The partial Substitution for (Bi) instead of (Pb) and studying the Effect on the Electrical Properties of the Superconducting System (BBCCO)

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ABSTRACT

In the current study, we investigate the effect of (Pb) substitution instead of (Bi) on the properties of the superconductor compound ($Bi_{2-x}Pb_xBa_2Ca_{n-1}Cu_nO_{10+\delta}$) with (x=0,0.05,0.1,0.15,0.2). The samples were prepared by solid state reaction method(SSR). X-ray diffraction technique (XRD) was used to estimate the structural properties of the specimens which show an orthorhombic crystalline structure for all the specimens.

X-ray diffraction analysis of the pure and substituted analysis showed that all samples contain a high percentage of high phase (Bi-2223) in addition to some other phases with a few impurities at the end of the chart and an increase in the intensity of the high phase peaks (Bi-2223) .

Keywords: substitution, (Bi-2223) superconductor, structural properties, Critical temperature

1- Introduction:

Many researches were interested in preparing structure and properties of the superconductive compound since the discovery of the high temperature superconductors for the system (Bi-Ba-Ca-Cu-O)(BBCCO)**[1]**.

The Bi-based superconductive systems has layers structure so it consists of three phases including Bi-2201,Bi-2212 and Bi-2223**[2]**.The last number of each phase means the number of layers of CuO which has the critical temperatures (10K,80Kand110K) consequently; the last means the temperature at which the electrical resistance equal to zero (R=0)**[3]**.

It is difficult to prepare the phase (Bi-2223) which is characterized by the highest critical temperature (110K) among the three phases as a single phase. The properties of superconductors can be controlled by adding or substituting an element different in its ionic radius and its bonding features, the improvement or deterioration in the superconductors properties depends on the features of added or replaced elements that are different in their radius and bonding properties so most studies concentrate on the fashioning and properties improvement in (Bi2223) depending on substitution studying**[4]**. The phase(Bi-2223) is considered the most important phase in the system(BBCCO) because it is characterized by high critical temperature and critical current intensity **[5]**.Also it has a promising future in high magnetic field applications at liquid nitrogen temperature; generally the third phase form is ($Bi_{2-x}Pb_xBa_2Ca_{n-1}CunO_{10+\delta}$) **]6]**.

The studies on Pb,Sb,Cd and Ag substitution instead of bismuth show that the addition of small amount of Pb improves the critical temperature from (92K to 106K) while the addition of Pb and Cd instead of bismuth leads to increase the transition temperature from (85K to 110K),also the partial substitution of(Ba) instead of(Sr),(Pb and Hg) instead of (Bi) leads to improvement of some ($Bi_2Sr_2Ca_2Cu_3O_{10+\delta}$) properties. These substitutions improve (Bi-2223) formation, support and improve the superconductivity because they lead to a high critical temperature reaching (129K and 125K) for the compounds (Bi1.75Hg0.25Sr1.9Ba0.1Ca2Cu3O10.271),(Bi1.75Pb0.25Sr1.9Ba0.1Ca2Cu3O10.26) consequently. Also the substitution of(Bi) by(Ag) leads to improvement in properties and increasing the critical temperature from (110Kto 129K). **[7,8]** Other researchers study the partial substitution effect of (Li) and (Cd) instead of (Bi) in the superconductive compound($Bi_2Pb_{0.3}Sr_2Ca_2Cu_3O_{10+\delta}$), the specimen prepared by solid state reaction and the (XRD) show that all specimens are orthorhombic crystalline structure and contain the phases (Bi-2212,Bi-2223) for both. The electrical resistivity measurement shows that the highest critical temperature values equal to (130K,126K) at substitution ratio (0.3,0.2) in(Li,Cd) usage respectively, with a noticeable increment of c/a in case of substitution by (Cd).**[9,10]**

Other study reached to the results that (Cu) substitution by metallic ions leads to deterioration of superconductive properties and the degree of deterioration depends especially on the type of ion. Generally, the greatest suppression in superconducting occurs when the ion occupies the (Cu) position in layers(Cu-O) while a less suppression occurs when the ion occupies the (Cu) position in the linear chain **[11]**. In this work we succeeded in preparation of a polycrystalline superconductor compound ($Bi_{2-x}Pb_xBa_2Ca_{n-1}CunO_{10+\delta}$) as a pellets shaped specimens by using the solidstate reaction and we study the effect of (Pb) substitution instead of (Bi) on its electrical and structural properties.

2- Materials and methods:

Preparation of samples by the solid-state reaction(SSR) for($Bi_{2-x}Pb_xBa_2Ca_n1Cu_nO_{10+\delta}$) compounds at (x=0,0.05,0.1,0.15,0.2) using a specific weight of highly purified oxides powder of (Bi_2O_3,Bao,CaO,CuO,Nio) then weighting by a highly sensitive digital balance, mixing and grinding by two method]manual mortar for (0.5 hr) and an electrical vortex mixer for(0.5 hr)[to get the best state of homogeneity . After that the resulted powders were compressed by a hydraulic compressor under (7tons/cm^2) compression force for (1 minute) as pellets of (1.5 cm) diameter and (0.15-0.25 cm) thickness. Sintering at (750˚C) for (48 hr) at heating rate (10˚C/min) to get an interlinked material and to ensure a gradual diffusion as much as possible. By use a mathematical program to calculate the lattice coefficients (a, b, c) and to calculate the lattice coefficients per unit cell from the X-ray chart (and given that the crystal structure is a rhombus) the following relationship was used [12-14].

$$\frac{1}{d^2} = \frac{h^2}{a^2} + \frac{k^2}{b^2} + \frac{l^2}{c^2} \quad \text{.....(1)}$$

Where: h, k, l are Miller's coefficients

Then the lattice coefficients of the cell unit (a, b, c) were calculated for each sample mathematically based on Bracke's law in X-ray diffraction. The ratio of each phase was calculated according to the following mathematical relationship: [15]

$$(V_{ph})\% = \frac{\Sigma I_o}{\Sigma I_1 + \Sigma I_2 + \Sigma I_{Other(peaks)}} * 100\% \quad \text{.....(2)}$$

The last step is cooling to room temperature at the same heating rate. Investigating the specimen by (XRD) for ($Bi_{2-x}Pb_xBa_2Ca_{n-1}Cu_nO_{10+\delta}$) compounds at (x=0,0.05,0.1,0.15,0.2) to get the structural properties in a diffraction angle ranging from (10˚-70˚)

3- Result and discussion.

