# COMMUNICATIONS

DE LA FACULTÉ DES SCIENCES
DE L'UNIVERSITÉ D'ANKARA

Série B: Chimie

TOME 26 ANNÉE 1980

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Ankara, Turquie

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# Complex Compounds of Indium (III) Chloride And Bromide With Some Organic Ligands.

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(Received January 10, 1980 and accepted March 6, 1980)

## ABSTRACT

This work describes the preparations and properties of some new complexes of Indium (III). The ligands contain atoms from groups V and VI.

Indium (III) exhibits class "A" accepter behaviour in which the strength of coordination is: N>P and O>S.

Complexes of In (III) chloride and-bromide with organic ligands containing nitrogen or oxygen atoms as their potential sites of donation have been prepared.

The infrared of the formed complexes are discussed and an attempt to explain the type of coordinate bond is made. No evidence has been obtained for the formation of complexes with $Me_2S$, $Me_2SO_2$, $Ph_2S$, $Ph_2SO_2$, $Ph_3P$ or $Ph_3PS$. This is probably because of the low donor strengths of sulphur and phosphorus atoms with respect to indium (III). Thermal stabilities of the adducts, molecular weights and the conductance of their solutions in organic solvents are measured.

The coordination chemistry of indium trihalides(¹), perchlorate(²), nitrate(³) and lower halides(⁴) have been investigated. Indium (III), like the corresponding boron, aluminium, and gallium compounds, readily forms addition compounds with a variety of donor molecules.

The purpose of the present work is to study systematically the reactions of indium trichloride and-bromide with organic ligands containing atoms from Groups V and VI. In order to gain some information about the structure, mode of bond in the complexes and their thermal stabilities, the solid species have been prepared and examined.

From the present studies, it is concluded- that indium (III) exhibits class "A" acceptor behaviour in which the strength of the coordination is $N>P$ and $O>S$.(5)

## Experimental

Infrared spectra were recorded on a Unicam SP 200G infrared spectrophotometer. Conductivities were measured using a Backman Electronic switchgear bridge model RA-2A with balance indicator. Molecular weights were measured using a vapvpour pressure osmometer model "Knauer". Thermogravimetric analysis was attempted using a Stato thermogravimetric balance. Considerable care was taken with the drying of solvents. Ethanol was boiled under reflux with magnesium ethoxide and then distilled. Other solvents were dried by conventional methods-. Analyses of carnon hydrogen, and nitrogen were carried out by the microanalytical laboratory of El-Nasr Company and that for phosphoruos was carried out by Alfred Microanalysis laboratory, West Germany. Chloride and bromide were determined by Volhard method(7). Indium was determined as EDTA complex(2). Melting points were measured using an ordinary Gallenkamp tube melting apparatus.

All chemicals used were of analytical grade reagents (A.R.), BDH, Merck, Sigma or extra pure grade. The organic ligands were prepared as previously mentioned[8-10].

## Results and Discussion

Re-investigation of the supposed complex of indium (III)(1), with triphenyl-phosphine $InCl_3$, $2Ph_3P$, suggested that the complex is probably the phosphine oxide one. The reaction between triphenylphosphine and indium (III) in the presence of air gave triphenylphosphine oxide adduct. The complexes are similar to authenic samples prepared from indium trihalides and triphenylphosphine oxide in ethyl acetate, $InX_3$, $2Ph_3PO$, and it seems that slow oxidation of triphenylphosphine in presence of air had occured. Similar results are reported-.

The addition of an ethanolic solution of $MePh_3PI$ to a solution of $InCl_3$ in ethanol saturated with HCI gave a product of the type $InCI_3$, $2MePh_3PCI$.

