

*Full Paper*

## **Preparation, Characterization of a New Fast Ionic Conductor [Ag<sub>2</sub>CdI<sub>4</sub>:0.x AgI]**

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**Abstract-** An experimental attempt was made to characterize A new composite fast ionic systems, [Ag<sub>2</sub>CdI<sub>4</sub>:0.x AgI] (x=0.2, 0.4, 0.6 mol. wt. %), were prepared, using [Ag<sub>2</sub>CdI<sub>4</sub>] mixed composite system as the host. [Ag<sub>2</sub>CdI<sub>4</sub>] compound belongs to the fast ion conductors of A<sub>2</sub>BX<sub>4</sub> (A=Ag, Cu, B=Hg, Cd, Zn, Pb and others. The compound [Ag<sub>2</sub>CdI<sub>4</sub>] becomes superionic near 388K as the crystal lattice changes from a tetragonal to a hexagonal structure. Near 445 K, [Ag<sub>2</sub>CdI<sub>4</sub>] is replaced by an equilibrium mixture of  $\alpha$ -AgI and CdI<sub>2</sub>. At each of these phase transition, ionic conductivity increases by an order of magnitude or more. The substitution of Cd<sup>2+</sup> from Ag<sup>+</sup> in [Ag<sub>2</sub>CdI<sub>4</sub>] is accompanied by a slight increase in the room temperature conductivity, as a result of either increased crystalline defects or an increased Ag<sup>+</sup> substitution also characterized.

X-ray powder diffraction, FTIR and Thermal (DTA, DSC, TGA) analyses were performed to confirm the formation of fast ion conductors [Ag<sub>2</sub>CdI<sub>4</sub>:0.x AgI].

**Keywords-** Electrical Conductivity, X-ray Diffraction, Thermal Analysis, Doping, Fast Ion Conductors, etc

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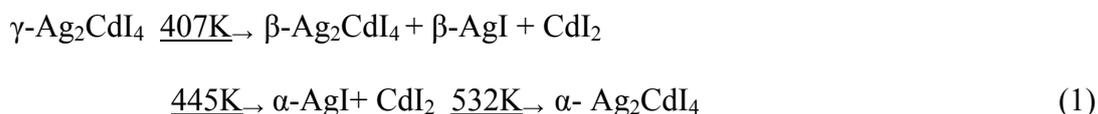
### **1. INTRODUCTION**

Studies on fast ionic conductors are interested not only for their great variety of technological applications such as electrochemical power sources, optical devices, lasers, fuels and double layer capacitors but also from the fundamental necessity to understand the

fast ionic behavior and to explore the possibility to improve the properties of such compounds [1]. Solid fast ion conductors are characterized by very high ionic conductivity, either anionic or cationic relative to the ionic conductivity of most crystalline solids [2]. This relatively small group of solids, also known as solid electrolytes, has a specific ion which is not confined to specified lattice sites but essentially free to move throughout the three dimensional structures [3]. The ternary solid electrolytes  $M_2NI_4$  ( $M=Ag,Cu$ ;  $N=Hg,Cd$ ) undergoes a phase transition at moderate temperatures. The temperature phase is characterized by the cation orientational disorder and an enhanced cationic mobility [2].

This paper is a part of our investigation on the synthesis, and characterization of  $Ag^+$  cation substituted  $[Ag_2CdI_4]$ . The fast ion conductor  $[Ag_2CdI_4]$  exhibits a number of solid state phase transition upon heating [4]. Room temperature covalent phase  $\gamma$ - $Ag_2CdI_4$  crystallized in a well defined tetragonal structure.

At heating of  $Ag_2CdI_4$  the next consequence of structural transitions is observed [5].



Hexagonal  $\beta$ - $Ag_2CdI_4$  is metastable. Others investigation show complex dependencies of thermal, electrical and optical properties of  $Ag_2CdI_4$  in 90-410 K temperature region [6].  $[Ag_2CdI_4]$  compounds possess smeared phase transition into the superionic state in the temperature region 330-380K [7]. Room temperature, covalent phase  $[Ag_2CdI_4]$  crystallized in a well defined structure.  $[Ag_2CdI_4]$  at  $T=330$  K belongs predominantly to hexagonal,  $\beta$ - $Ag_2CdI_4$  with space group  $P6/mmm$  and unit cell dimensions  $a=4.578$  and  $c=7.529\text{\AA}$  and changes to cubic at  $T > 380K$  with space group  $Pm3m$  and unit cell dimension  $a=5.05\text{\AA}$  [8]. The hexagonal  $\beta$ - $Ag_2CdI_4$  phase, is found to contain significant quantities of  $\beta$ - $AgI$  with increasing temperature,  $\beta$ - $AgI$  transforms to the  $\alpha$ -phase. Finally, near 445K, all  $\beta$ -phase  $Ag_2CdI_4$  vanishes in favor of an equilibrium mixture of  $\alpha$ - $AgI$  and  $CdI_2$ . [9].

