, impregnated with the test compounds (10 µg/ml of ethanol) along with standard were placed on the nutrient agar plate at 37°C for 24 hrs in BOD incubator. The inhibition zone around the dried impregnated disc was measured after 24 hrs. The activity was classified as highly active (dia = > 15 mm), moderately active (dia = 10-15 mm) and slight active (dia = 5-10 mm). The diameter less than 5 mm was regarded as inactive.

## Antifungal Activity:

The antifungal activity of the organotin compound was tested by agar plate diffusion method [10], using ampicillin as standard. The two concentrations of the test compounds viz., 50 and 100 µg/ml were prepared and tested against two pathogenic fungal strains, *Aspergillus flavus* and *Aspergillus niger*. The one ml of each compound was poured into a Petri dish containing 20-25 ml of molten potato dextrose-agar medium. As the medium solidify, Petri dishes were inoculated at 37°C for 96 hrs in BOD incubator. After 96 hrs the colony diameter was measured and % inhibition was calculated using standard method.

## Antitumor Activity:

The *in-vitro* antitumor activity of these compounds was carried out by MTT-Method [11]. This method was performed to estimate the effect of compounds on the growth of cell. The human breast adenocarcinoma (MCF-7) and mammary cancer (EVSA-7) cell lines were used for this purpose. The principle behind this assay depends upon the reduction of tetrazoleum salt. The yellow colored tetrazoleum MTT [3-(4, 5-dimethylthiazolyl-2)-2, 5-diphenyl tetrazoleum bromide] was reduced partially by metabolically active cells by the action of dehydrogenase enzyme to generate NADH and NADPH as reducing equivalents. The resulting intracellular purple Colour zone was solubilized and quantified by spectrophotometer. The MTT was first dissolved in Phosphate buffer saline at a concentration of 5 mg/ml. The MTT solution (50 µl) was added to each well of 96 well culture plate containing 100 µl of culture medium and incubates at 37°C for 4 hrs. The medium was then removed carefully without disturbing the crystals of purple colored zone. 50 µl of DMSO was then added to each well and mixed thoroughly to dissolve the crystals of the zone. The plate was then read on a micro ELISA

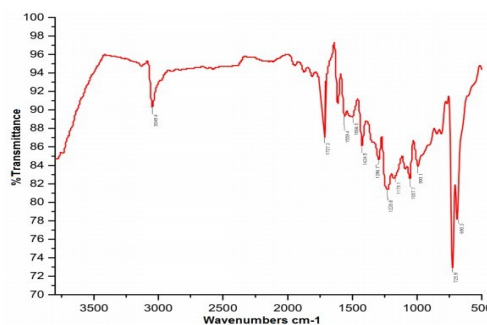
plate reader at a wavelength of 570 nm to find out the optical density and cell count value.

## Results and Discussion

All the newly synthesized 2-mercaptobenzimidazole derivatives of antimony are crystalline solids. All the reactions were conducted at room temperature and the products were recrystallized from petroleum ether (40-60°C) or in benzene. The complexes are off-white to light brown solids and obtained as a sticky mass which on treatment with sodium in dry benzene gets solidified and subsequently crystallized with benzene/pet-ether. The complexes have sharp melting point. There is no regular trend of the melting point of the complexes and they melt without decomposition. Complexes are also soluble in chloroform and acetonitrile. They can be stored at room temperature without decomposition for several weeks. The consistency in melting points after repeated crystallization as well as TLC run in chloroform hexane mixture (1:1) with the observation of a single spot excluded the presence of mixture of reactants. The molar conductance value of 10<sup>-3</sup>M solution of these compounds were recorded in methanol and found in the range of 15-25 Ohm<sup>-1</sup> mole<sup>-1</sup> cm<sup>2</sup> indicating the absence of ionic species in solution.

## IR Spectra:

As expected infrared absorptions inherent to phenyl and fluorophenyl groups bound to metal have no difference appreciably and hence not discussed. The Infrared absorptions having diagnostic value related to the ligand, have been identified which on preliminary stage indicates the bonding with ligand. A noticeable feature of the IR spectra of all the derivatives is the absence of absorption corresponding to t mode which should be located in the region 250-300 cm<sup>-1</sup>. A medium strong intensity band consistently appearing in the range 440-470 cm<sup>-1</sup> is assigned to  $\nu_{\text{sym}}\text{Sb-C}$  stretching corresponding to the Y-mode. The assignment of the Sb-S stretching mode is uncertain due to complex nature of the spectra in this region. Absorption frequencies having diagnostic value are listed in table.