Carty and Tuck(1) reported the preparations of $InX_3$, DiPhOS (where X = Br or I and DiPhOS = 1,2 - bis (diphenyl-phosphino) ethane), but they were unable to prepare the corresponding chloride adduct. During this work we report the preparations of $InCI_3$, DiPhOS and the indium trichloride adduct with DiPhOS oxide, $InCI_3$, DiPhOS oxide. The reaction of ethanolic solutions of $InX_3$ and diphenyl sulphoxide, $Ph_2SO$, applying the mole ratio of 1:2 gave adducts analysed as $InX_3$, $3Ph_3SO$. These adducts are recovered unchanged after boiling with ethanol. When a solution of $InCI_3$ in ethanol was added to dimethyl sulphoxide, $Me_2SO$, the adduct obtained proved by analysis to be $InCI_3$, $4Me_2SO$. The same product was obtained without using any solvent and the excess of the ligand was pumped off at 60°C under reduced pressure.

Reaction of $InCI_3$ and bipyridly, bipy, in the mole ratio 1:1.5 gave a product similar to that previously reported(10). On using excess of the ligand, five-fold, different product was obtained, $InCI_3$, 2bipy, $3H_2O$. The adduct $InCI_3$, 3bipy, was reported by Sutton applying diffrent method of preparation(11).

On mixing solutions of $InCl_3$ and organic compounds in the mole ratio of 1:2, adducts of the type $InCl_3$, 1.5L (where L = o-phen., DM-bipy, pyrazine) were obtained. The possible structure of such adducts with this unusual stoicheiometry was discussed by Johnson and Walton(10).

Monoadducts of the type $InX_3$, L (where L = DM-o-phen., and 2,2',2"-tripyridyl) were obtained on adding ethanolic solutions of indium trihalides to solutions of the ligands in the same solvent. No other adducts were obtained even on using excess of the ligand.

Reactions in the presence of HCI or HBr solutions using the mole ratio of 1:2, gave products proved by analyses and infrared studies to have the general formula, $InX_3$, 2L, $2H_2O$ (where L = o-phen. or bipy.).

In the reactions of o-phenanthroline and bipyridly with either $InCl_3$ or $InBr_3$, it was found that a change in the reaction conditions brought about a change in the adducts obtained.

On using bulky ligands, the products obtained were the mono-adducts, $InX_3$,L (where X = Cl or Br and L = 2,9-dimethyl-o-phenanthroline, and 2,2',2"-tripyridyl), m.ps., yields and analytical data are given in Table 1.

## Infrared Measurement

The infrared spectra in the region 650–4000 cm$^{-}$- for indium (III) adducts are discussed. The coordinate bond in such type of complexes is predicted to be below 150 cm$^{-}$(12).

As indicated in Table (2), shifts in the P = O stretching frequency occurs due to coordination to $InX_3$ (X = Cl or Br) through oxygen. This is in agreement with earlier reports. Coordination occurs through the oxygen atom in indium sulphoxide complexes. The split of the S-O bond in case of $InBr_3$, $3Ph_2SO$ may be attributed to differently coordinated $Ph_2SO$ molecules. The compound may be formulated as $InBr_3$, $2Ph_2SO$, $Ph_2SO$ Fig. 1. Similar behaviour of $Ph_2SO$ complexes are reported$_{33}$.

The infrared spectra of the complexes $InX_3$, nL (where X = Cl or Br and L = o-phen., DM-o-Phen., 2,2',2"-tripyridyl, 2,2'-bipy, and DM-Bipy.), show in general a change in the C–H bending frequencies in the range 860–730 cm$^{-1}$, and another change with multiple splitting in the region 1700–1400 cm$^{-1}$.

*Conductivity Studies.*– Conductivity measurements in nonaqueous solutions have frequently been used in structural studies of indium (III) complexes. Within the limits of the solubilities of the complexes prepared, we have measured the molar conductivities of millimolar solutions in organic solvents. The results are recorded in Table (3). From the table, it is clear that the solution of $InCl_3$, DM-o-Phen., behaves as a weak electrolyte in the organic solvents used. The complex $InCl_3$, tripy. behaves as strong electrolyte in DMF (Fig. 1).