Electrical measurements performed on polycrystalline samples of  $Ag_2CdI_4$  suggest an increase in ionic conductivity by almost two orders of magnitude at the  $\gamma$ -  $\beta$  phase transitions with a similar increase near 445 K when  $\beta$ - $Ag_2CdI_4$  vanishes [10,11]. Chemical substitution has been used extensively in recent years to modify either the magnitude of ionic conductivity or the transition temperature separating super ionic and covalent phases in various solid electrolytes. Anion substitution in the fast ion conductors  $AgI$ ,  $Ag_3SI$  and  $Ag_3SBr$ , for example, have been found to either raise or lower ionic conductivities and to either raise or lower ionic conductivities and to either raise or lower phase transition temperature, depending upon the specific substitute anion [12-16]. By contrast, cation substitute have typically been found to modify ionic conductivities while leaving the phase transition temperatures unchanged [17,18].

In, the present investigation, we seek to determine the effect of silver substitution on the ionic conductivity and phase transitional characterization of  $\text{Ag}_2\text{CdI}_4$ .

## 2. Experimental Procedure

### 2.1. Material

The following materials were used as received; silver iodide and  $\text{cd}^{2+}$  iodide were of CDH anal grade, each of which had a purity of 99%, 99% respectively.

### 2.2. Preparation and characterization of pure and doped samples

#### 2.2.1. Preparation of pure $[\text{Ag}_2\text{CdI}_4]$ host sample

Silver tetraiodocadmiate  $[\text{Ag}_2\text{CdI}_4]$  was prepared by the solid state reactions method between AgI and  $\text{CdI}_2$ . AgI and  $\text{CdI}_2$  were mixed in the requisite composition in an Agate mortar (each above 300-mesh size). The finely ground stoichiometric mixture of the binary components AgI and  $\text{CdI}_2$ ; was sealed in a glass ampoule and was placed in an air oven (CE 0434 NSW-144) at  $150^\circ\text{C}$  (423 K) for 5 days (120 h) with intermittent grinding. The rate of heating was initially kept at  $50^\circ\text{C}$  per hours for 12 h. A light lemony yellow color compound was formed which changed to dark lemony yellow on cooling,  $\text{Ag}_2\text{CdI}_4$  is dark lemony yellow above  $57\text{--}107^\circ\text{C}$  [19]. X-ray diffraction studies showed this light lemony yellow color compound to be single phase  $\beta$ -  $\text{Ag}_2\text{CdI}_4$ .

#### 2.2.2. Preparation of doped sample $[\text{Ag}_2\text{CdI}_4:0.x \text{ AgI}]$

Doped composite fast ion conductors were prepared by adding AgI to the host,  $\text{Ag}_2\text{CdI}_4$ .  $[\text{Ag}_2\text{CdI}_4:0.x \text{ AgI}]$  solid solutions was prepared by mixing 1 mol. wt.%  $\text{Ag}_2\text{CdI}_4$  and  $x=0.2, 0.4, 0.6$  mol. wt.% AgI respectively, in an agate mortar at room temperature with intermittent grinding adopting the procedure reported earlier [20], in different ratios of  $x$  ( $x=0.2, 0.4, 0.6$  mol. wt.%), mixed thoroughly in an agate mortar at room temperature using previously reported procedures [21]. The powder mixture, were ground thoroughly in an agate mortar and collected in a silica crucible which is then kept in an air oven (CE 0434 NSW- 144) for 24 h at  $150^\circ\text{C}$ . The resulting material at room temperature was used for further studies [22].

### 2.3. Characterization of pure and doped samples

#### 2.3.1. Electrical conductivity measurements

Specific conductivity as a function of temperature was measured on pellets (2.4 cm diameter, 0.1 cm thick) prepared by pouring the requisite amount of the compound into a stainless steel die at a pressure of  $5 \text{ tons cm}^{-2}$  using a hydraulic press (Spectra Lab Model SL-89). In effect of pressure on pellets was also studied prior to making measurements, samples were cycled to above and below the transition temperature two or three times in order to

relieve strains and improve their homogeneity. Conductivity measurements were measured using the two probe method. The pellet was mounted on a stainless steel sample holder assembly between copper leads using two polished platinum electrodes. The copper leads were electrically insulated by Teflon sheets. The electrical conductivity of samples in the temperature range of 25°-250°C was measured by a Gen Rad 1659 RLC Digibridge at different frequencies (1 kHz) at 30 min intervals. The rate of heating was maintained at 1°C min<sup>-1</sup> [23].