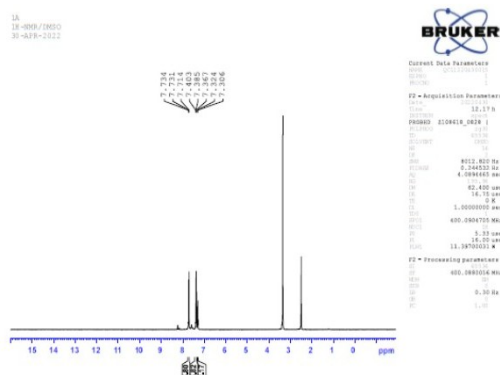
## FTIR Spectra of representative Compound

## NMR Spectra:

The <sup>1</sup>H NMR spectra of the representative of organoantimony compounds showed a multiplet in the

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range  $\delta$ 7.82ppm to  $\delta$  8.12ppm which could be assigned to aromatic protons. The  $^{19}\text{F}$ NMR spectra of the compound was carried out at room temperature and the compounds showed peaks appearing in the range of -108.30ppm to -112.30ppm and is consistent with the presence of fluorophenyl groups. Thus on the basis of above discussions the newly synthesized organoantimony (III) compounds assigned a pyramidal structure.



**$^1\text{H}$ NMR Spectra of representative Compound**

## Antibacterial Efficacy:

All the organoantimony (III) derivatives of 2-mercaptobenzimidazole were tested for antibacterial activity against three pathogenic bacterial strains *Pseudomonas aeruginosa*, *Staphylococcus aureus* and *Klebsiella pneumoniae* using 10  $\mu\text{g}/\text{ml}$  concentration of test compound. All the compounds show higher to moderate activity against the bacterial strains. It was found that compounds having fluoro and pentafluorophenyl ring are more effective because of their polarity and lipid solubility. The fluorine containing compounds may generally form complexes with metalloenzymes, particularly those which responsible in basic physiology such as cytochrome oxidase. These compounds may interact with peptidoglycan layer of bacterial cell wall and damage it by penetrating in such a manner that the phenyl ring gets entered inside the cell by puncturing it followed by death of bacterial cell. Sometimes these compounds in low concentration may cause bacteriostatic condition by slow down the growth of bacteria.

## Antifungal Efficacy:

The antifungal activity of all the organoantimony (III) derivatives of 2-mercaptobenzimidazole were tested against *Aspergillus flavus* and *Aspergillus niger* using 50 and 100  $\mu\text{g}/\text{ml}$  concentration. The activity of these compounds was found variable at 50 $\mu\text{g}/\text{ml}$  concentration but at higher concentration all the derivatives show high efficacy against fungal strains. Presence of nitrogen, sulphur, phenyl and pentafluorophenyl ring along with antimony in +3 oxidation state are considered for antifungal efficacy.

The role of ligands was also commendable. These compounds generally damage the fungal strains by puncturing the cell wall similarly as in the case of bacteria. Solubility of these compounds, due to presence of fluorine, also increases the efficacy.

## Antitumor Efficacy:

The antitumor activity of these compounds was studied against the human breast adenocarcinoma (MCF-7) and mammary cancer (EVSA-7) cell lines. 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 presence of ligand along with fluorine on main moiety of the compound. The compounds generally interact with the receptor site of multienzyme complex responsible for the cytostatic and cytotoxic conditions. The compounds generally binds with nitrogen 7 position of purine bases in DNA molecule and form complexes with DNA strands affecting replication and transcription of DNA molecule and stop the cell division along with protein synthesis.

## Conclusion

The above discussion of results clearly indicates that the organoantimony(III)derivatives of 2-mercaptobenzimidazole are structurally stable and show better results against tumor cell lines *in-vitro* along with bacterial and fungal strains. These compounds would be treated as drugs in future for the treatment of such kinds of chronic diseases.