TABLE 1:

| Comound | Found (%) |  |  |  |  |  | Required (%) |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | C | H | P/N | In | Halide Cl/Br | Formula | C | H | P/N | In | Halide Cl/Br | Yield % | M.P.°C |
| In $Cl_3$, $2MePh_3Cl$ | 53.4 | 4.1 | 7.1 | 13.3 | 20.8 | $C_{38}H_{36}Cl_5P_2In$ | 53.9 | 4.3 | 7.3 | 13.6 | 21.0 | 86.6 | 130 |
| In $Cl_3$, Diphos | 49.0 | 4.4 | — | 18.2 | 17.0 | $C_{26}H_{24}Cl_3P_2In$ | 50.4 | 3.9 | — | 18.5 | 17.2 | 82 | 231 |
| In $Cl_3$, Diphos Oxide | — | — | — | 17.4 | 16.35 | $C_{26}H_{24}Cl_3P_2O_2In$ | — | — | — | 17.6 | 16.34 | 72.9 | >240 |
| In $Cl_3$, 3 $Ph_2$ SO | 52.3 | 4.4 | — | 13.6 | 12.7 | $C_{36}H_{30}Cl_3O_3S_3In$ | 52.2 | 3.6 | — | 13.9 | 12.9 | 97.6 | 125 |
| In $Br_3$, 3 $Ph_2$ SO | 46.1 | 4.4 | — | 11.8 | 25 | $C_{36}H_{30}Br_3O_3S_3In$ | 45.0 | 3.2 | — | 11.9 | 24.9 | 94.4 | 110 |
| In $Cl_3$, 4 DMSO | 18.8 | 5.6 | — | 21.3 | 19.5 | $C_8H_{24}Cl_3O_4S_4In$ | 18.0 | 4.5 | — | 21.5 | 19.95 | 86 9 | 158 |
| In $Cl_3$, dimethyl-o-phenanthroline | 39.2 | 3.2 | 6.5 | 16.5 | 24.5 | $C_{14}H_{12}Cl_3N_2In$ | 39.2 | 2.8 | 6.5 | 26.7 | 24.8 | 89.9 | >240 |
| In $Br_3$, dimethyl-o-phenanthroline | 28.9 | 2.3 | 4.8 | 20.3 | 42.3 | $C_{14}H_{12}Br_3N_2In$ | 29.9 | 2.2 | 5.0 | 20.4 | 42.6 | 87.5 | >240 |
| In $Cl_3$, o-phenanthroline | 34.5 | 3.2 | 6.2 | 28.4 | 26.2 | $C_{12}H_8Cl_3N_2In$ | 35.9 | 2.0 | 6.7 | 28.6 | 26.5 | 93. | >240 |
| In $Cl_3$, 1.5-o-phenanthroline | 43.8 | 3.3 | — | 23.2 | 21.0 | $C_{18}H_{12}Cl_3N_3In$ | 44 | 2.5 | — | 23.4 | 21.1 | 93.9 | >240 |
| In $Cl_3$, 2.0-phenanthroline dihydrate | 46.7 | 3.5 | — | 18.5 | 17.1 | $C_{24}H_{20}Cl_3N_3O_2In$ | 46.6 | 3.6 | — | 18.6 | 17.2 | 91.7 | >240 |
| In $Br_3$, o-phenanthroline. | 27.0 | 2.8 | — | 21.45 | 44.5 | $C_{12}H_8Br_3N_2In$ | 26.95 | 1.5 | — | 21.5 | 44.8 | 98.2 | >240 |
| In $Br_3$, 2.0 = phenanthrolir$2H_2O$ | 38.3 | 3.1 | 6.7 | 15.3 | 31.65 | $C_{24}H_{20}Br_3N_4O_2In$ | 38.4 | 2.7 | 6.4 | 15.3 | 31.9 | 80.9 | >240 |
| In $Cl_3$, 1.5 (2.2-bipyridyl), $H_2O$ | 37.5 | 4.2 | — | 24.1 | 22 | $C_{15}H_{14}Cl_3N_3O$ In | 38 | 3 | — | 24.3 | 22.5 | 94.6 | >240 |
| In $Cl_3$,2 (bipyridly), $3H_2O$ | 40.2 | 3.9 | — | 19.35 | 17.7 | $C_{20}H_{22}Cl_3N_4O_3In$ | 40.8 | 3.8 | — | 19.5 | 18.1 | 93.6 | >240 |
| In $Cl_3$, 2(2.2-bipyridyl), $2H_2O$ | 41.9 | 3.8 | 9.8 | 20.2 | 18.8 | $C_{20}H_{20}Cl_3N_4O_2$ In | 42.2 | 3.5 | 9.8 | 20.2 | 18.7 | 98.7 | 240 |
| In $Cl_3$, 1.5 (dimethyl-2-.2-bipyridyl) | 43.9 | 4.3 | 8.1 | 22.8 | 21.0 | $C_{18}H_{18}Cl_3N_3In$ | 43.5 | 3.5 | 8.4 | 23 | 21.4 | 93.4 | 245 |
| In $Br_3$, DM-bipy., EtOH | 28.6 | 3.9 | — | 19.5 | 40.5 | $C_{14}H_{18}Br_3N_2OIn$ | 28.8 | 3.1 | — | 19.6 | 40.9 | 93.9 | 245 |
| In $Cl_3$, 2,2', 2''-tripyridyl). | 39.9 | 3.1 | 8.2 | 25.1 | 23.1 | $C_{15}H_{11}Cl_3N_3In$ | 39.6 | 2.4 | 9.2 | 25.3 | 23.4 | 81 | >240 |
| In $Br_3$, 2.2',2''-tripyridyl. | 31.3 | 2.7 | — | 19.4 | 40.4 | $C_{15}H_{11}Cl_3N_3In$ | 30.7 | 1.9 | — | 19.5 | 40.8 | 94 | >240 |
| In $Cl_3$, 1.5 (Pyrazine). | 21.7 | 2.4 | — | 33.5 | 30.8 | $C_6H_6Cl_3N_3In$ | 21.1 | 1.8 | — | 33.6 | 31.1 | 93.6 | >240 |
| In $Br_3$, 2 (Pyrazine). | 18.4 | 2.4 | — | 22.1 | 46 | $C_8H_8Br_3N_4In$ | 18.6 | 1.6 | — | 22.2 | 46.6 | 97.3 | >240 |