### 2.3.2. X-ray powder diffraction

The X-ray diffraction studies were performed for the pure hosts [Ag<sub>2</sub>CdI<sub>4</sub>] and the mixed composite systems [Ag<sub>2</sub>CdI<sub>4</sub>:0.x AgI] after the reaction was completed using Rigaku-ultima D/Tex-25 with a K-beta filter with CuK $\alpha$  ( $\lambda=1.5406$  Å) radiation at room temperature. The angle range for measurement was 10–70° and the scanning speed was 1°/min. X-ray diffraction patterns suggest the formation of the product Ag<sub>2</sub>CdI<sub>4</sub> and doped [Ag<sub>2</sub>CdI<sub>4</sub>:0.x AgI] samples

### 2.3.3. Thermal analysis

Differential thermal analysis (DTA), Differential scanning calorimetry (DSC) and Thermo-gravimetric analysis (TGA) was done by DTG-60H thermal analyzer in nitrogen atmosphere with flow rate of 30 mL min<sup>-1</sup> and heating rate 25°C min<sup>-1</sup> in the temperature range 20°- 400°C. The reference used was 10 mg alumina powder.

## 3. Results and discussion

### 3.1. Conductivity studies

#### 3.1.1. Temperature dependence of conductivity

The temperature dependence of conductivity is given by the Arrhenius expression. The equation can be written in a simpler form as;

$$\sigma_{\text{ionic T}} = \sigma_0 \exp(-E_a / kT) \quad (2)$$

Where  $\sigma_0$  is the pre-exponential-factor of the ionic conductivity,  $k$  the Boltzmann constant,  $T$  the absolute temperature and  $E_a$  is the activation energy for the ionic conductivity [21].

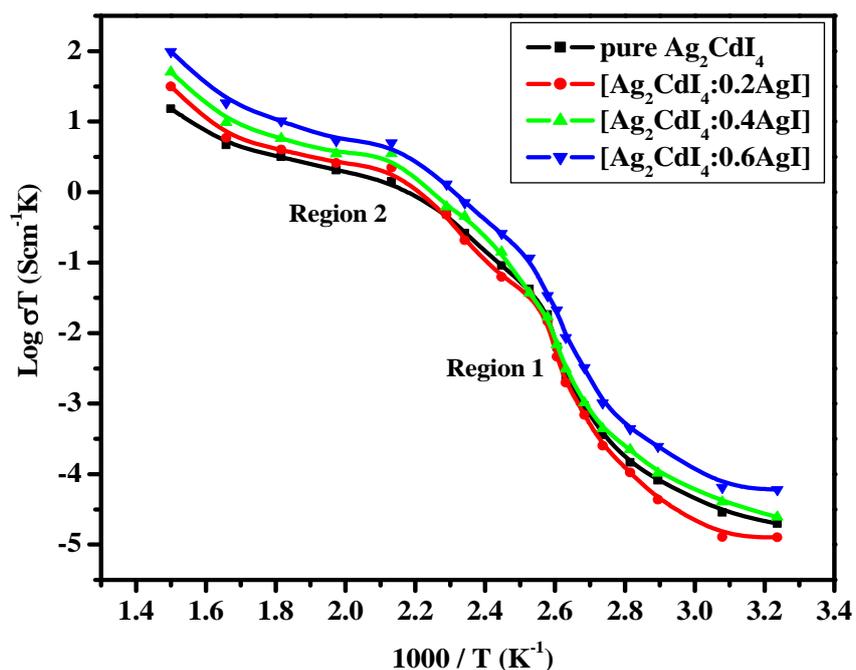
The temperature dependence of the conductivity is shown in Fig. 1 for pure and all the Ag<sup>+</sup> doped composite samples [Ag<sub>2</sub>CdI<sub>4</sub>:0.x AgI], (where  $x=0.2, 0.4, 0.6$  mol. wt.%) respectively.

The conductivity values of undoped Ag<sub>2</sub>CdI<sub>4</sub> were found to have increased slowly initially but a sharp increase in conductivity was noted above 395 K.

Electrical conductivity ( $\sigma$ ), measurements were performed on several  $\text{Ag}^+$  doped  $\text{Ag}_2\text{CdI}_4$  sample throughout the temperature range 298-523 K. Arrhenius plot of pure  $\text{Ag}_2\text{CdI}_4$  shows gradual increase in conductivity up to 380 K and above this temperature a sharp change in conductivity indicates the occurrence of phase transition at 380 K (Fig. 1) [24,25]. The conductivity increase observed in the present investigation can be explained on the basis of the space charge model reported by Maier *et al.* [26]. In thermal equilibrium, the surface and grain boundaries of an ionic crystal may carry an electric charge resulting from the presence of excess ions of one sign. This charge is just compensated by a space charge cloud of the opposite sign adjacent to the boundary. For a pure material, this charge arises if the energies to form anion and cation vacancies or interstitials at the boundary are different. The magnitude and sign of the boundary charge changes if there are aliovalent solutes present in the matrix which alter the concentration of the lattice defects in the crystal. Space charge effects will be predominantly important in very small crystals since the grain boundaries contain a large number of defects compared to the coarser grained polycrystalline materials [27].

The  $\log\sigma T$  vs.  $1/T$  plot shift from lower temperatures to high temperatures is responsible for the respective color change of  $\text{Ag}_2\text{CdI}_4$  and is associated with a charge transfer process between electron levels of Hg and I. These observed change in the phase transition can be explained by assuming an increase of the interaction between I and Ag atoms above the phase transition, and consequent decrease of the I-----Hg interaction. These changes would be induced by a decrease of the Ag-----I distance above the phase transition, as a consequence of a structural distortion, consequently the Hg-----I distance would increase and lead to the observed changes in pure  $\text{Ag}_2\text{CdI}_4$  [20].