## Acknowledgement

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**Table-1: Physicochemical Properties of organoantimony (III) derivatives of 2-mercaptobenzimidazole**

| S.N. | Compounds                                                                                         | Formula                                                           | Formula Weight | M.P (°C) | Elemental Analysis |      |       |       |
|------|---------------------------------------------------------------------------------------------------|-------------------------------------------------------------------|----------------|----------|--------------------|------|-------|-------|
|      |                                                                                                   |                                                                   |                |          | C%                 | H%   | N%    | S%    |
| 1    | (C <sub>6</sub> H <sub>5</sub> ) <sub>2</sub> Sb(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> )  | C <sub>20</sub> H <sub>18</sub> N <sub>2</sub> Sb                 | 425            | 116      | 53.64              | 3.52 | 6.58  | 7.52  |
| 2    | (C <sub>6</sub> F <sub>5</sub> ) <sub>2</sub> Sb(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> )  | C <sub>9</sub> H <sub>5</sub> F <sub>10</sub> N <sub>2</sub> Sb   | 605            | 97       | 37.68              | 0.82 | 4.62  | 5.28  |
| 3    | (FC <sub>6</sub> H <sub>4</sub> ) <sub>2</sub> Sb(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> ) | C <sub>10</sub> H <sub>5</sub> F <sub>9</sub> N <sub>2</sub> Sb   | 461            | 104      | 49.45              | 2.81 | 6.07  | 6.94  |
| 4    | (C <sub>6</sub> H <sub>5</sub> )SbCl(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> )              | C <sub>11</sub> H <sub>10</sub> N <sub>2</sub> SbCl               | 383.5          | 118      | 40.67              | 2.60 | 7.30  | 8.34  |
| 5    | (C <sub>6</sub> H <sub>5</sub> )Sb(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> ) <sub>2</sub>   | C <sub>20</sub> H <sub>18</sub> N <sub>4</sub> Sb                 | 497            | 112      | 48.28              | 3.01 | 11.26 | 12.87 |
| 6    | (C <sub>6</sub> F <sub>5</sub> )SbCl(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> )              | C <sub>10</sub> H <sub>5</sub> F <sub>9</sub> N <sub>2</sub> SbCl | 473.5          | 110      | 32.94              | 1.05 | 5.91  | 6.75  |
| 7    | (C <sub>6</sub> F <sub>5</sub> )Sb(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> ) <sub>2</sub>   | C <sub>20</sub> H <sub>5</sub> F <sub>10</sub> N <sub>4</sub> Sb  | 587            | 106      | 40.88              | 1.70 | 9.54  | 10.90 |
| 8    | (FC <sub>6</sub> H <sub>4</sub> )SbCl(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> )             | C <sub>11</sub> H <sub>5</sub> F <sub>9</sub> N <sub>2</sub> SbCl | 401.5          | 108      | 38.85              | 2.24 | 6.97  | 7.97  |
| 9    | (FC <sub>6</sub> H <sub>4</sub> )Sb(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> ) <sub>2</sub>  | C <sub>20</sub> H <sub>5</sub> F <sub>10</sub> N <sub>4</sub> Sb  | 515            | 102      | 46.60              | 2.71 | 10.87 |       |

**Table-2: Antibacterial activity of organoantimony (III) derivatives of 2-mercaptobenzimidazole**

| S | Compounds                                                                                         | <i>Pseudo monas aeruginosa</i> | <i>Staphylococcus aureus</i> | <i>Klebsiella pneumoniae</i> |
|---|---------------------------------------------------------------------------------------------------|--------------------------------|------------------------------|------------------------------|
| 1 | (C <sub>6</sub> H <sub>5</sub> ) <sub>2</sub> Sb(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> )  | 11.00±0.57                     | 8.10±0.16                    | 12.00±1.15                   |
| 2 | (C <sub>6</sub> F <sub>5</sub> ) <sub>2</sub> Sb(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> )  | 11.33±0.66                     | 11.00±0.57                   | 08.50±0.29                   |
| 3 | (FC <sub>6</sub> H <sub>4</sub> ) <sub>2</sub> Sb(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> ) | 08.00±0.28                     | 19.00±0.57                   | 13.00±0.50                   |
| 4 | (C <sub>6</sub> H <sub>5</sub> )SbCl(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> )              | 17.33±0.66                     | 19.00±0.57                   | 15.00±                       |