* Low carbon value was obtained.

Table 2: Infrared Spectra

| Compound | cm$^{-1}$ | $\Delta v$ (cm$^{-1}$) | Ref. |
|---|---|---|---|
| Ph$_3$PO | 1195 | — | 8 |
| InCl$_3$, 2Ph$_3$ PO | 1170 | 25 | |
| InBr$_3$, 2Ph$_3$ PO | 1170 | 25 | |
| DiPhOS oxide | 1190 | — | 9 |
| InCl$_3$, DiPhOS oxide | 1160 | 35 | |
| Ph$_3$SO | 1040 | — | |
| | | } | 13 |
| Me$_3$SO | 1055 | — | |
| InCl$_3$, 3Ph$_2$SO | 970 | 70 | |
| InBr$_3$, 3Ph$_2$SO | 980 | 60 | |
| | 960 | 80 | |
| InCl$_3$, 4Me$_2$ SO | 1040 | 15 | |

Table 3: Conductivities in Different Solvents

| Compound | —— o Ohm$^{-1}$ Cm$^{1}$ | | | |
|---|---|---|---|---|
| | Acetonitrile (150)$^{11}$ | PhNO$_3$ (20–40)$^{11}$ | MeNO$_3$ (70–120)$^{11}$ | DMF (70–100)* |
| MePh$_3$PI | — | — | — | 60–100* |
| InCl$_3$, 2(o-Phen.), 2H$_2$0 | — | — | — | 83 |
| InBr$_3$, 2(0-Phen.), 2H$_2$0 | — | — | — | 83 |
| InCl$_3$, 1.5(o-Phen.) | — | — | — | W |
| InBr$_3$, 1.5(o-Phen.) | — | — | — | W |
| InCl$_3$, DM-o-Phen. | W | W | — | W |
| InBr$_3$, DM-o-Phen. | W | W | — | W |
| InCl$_3$, 1.5(bipy.) H$_2$O | W | — | W | — |
| InCl$_3$, 2(bipy), 2H$_2$O | W | W | W | — |
| InBr$_3$, 1.5 (bipy.) | W | 30.6 (s) | W | — |
| InCl$_3$, 1.5 (DM-bipy.) | W | — | — | — |
| InBr$_3$, (DM-bipy.), EtOH | 151 (s) | — | — | — |
| InCl$_3$, 2,2', 2"-tripy. | — | — | — | 104 (s) |
| InBr$_3$, 2,2', 2"–tripy. | — | — | — | W |