$\text{Ag}^+$  ion was chosen as the dopant with the expectation that it would enhance the conductivity of  $\text{Ag}_2\text{CdI}_4$  on the basis of Frenkel defects dominate the electrical conductivities in Ag halides so more defects formed on further doping in host and transition shift to higher temperature, therefore in mixed system [ $\text{Ag}_2\text{CdI}_4:0.2 \text{AgI}$ ], one may expect the fraction of mobile charge carriers,  $\text{Ag}^+$  increases leading to Ag-----I distance decreases and so phase transition shift to high temperature, on further doping of  $\text{Ag}^+$  ions in the host [ $\text{Ag}_2\text{CdI}_4$ ], the fraction of mobile charge carriers,  $\text{Ag}^+$ , increases proportionately leading to Ag-----I distance decrease and so phase transition shift to high temperature with increased  $x=0.4$ ,  $x=0.6$  ratio  $\text{Ag}^+$  increases in the host system [ $\text{Ag}_2\text{CdI}_4$ ], therefore increased in ionic conductivity and activated up-to  $T_c$  in  $x=0.4$ ,  $x=0.6$  ratio  $\text{Ag}^+$  increases, but due to most of the defects occupied by  $\text{Ag}^+$  ions in host [ $\text{Ag}_2\text{CdI}_4$ ], phase transition shift to higher temperature [28].



**Fig. 1.** Log  $\sigma T$  vs.  $(1/T)$  plots for fast ionic systems,  $[\text{Ag}_2\text{CdI}_4:0.x \text{ AgI}]$  where  $(x = 0.2, 0.4, 0.6 \text{ mol. Wt})$

**Table 1.** Comparisons of ionic conductivity activation energy values for pure and doped host composite  $[\text{CdHgI}_4:0.2 \text{ AgI}]$  system

Sample	Temperature range (K)	Activation Energy (eV)
Pure $[\text{Ag}_2\text{CdI}_4]$	303-383	0.7476
	383-463	0.9320
	463-523	0.2190
$[\text{Ag}_2\text{CdI}_4:0.2\text{AgI}]$	303-383	0.7994
	383-463	1.0455
	463-523	0.3343
$[\text{Ag}_2\text{CdI}_4:0.4\text{AgI}]$	303-383	0.7291
	383-463	1.0942
	463-523	0.3457
$[\text{Ag}_2\text{CdI}_4:0.6\text{AgI}]$	303-383	0.7820
	383-463	0.9760
	463-523	0.3934

The existence of different regions in the  $\log\sigma T$  vs.  $1/T$  plot of pure and  $\text{Ag}^+$  doped samples, above 450 K is an interesting feature as shown in Fig. 1. Above the phase transition temperature the conductivity data showed clearly two linear regions. The increase of the slope from region I to region II occurred at about 450K. The region I (395-450 K) is associated with higher activation energy and a lower conductivity whereas; region II (450-520 K) is associated with lower activation energy and higher conductivity.

$$E_a = \Delta H_{\text{migration}} + \frac{1}{2} \Delta H_{\text{defect formation}} \quad (3)$$

Since the higher activation energy in the range 395-450 K might be due to the defect formation enthalpy contribution. The range 440-520 K could be identified as the region where all the carrier ions are free and therefore, the enthalpy of activation could be related to migration enthalpy of ions only.

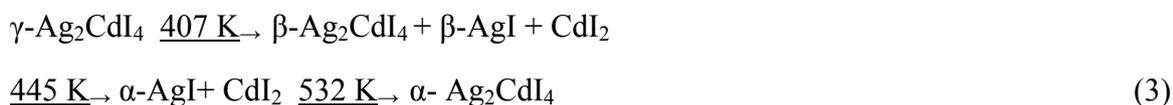
Ionic conduction is determined by thermally activated defect. The increase of conductivity up-to 450 K can be attributed to the extra enhancement of  $\bar{I}$  orientational disorder. Upon cooling, however, the higher conductivity was regained. This argument of lattice collapse and its subsequent recovery on cooling implies restructuring of the sublattice. [29].