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|    |                                                                                                     |            |            |            |
|----|-----------------------------------------------------------------------------------------------------|------------|------------|------------|
|    |                                                                                                     | 60         | 7          | 0.57       |
| 5  | (C <sub>6</sub> H <sub>5</sub> )Sb(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> ) <sub>2</sub>     | 18.66±0.66 | 7.83±0.44  | 10.5±0.76  |
| 6  | (C <sub>6</sub> F <sub>5</sub> )SbCl(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> )                | 15.66±0.33 | 16.00±0.57 | 17.00±0.57 |
| 7  | (C <sub>6</sub> F <sub>5</sub> )Sb(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> ) <sub>2</sub>     | 11.00±0.57 | 8.10±0.16  | 12.00±1.15 |
| 8  | (FC <sub>6</sub> H <sub>4</sub> ) <sub>2</sub> SbCl(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> ) | 10.94±0.48 | 8.04±0.10  | 11.88±0.70 |
| 9  | (FC <sub>6</sub> F <sub>5</sub> )Sb(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> ) <sub>2</sub>    | 11.33±0.66 | 11.00±0.57 | 8.58±0.29  |
| 10 | Ampicilin (standard)                                                                                | 18.0±0.21  | 12.66±0.50 | 16.26±0.30 |

**Table-3: Antifungal Activity of organoantimony (III) derivatives of 2-mercaptobenzimidazole at 50 µg/ml conc.**

| S. No. | Compounds                                                                                           | <i>Aspergillus flavus</i> Col. Dia. (mm) | % Inhibition | <i>Aspergillus niger</i> Col. Dia. (mm) | % Inhibition |
|--------|-----------------------------------------------------------------------------------------------------|------------------------------------------|--------------|-----------------------------------------|--------------|
| 1      | (C <sub>6</sub> H <sub>5</sub> ) <sub>2</sub> Sb(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> )    | 0.7                                      | 76.6         | 0.5                                     | 75.0         |
| 2      | (C <sub>6</sub> F <sub>5</sub> ) <sub>2</sub> Sb(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> )    | 0.5                                      | 83.3         | 0.4                                     | 80.0         |
| 3      | (FC <sub>6</sub> H <sub>4</sub> ) <sub>2</sub> Sb(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> )   | 0.5                                      | 83.3         | 0.4                                     | 80.0         |
| 4      | (C <sub>6</sub> H <sub>5</sub> )SbCl(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> )                | 0.6                                      | 80.0         | 0.7                                     | 65.0         |
| 5      | (C <sub>6</sub> H <sub>5</sub> )Sb(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> ) <sub>2</sub>     | 0.7                                      | 76.63        | 0.6                                     | 70.0         |
| 6      | (C <sub>6</sub> F <sub>5</sub> )SbCl(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> )                | 0.8                                      | 73.3         | 0.8                                     | 60.0         |
| 7      | (C <sub>6</sub> F <sub>5</sub> )Sb(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> ) <sub>2</sub>     | 0.7                                      | 76.6         | 0.7                                     | 65.0         |
| 8      | (FC <sub>6</sub> H <sub>4</sub> ) <sub>2</sub> SbCl(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> ) | 0.2                                      | 93.3         | 0.7                                     | 65.0         |
| 9      | (FC <sub>6</sub> F <sub>5</sub> )Sb(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> ) <sub>2</sub>    | 0.2                                      | 93.3         | 0.7                                     | 65.0         |
| 10     | Control                                                                                             | 3.0                                      | —            | 2.0                                     | —            |