* Values for the molar conductivities of millimolar solution of 1:1 electrolytes in these solvents.

Where s = strong and W = Weak electrolytes.

Table 4: Molecular Weights Determinations of some Indium (III) Complexes

| Compound | Mobs | Mcal | F | Solvent |
|---|---|---|---|---|
| InCl$_3$, 2Ph$_3$PO | 135 | 777.83 | 5.76 | DMF |
| InBr$_3$, 2Ph$_3$PO | 188 | 911.15 | 4.85 | DMF |
| InCl$_3$, o-Phen. | 200 | 401.4 | 2 | DMF |
| InCl$_3$, 1.5-o-Phen. | 434 | 491.5 | 1.1 | DMF |
| InCl$_3$, 2-o-Phen, 2H$_2$O | 212 | 617.65 | 2.9 | DMF |
| InBr$_3$, o-Phen | 270 | 543.7 | 1.9 | DMF |
| InBr$_3$, 1.5-o-Phen | 454 | 624.86 | 1.38 | DMN |
| InBr$_3$, 2-o-Phen., 2H$_2$O | 227 | 750.97 | 3.3 | DMF |
| InCl$_3$, DM-o-Phen. | 229 | 429.46 | 1.88 | DMF |
| InCl$_3$, 2,2', 2"-tripy. | 294 | 454.44 | 1.55 | DMF |
| InBr$_3$, 2,2', 2"-tripy. | 227 | 587.81 | 2.6 | DMF |
| InCl$_3$, 1.5-bipy., H$_2$O | 380 | 491.5 | 1.3 | Acentonitrile |
| InCl$_3$, 2-bipy., 2H$_2$O | 208 | 569.57 | 2.7 | Acentonitrile |
| InBr$_3$, 1.5-bipy. | 212 | 588.8 | 2.7 | Acentonitrile |
| InCl$_3$, 1.5-DM-bipy. | 450 | 497.55 | 1.1 | Acentonitrile |
| InBr$_3$, DM-bipy., EtOH | 493 | 556.7 | 1.13 | Acentonitrile |