### 3.1.2. Compositional variation in conductivity

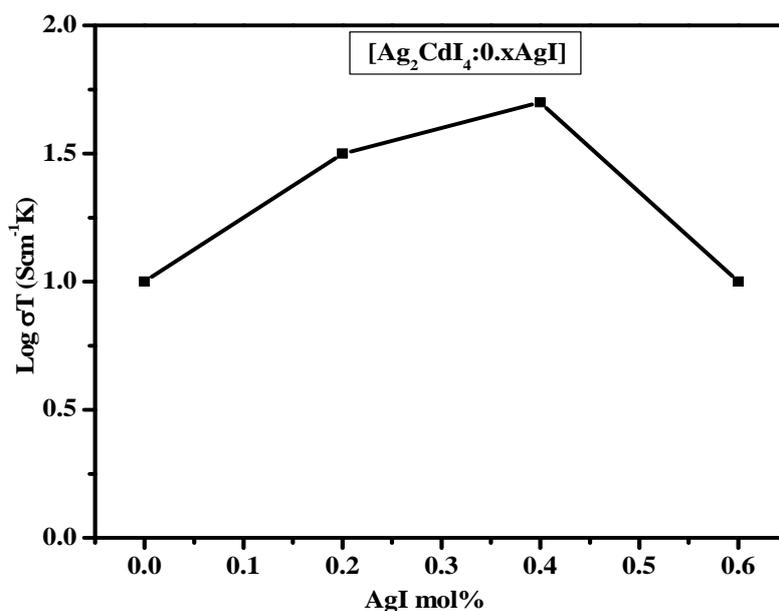
The variations in the conductivity as a function of 0.x mol. wt.% of AgI in the mixed composite system  $[\text{Ag}_2\text{CdI}_4:0.x \text{ AgI}]$ , at 250°C temperatures are shown in Fig. 2.

Maximum conductivity values for a composition of  $x=0.4$  mol. wt. % AgI are obtained. As this conductivity values is higher than that of the parent compounds i.e., AgI and  $\text{M}_2\text{HgI}_4$ , the possibility of the formation of some new intermediate compounds, at this composition may be concluded. [30].

In all the composition there is a jump in conductivity at around 423 K which may be due to the characteristic transition temperature ( $\beta$ - $\alpha$ ) of AgI, formed as one of the reaction products. The proposed reaction in the solid-state for the system  $\text{Ag}_2\text{CdI}_4$  may be written as:



This is consistent with the reaction proposed by S. Hull et. al. [5].  $(\text{M}, \text{Ag})\text{HgI}_4$  (where  $\text{M}=\text{Ag}, \text{Cu}$  and  $\text{Cd}$ ), possibly a new compound formed in the above reaction with a disordered structure may be responsible for the enhancement in the electrical conductivity in the case of compositions 0.4 mol% of AgI.



**Fig. 2.** Log  $\sigma T$  vs.  $x$  plots for fast ionic systems,  $[\text{Ag}_2\text{CdI}_4:0.x \text{AgI}]$  where ( $x=0.2, 0.4, 0.6$  mol. wt. %)

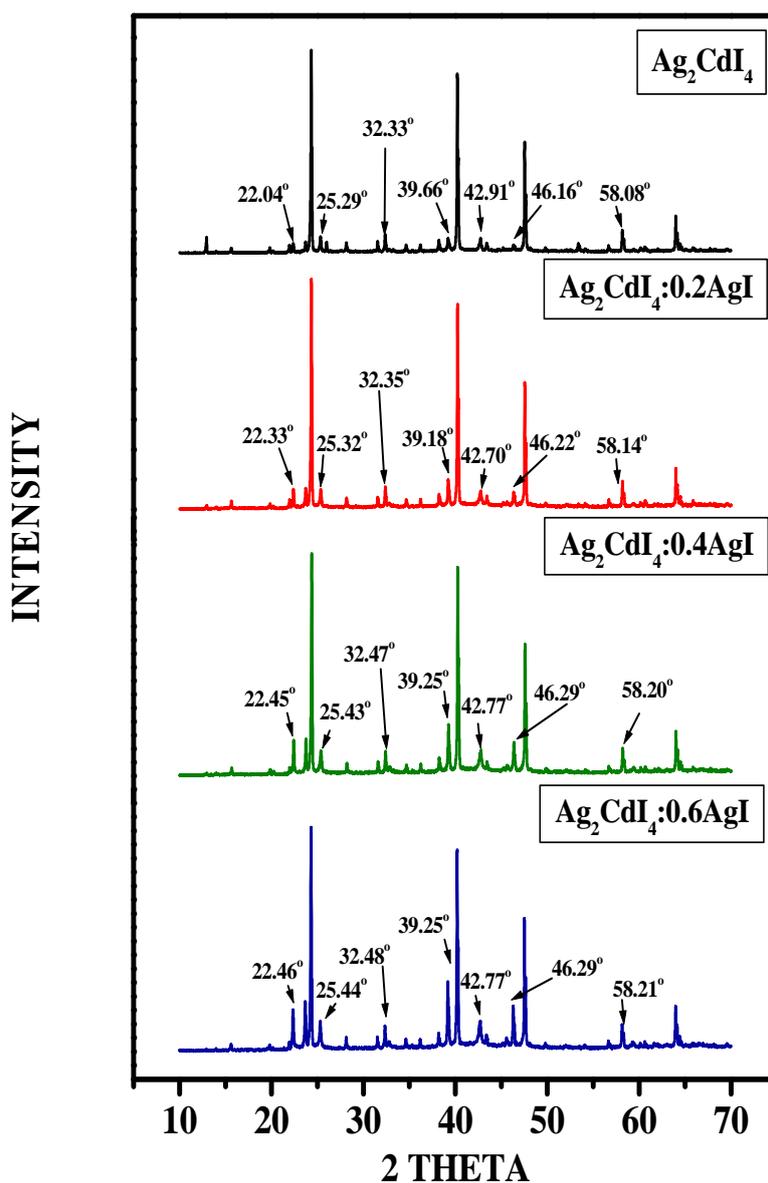
Further increase in the concentration of AgI results in the decrease in conductivity which may be due to the formation of some other low conducting substance in addition to  $\beta\text{-Ag}_2\text{CdI}_4 + \beta\text{-AgI} + \text{CdI}_2$ . In samples having low concentration of AgI, there is also an increase in conductivity than the parent compounds which may be attributed to the formation of  $\alpha\text{-AgI} + \text{CdI}_2$  by the higher concentration of  $\text{Ag}_2\text{CdI}_4$  consuming AgI appreciably.