**Table-4: Antifungal Activity of organoantimony (III) derivatives of 2-mercaptobenzimidazole at 100 µg/ml conc.**

| S. No. | Compounds                                                                                        | <i>Aspergillus flavus</i> Col. Dia. (mm) | % Inhibition | <i>Aspergillus niger</i> Col. Dia. (mm) | % Inhibition |
|--------|--------------------------------------------------------------------------------------------------|------------------------------------------|--------------|-----------------------------------------|--------------|
| 1      | (C <sub>6</sub> H <sub>5</sub> ) <sub>2</sub> Sb(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> ) | 0.1                                      | 96.7         | 0.2                                     | 90.0         |
| 2      | (C <sub>6</sub> F <sub>5</sub> ) <sub>2</sub> Sb(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> ) | 0.2                                      | 93.3         | 0.1                                     | 95.0         |

|    |                                                                                                     |     |      |     |      |
|----|-----------------------------------------------------------------------------------------------------|-----|------|-----|------|
| 3  | (FC <sub>6</sub> H <sub>4</sub> ) <sub>2</sub> Sb(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> )   | 0.1 | 96.7 | 0.1 | 95.0 |
| 4  | (C <sub>6</sub> H <sub>5</sub> )SbCl(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> )                | 0.4 | 86.7 | 0.2 | 90.0 |
| 5  | (C <sub>6</sub> H <sub>5</sub> )Sb(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> ) <sub>2</sub>     | 0.2 | 93.3 | 0.2 | 90.0 |
| 6  | (C <sub>6</sub> F <sub>5</sub> )SbCl(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> )                | 0.1 | 96.7 | 0.4 | 80.0 |
| 7  | (C <sub>6</sub> F <sub>5</sub> )Sb(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> ) <sub>2</sub>     | 0.2 | 93.3 | 0.3 | 75.0 |
| 8  | (FC <sub>6</sub> H <sub>4</sub> ) <sub>2</sub> SbCl(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> ) | 0.1 | 96.7 | 0.3 | 75.0 |
| 9  | (FC <sub>6</sub> F <sub>5</sub> )Sb(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> ) <sub>2</sub>    | 0.1 | 96.7 | 0.2 | 90.0 |
| 10 | Control                                                                                             | 3.0 | —    | 2.0 | —    |

**Table-5: Antitumor activity of organoantimony (III) derivatives of 2-mercaptobenzimidazole**

| S. No. | Compounds                                                                                           | MCF-7 Cell No. x 10 <sup>4</sup> | EVSA-7 Cell No. x 10 <sup>4</sup> | Activity |
|--------|-----------------------------------------------------------------------------------------------------|----------------------------------|-----------------------------------|----------|
| 1      | (C <sub>6</sub> H <sub>5</sub> ) <sub>2</sub> Sb(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> )    | 11.69 ± 1.04                     | 11.82 ± 1.06                      | Negative |
| 2      | (C <sub>6</sub> F <sub>5</sub> ) <sub>2</sub> Sb(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> )    | 9.17 ± 0.90                      | 8.67 ± 0.69                       | Positive |
| 3      | (FC <sub>6</sub> H <sub>4</sub> ) <sub>2</sub> Sb(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> )   | 8.79 ± 0.52                      | 8.42 ± 0.46                       | Positive |
| 4      | (C <sub>6</sub> H <sub>5</sub> )SbCl(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> )                | 12.31 ± 1.02                     | 12.39 ± 1.03                      | Negative |
| 5      | (C <sub>6</sub> H <sub>5</sub> )Sb(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> ) <sub>2</sub>     | 8.95 ± 0.67                      | 8.55 ± 0.62                       | Positive |
| 6      | (C <sub>6</sub> F <sub>5</sub> )SbCl(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> )                | 11.59 ± 1.06                     | 11.29 ± 1.02                      | Negative |
| 7      | (C <sub>6</sub> F <sub>5</sub> )Sb(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> ) <sub>2</sub>     | 9.29 ± 0.88                      | 9.89 ± 0.92                       | Positive |
| 8      | (FC <sub>6</sub> H <sub>4</sub> ) <sub>2</sub> SbCl(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> ) | 12.79 ± 1.20                     | 12.69 ± 1.16                      | Negative |
| 9      | (FC <sub>6</sub> F <sub>5</sub> )Sb(SN <sub>2</sub> H <sub>5</sub> C <sub>7</sub> ) <sub>2</sub>    | 11.52 ± 1.02                     | 11.82 ± 1.06                      | Negative |
| 10     | Negative control                                                                                    | 10.21 ± 1.01                     | 10.22 ± 1.01                      | —        |
| 11     | Positive control                                                                                    | 40.26 ± 3.23                     | 41.23 ± 3.28                      | —        |

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