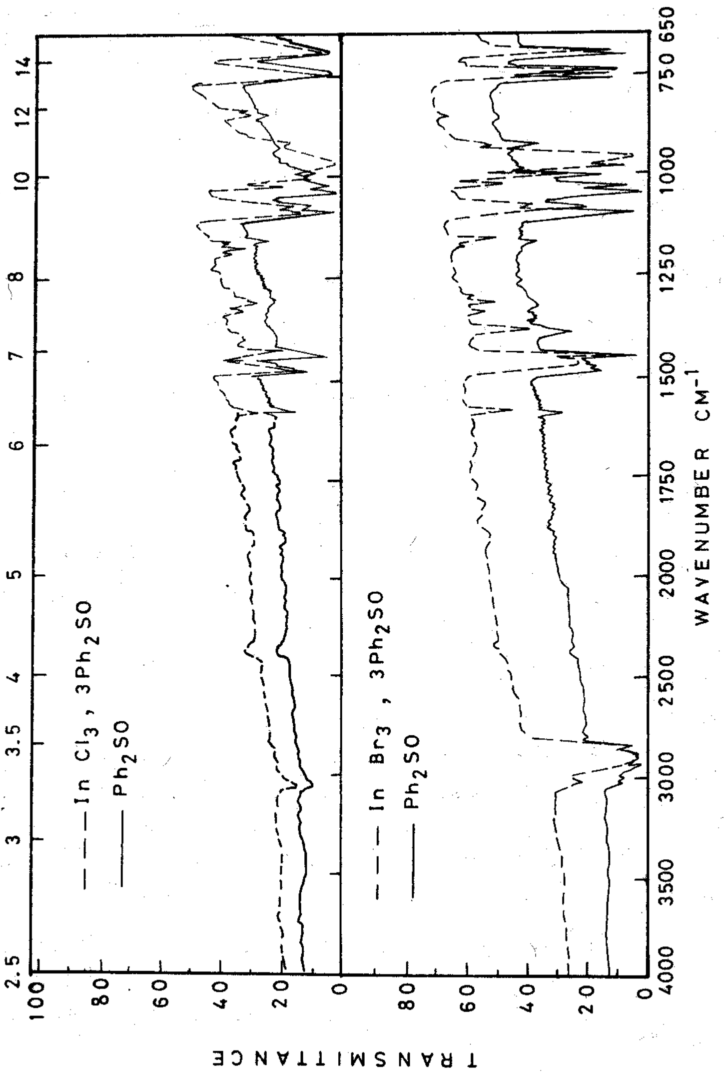

Fig.(1) The infrared spectra of diphenyl sulphoxide adducts.

*Molecular Weights.* The molecular weights of some adducts of indium trichloride and tribromide have been determined in DMF and acetonitrile (Table 4).

The dissociation factors, F, show that the addition compounds $InCl_3$, 1.5L (L = o-Phen., DM-bipy.) and $InBr_3$, DM-bipy

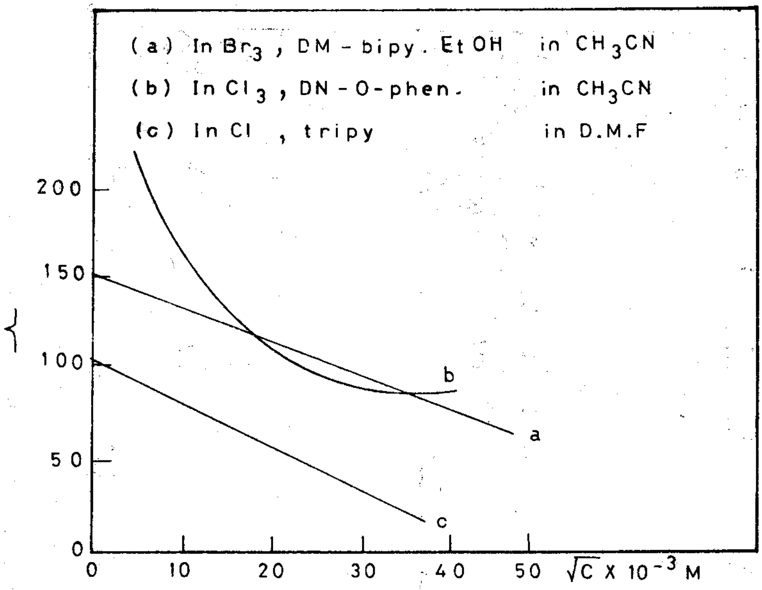

Fig. (2) The relationship between the conductivity and conc. of some indium (III) complexes.

EtOH are all monomers within the limits of the experimental error. Apart from these adducts, all the other indium trichloride and tribromide complexes undergo some dissociation in organic solvents. This lability is presumably due to the comparable stabilities of 4-, 5-, and 6- coordinate states of indium (III).

The overall conclusion from these studies is that the molecular weight determination imply a more complete dissociation than do the conductometric results for the indium (III) complexes. Similar results are reported-.