Thus the best conductivity observed in the case of  $x=0.4$  mol. % AgI can be attributed to the possible disordered phase [31].

### 3.2. X-ray diffraction

X-ray diffraction patterns for pure host  $[\text{Ag}_2\text{CdI}_4]$ , and doped samples of  $[\text{Ag}_2\text{CdI}_4:0.x \text{AgI}]$ , recorded at room temperature are shown in Fig. 3, at room temperature. The X-ray diffractogram values of all the composite samples  $[\text{Ag}_2\text{CdI}_4:0.x \text{AgI}]$ , correspond to standard values of  $[\text{Ag}_2\text{CdI}_4]$  and careful analysis revealed that in addition to standard peaks of pure host  $[\text{Ag}_2\text{CdI}_4]$ , a number of peaks appeared for the  $\text{Ag}^+$ -doped host composite system.

The appearance of seven tiny peaks (reflections at  $22.04^\circ, 25.29^\circ, 32.33^\circ, 39.66^\circ, 42.91^\circ, 46.16^\circ, 58.08^\circ$ ) observed in pure host, shifted to  $(22.33^\circ, 25.32^\circ, 32.35^\circ, 39.18^\circ, 42.70^\circ, 46.22^\circ, 58.14^\circ)$ ,  $(22.45^\circ, 25.43^\circ, 32.47^\circ, 39.25^\circ, 42.77^\circ, 46.29^\circ, 58.20^\circ)$  and  $(22.46^\circ, 25.44^\circ, 32.48^\circ, 39.25^\circ, 42.77^\circ, 46.29^\circ, 58.21^\circ)$  in the  $x=0.2, 0.4$  and  $x=0.6$  AgI -doped composite systems, respectively, and the corresponding peaks were more intense upon doping.



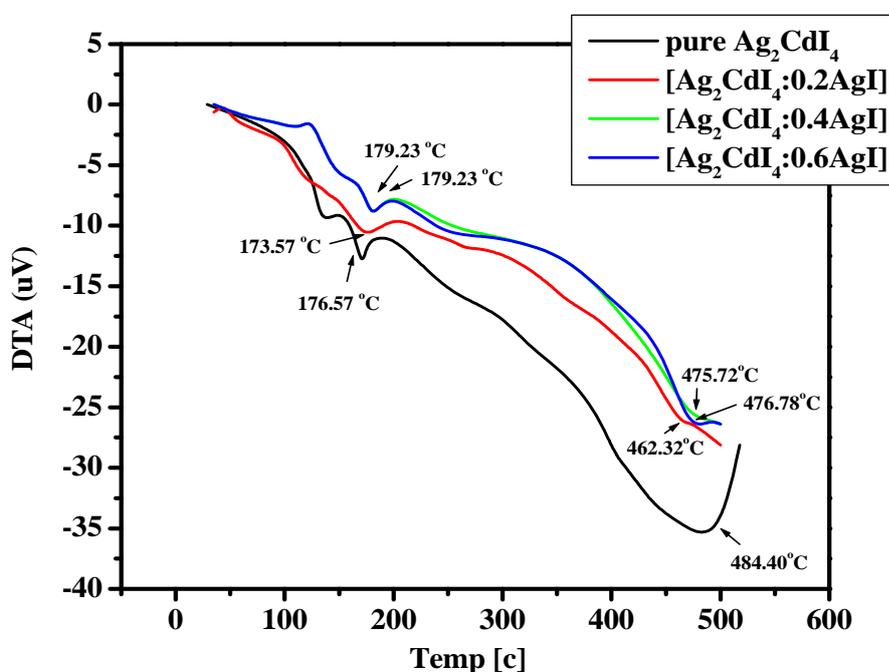
**Fig. 3.** X-ray diffractogram for  $[\text{Ag}_2\text{CdI}_4:0.x \text{ AgI}]$  where  $(x=0.2, 0.4, 0.6 \text{ mol. wt. \%})$  where  $(x=0.2, 0.4, 0.6 \text{ mol. wt. \%})$

The findings indicate a significant structural changes with only small compositional changes [32] in the host composite system  $[\text{Ag}_2\text{CdI}_4]$ , with a gradual increase in AgI respectively. It is therefore concluded that the phase composition is influenced by the presence of the dopant [23,33].

### 3.3. Thermal analysis

#### 3.3.1. Differential thermal analysis

DTA curves for  $[\text{Ag}_2\text{CdI}_4:0.x \text{ AgI}]$ , are shown in Fig. 4. All the DTA curves contained three endothermic peaks, the first endotherm attributed to interface interactions between AgI and  $[\text{Ag}_2\text{CdI}_4]$  [34], second endotherm corresponded to a  $\beta$ - $\alpha$  transition ( $\approx 180.5^\circ\text{C}$  for  $[\text{Ag}_2\text{CdI}_4]$ ) and the third endotherm corresponded to melting of the material [35]. It is observed that, in  $[\text{Ag}_2\text{CdI}_4:0.x \text{ AgI}]$  composite samples, the melting point of pure  $[\text{Ag}_2\text{CdI}_4]$  sample is  $484.40^\circ\text{C}$ , which thereafter decreases to increases as  $462.32^\circ\text{C}$ ,  $476.78^\circ\text{C}$ , and  $475.72^\circ\text{C}$  in 0.2, 0.4 and 0.6 mol. wt.% AgI doped sample, with increasing AgI concentration in host sample. There is clear evidence that the transition temperature shifted to higher temperature as  $\text{Ag}^+$ -dopant concentration increases. This indicate the significant interaction between host  $[\text{Ag}_2\text{CdI}_4:0.x \text{ AgI}]$  system with dopant AgI content.



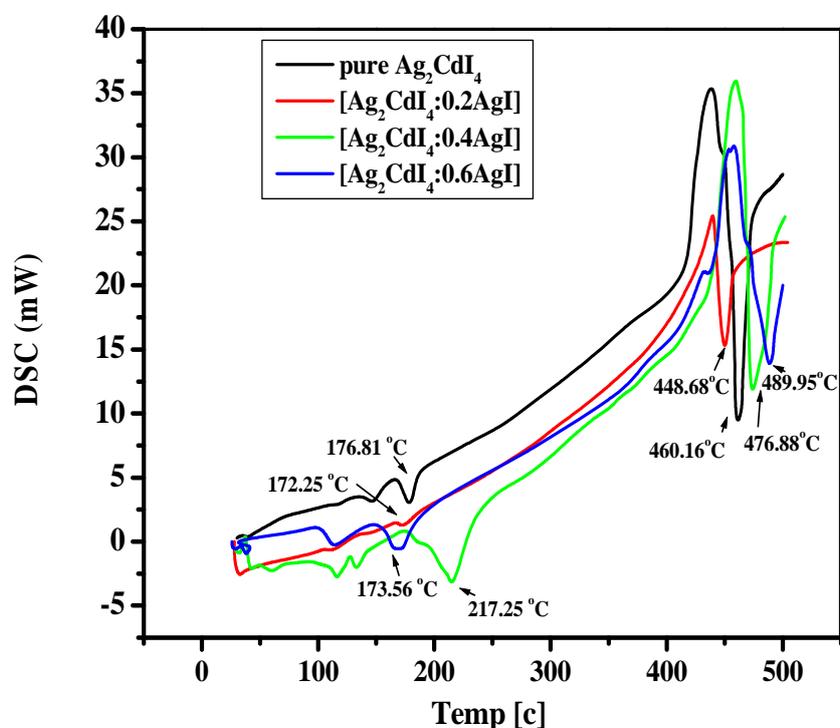
**Fig. 4.** Differential thermal analysis (DTA) curves for mixed composite systems  $[\text{Ag}_2\text{CdI}_4:0.x \text{ AgI}]$  where ( $x=0.2, 0.4, 0.6$  mol. wt. %)

#### 3.3.2. Differential scanning calorimetry

Fig. 5 shows the heating mode of DSC curves of all the  $[\text{Ag}_2\text{CdI}_4:0.x \text{ AgI}]$  composite samples taken in the temperature range  $25$ – $300^\circ\text{C}$ . In the  $[\text{Ag}_2\text{CdI}_4]$  samples, shows the expected behavior with moderate strength peak when it appeared at  $176.81^\circ\text{C}$ , which corresponds to  $\beta$ - $\alpha$  phase transition of the compound [34], and intensive peak at  $460.16^\circ\text{C}$ , which is attributed to melting point.  $\beta$ - $\alpha$  phase transition peak becomes broad with AgI

content; this is due to the form of crystalline phase within space charge layer that is expected to form between AgI and  $[\text{Ag}_2\text{CdI}_4]$ . Melting peak of 0.2 mol. wt.% AgI has a small hump at about  $448.68^\circ\text{C}$  on the low-temperature side of the melting peak, which slightly shifts toward higher temperature side with increase in AgI content in 0.4 and 0.6 mol. wt. % respectively. It has been observed from the DSC curve that an additional peak is obtained before the  $\beta$ - $\alpha$  phase transition peak with the addition of AgI and its intensity increase with the mole fraction of silver iodide. This peak attributed to interface interactions between AgI and  $[\text{Ag}_2\text{CdI}_4]$ .