*Thermal Stability.*- The compound $In(NO_3)_3, 3H_2O$-- was reported to loose 2 moles of water at 100°C, whereas $In(NO_3)_3.4.5 H_2O$-- was said to be dehydrated completely at this temperature. Thermogravimetric analysis of $In(NO_3)_3$-$5H_2O$ shows that a complex series of changes occur on heating which were illustrated by the equations

## Table 5: Thermal Decomposition of Some Indium (III) Complexes

| Temp. (°C.) | Mobs. | Formula | Mcal. |
|---|---|---|---|
| $InCl_3$, $3H_2O$ | | | |
| 25 – 200 °C | 275.2 – 212.1 | | 275.22 – 212.1 |
| 200 – 300 | 207 | $In(OH)_2Cl,H_2O$ (A) | 202.3 |
| 300 – 440 | 185.0 | $IN(OH)_2Cl$ (B) | 184.3 |
| 440 – 460 | 110 | In | 114.8 |
| $In(NO_3)_3$, $5H_2O$ | | | |
| 25 – 105 °C | 390.8 – 370 | $In(NO_3)_3,4H_3O$ (I) | 372.8 |
| 140 – 165 | 262 | $In(NO_3)_2O_2H_2O$ (II) | 264 |
| 165 – 200 | 188 | $InO(NO_3)$ (III) | 192 |
| $InBr_3$, $2Ph_3PO$ | | | |
| 25 – 200 °C | 911.1 | $InBr_3,2Ph_3PO$ | 911.1 |
| 400 | 110 | In (c) | 114.8 |
| $InCl_3,3Ph_2SO$ | | | |
| 25 – 200 | 828 – 813 | $InCl_3$, $3Ph_2SO$ | 828 |
| 550 °C | 163 | InOCl | 165.5 |
| $InCl_3$, 4DMSO | | | |
| 25 – 100 | 533.47 | $InCl_3$, 4DMSO | 533.47 |
| 350 – 450 | 2.10 | $InCl_3$ (d) | 221.1 |
| 550 – 800 | 170 | InOCl (E) | 165.5 |
| $InCl_3$, 1.5(o-phen) | | | |
| 25 – 450 | 491.5 – 398.5 | $InCl_3$, o-phen | 491.5 – 401.4 |
| 750 | — | Volalite | — |
| $InCl_3$, 2(o-phen)$2H_3O$ | | | |
| 25 – 200 | 617.65 | $InCl_3$, 2(o-phen) $2H_2O$ | 617.65 |
| 770 | 580 | $InCl_3$, 2(o-phen) | 581.65 |
| 750 | 170 | InOCl (f) | 165.5 |
| $InBr_3$, 2-o-phen,$2H_2O$ | | | |
| 25 – 200 | 750.97 | $InBr_3$,2-o-phen,$2H_2O$ | 750.97 |
| 300 | 713.4 | $InBr_3$,2-o-phen, (G) | 714.97 |
| 750 | 112 | In (H) | 114.82 |
| $InCl_3$(DM-o-phen) | | | |
| 25 – 400 | 429 – 395 | $InCl_3$(DM-o-phen). | 429 |
| 750 | 110 | In (I) | 114.8 |
| $InBr_3$, (2,2,2"-tripy) | | | |
| 25 – 300 | 587.81 | $InBr_3$(2,2,2"-tripy) | 587.81 |
| 650 – 800 | 118 | In (j) | 114.8 |
| $InCl_3$(2,2,2"-tripy) | | | |
| 25 – 300 | 454.5 | $InCl_3$,2,2',"-tripy | 454.5 |
| 650 | 210 | $InCl_3$ (k) | 221.19 |
| $InCl_3$, 1.5 bipy, $H_2O$ | | | |
| 25 – 100 | 473.47 | $InCl_3$, 1.5 bipy, $H_2O$ | 473.47 |
| 700 °C | 175 | InOCl (L) | 165.5 |
| $InCl_3$, 2(bipy) $3H_2O$ | | | |
| 25 – 200 | 587.6 | $InCl_3$, 2bipy, $3H_2O$ | 587.6 |
| 350 | 520 | $InCl_3$, 2bipy, (M) | 516 |
| 600 | 270 | $In_3O_3$ (N) | 277 |
| $InCl_3$ $(bipy)_3$ $2H_2O$ | | | |
| 25 – 100 °C | 569.57 | $InCl_3$, 2 (bipy) $2H_2O$ | 569.57 |
| 200 | 533.97 | $InCl_3$, 2 bipy (O) | 533.57 |
| 240 – 300 °C | 462.8 | $InCl_3$, 1.5. bipy (P) | 455 |
| 450 – 500 °C | 320.4 | InOCl, bipy (Q) | 321.7 |
| 600 °C | 275.9 | $In_3O_3$ | 277 |
| ($InBr_3$, 1.5 bipy) | | | |
| 25 – 100 °C | 588.8 | $InBr_3$, 1.5 bipy | 588.8 |
| 700 | — | Volatile. | — |
| $InBr_3$,DM-bipy EtOH | | | |
| 25 – 100 °C | 584.8 – 570 | $InBr_3$,DM-bipy,EtOH | 584.8 |
| 200 – 300 °C | 533 | $InBr_3$,DM-bipy (R) | 538.8 |
| 650 °C | 215 | InOBr (S) | 211 |
| $InCl_3$, 1.5 (DM-bipy) | | | |
| 25 – 100 | 497.5 – 486.7 | $InCl_3$, 1.5 (DM-bipy). | 497.55 |
| 300 – 400 | 405 | $InCl_3$, DM-bipy.(T) | 405.4 |
| 650 °C | 160 | InOCl | 165.5 |