The mixture samples show no appreciable effect on the temperature of the phase transition:  $\text{RbNO}_3\text{-Al}_2\text{O}_3$  [36],  $\text{CsCl-Al}_2\text{O}_3$  [37], and  $\text{Cs}_2\text{H}_3(\text{SO}_4)_4\text{-SiO}_2$  [38]. This behavior has been observed frequently in the ionic salt oxide composite such as that noticed with an increase in alumina content, the formation of the composite.



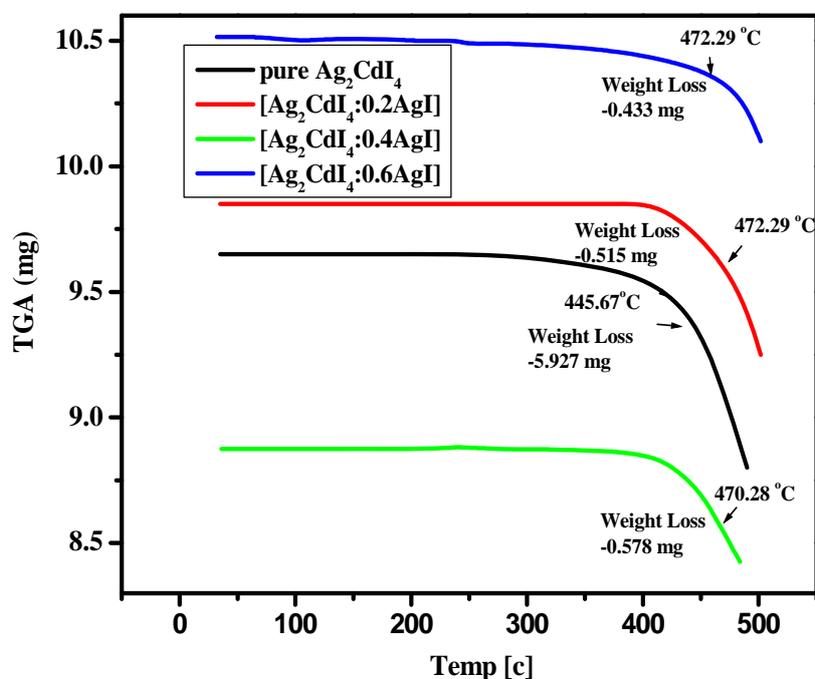
**Fig. 5.** Differential scanning calorimetry (DSC) curves for mixed composite systems  $[\text{Ag}_2\text{CdI}_4:0.x \text{AgI}]$ , where ( $x=0.2, 0.4, 0.6$  mol. wt. %)

### 3.3.3. Thermogravimetric analysis analysis

Phase transition of all the composites were studied by thermogravimetric analysis in the temperature range  $20\text{-}400^\circ\text{C}$  [Fig. 6].

In the TGA curves of  $[\text{Ag}_2\text{CdI}_4:0.x \text{AgI}]$  [Fig. 6], from room temperature up to about  $500^\circ\text{C}$ . One distinct peak of TGA are obtained for the  $[\text{Ag}_2\text{CdI}_4:0.x \text{AgI}]$  in the temperature

range 400–500°C with corresponding mass loss of -5.927 mg for pure sample, -0.515 mg for 0.2 AgI mol. wt.%, -0.578 mg for 0.4 AgI mol. wt. %, and -0.433 mg for 0.6AgI mol. wt.% [39]. These data corroborate the observations of TGA studies.



**Fig. 6.** Thermogravimetric analysis (TGA) curves for mixed composite systems  $[\text{Ag}_2\text{CdI}_4:0.x \text{ AgI}]$ , where  $(x=0.2, 0.4, 0.6 \text{ mol. wt. } \%)$

#### 4. CONCLUSION

A novel composite superionic systems  $[\text{Ag}_2\text{CdI}_4:0.x \text{ AgI}]$ , were investigated. An alternative host salt  $[\text{Ag}_2\text{CdI}_4]$  mixed system was used in place of the traditional host  $\text{Ag}_2\text{CdI}_4$ . The increase of conductivity upto 177°C can be attributed to the extra enhancement of  $\text{I}^-$  orientational disorder. In the host  $[\text{Ag}_2\text{CdI}_4]$  structure, doping with  $\text{Ag}^+$  in the host induces a decrease in the mobile charge carriers,  $\text{Ag}^+$  ions that is proportionate with the increased  $0.x \text{ mol. wt. } \%$  in the host mixed system.

X-ray powder diffraction, DTA, DSC and TGA studies confirmed the formation of a superionic phase in the composite system. The temperature dependence of various ionic parameters was determined to characterize the ion transport properties and doping effect.

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