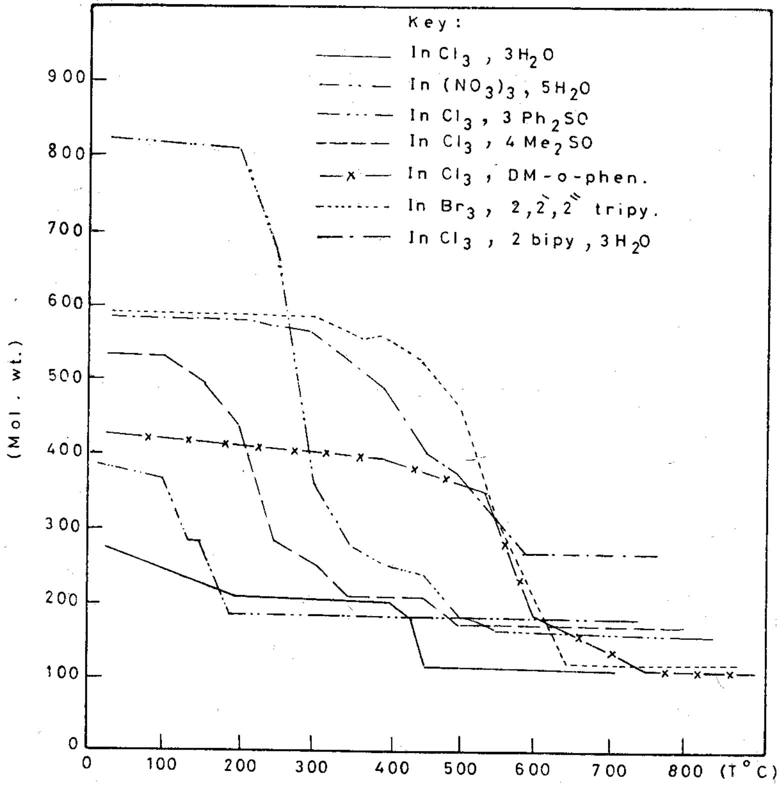

Fig. (3) Thermal decomposition of some indium (III) complexes.

$$\mathrm{In(NO_3)_3,\ 5H_2O} \xrightarrow{20\text{–}105^\circ C} \underset{(I)}{\mathrm{In(NO_3)_3.4H_2O}} \xrightarrow{140\text{–}165^\circ C}$$

$$\mathrm{InO(NO_3)}\ (III)\ \overline{\text{above } 200^\circ C}\ \underset{(II)}{\mathrm{In(NO_3)_3.01/2H_2O}}$$

The final product is indium oxynitrate.

The present work showes that indium (III) compounds decompose on heating up to 800°C. The molecular weights of the intermediate compounds are calculated from the graphs. The final products, as indicated in Table 5, are usually In, $In_2O$, InOX (X = Cl or Br), or InO ($NO_3$) as shown in Fig. 3.

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