From **figure1** shows XRD patterns for of ($Bi_{2-x}Pb_xBa_2Ca_{n-1}Cu_nO_{10+\delta}$) system BBCC0 with x= 0, 0.05, 0.1, 0.15 and 0.2

When the value of (Pb) is increased, there is a change in the intensity of the peaks as well as their locations, where we notice an increase in the intensity of some peaks and a decrease in the intensity of other peaks, as well as the presence of displacements at the locations of these peaks.

The figure (1) observes high transition temperature phase (Bi-2223 phase) .

We calculated the sample mathematically the lattice constants were extracted by determining Miller coefficients (hkl) and (2θ) for each vertex by using the equation (1).. 2θ(Degree)

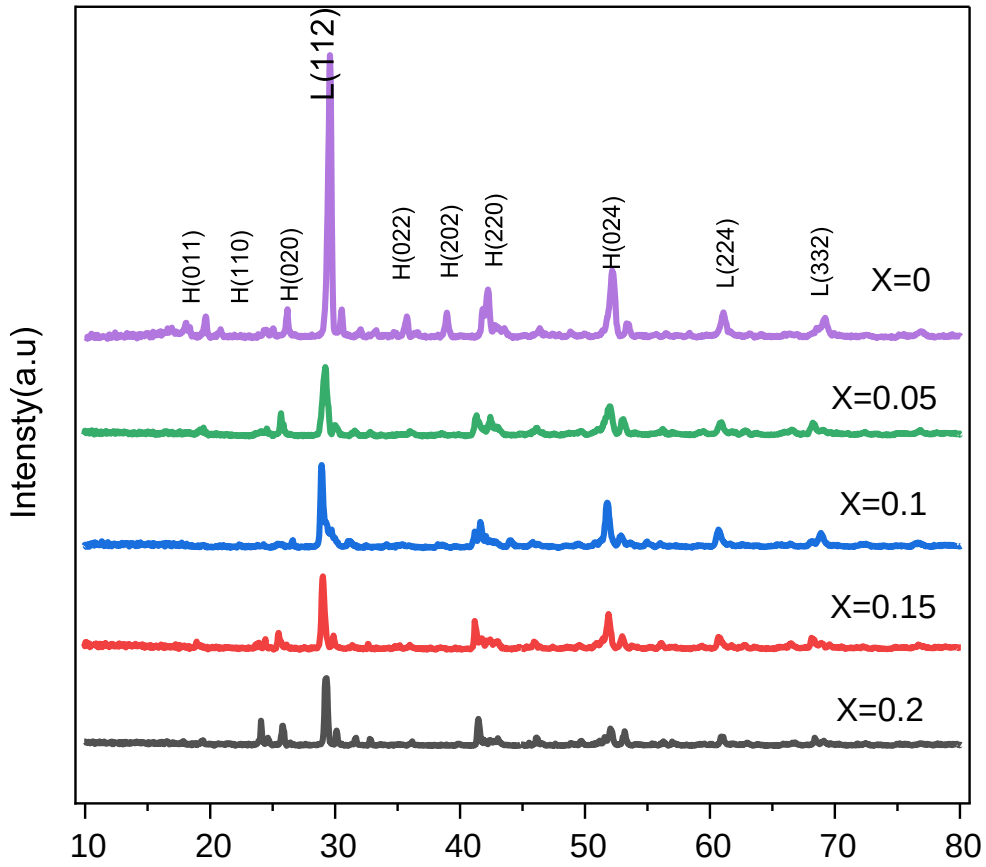

Figure (1). X– Ray diffraction pattern of ($Bi_{2-x}Pb_xBa_2Ca_{n-1}Cu_nO_{10+\delta}$) system with x= 0, 0.05, 0.1, 0.15 and 0.2 For high phase (Bi-2223).

Table 1: Demonstrates the generated samples' phase ratios, lattice coefficients (c/a).

X	$V_{ph}(H)$%	$V_{ph}(L)$%	a (A°)	b(A°)	C(A°)	c/a
0	61.53%	38.47%	6.9	5.9	8.8	1.2753
0.05	63.63%	36.37%	6.22	5.4	9.01	1.4485
0.1	50%	50%	6.14	6.01	8.61	1.4022
0.15	67%	33%	6.3	5.2	7.91	1.2555
0.2	75%	25%	5.9	5.4	9.1	1.5423

From **table-1**- It can be clearly seen that decrease the lattice parameters (a) while c parameter and ratio (c/a) is significantly increasing, and we notice increase in the(c axis, c/a and in $V_{ph(H)}$)is due to the increase in the ratio of the oxide layers(cuo) due to the partial replacement of lead (Pb) instead of bismuth (Bi), and this increase leads to an increase in the ionic bonds in the oxide layers, and thus increase in the lattice constant (c).

Figure (2) shows the decrease in the lattice parameters (a,b) and increase in the lattice parameters (c) of the grafted sample compared to the pure sample, which is reflected in the increase in the ratio of (c/a).

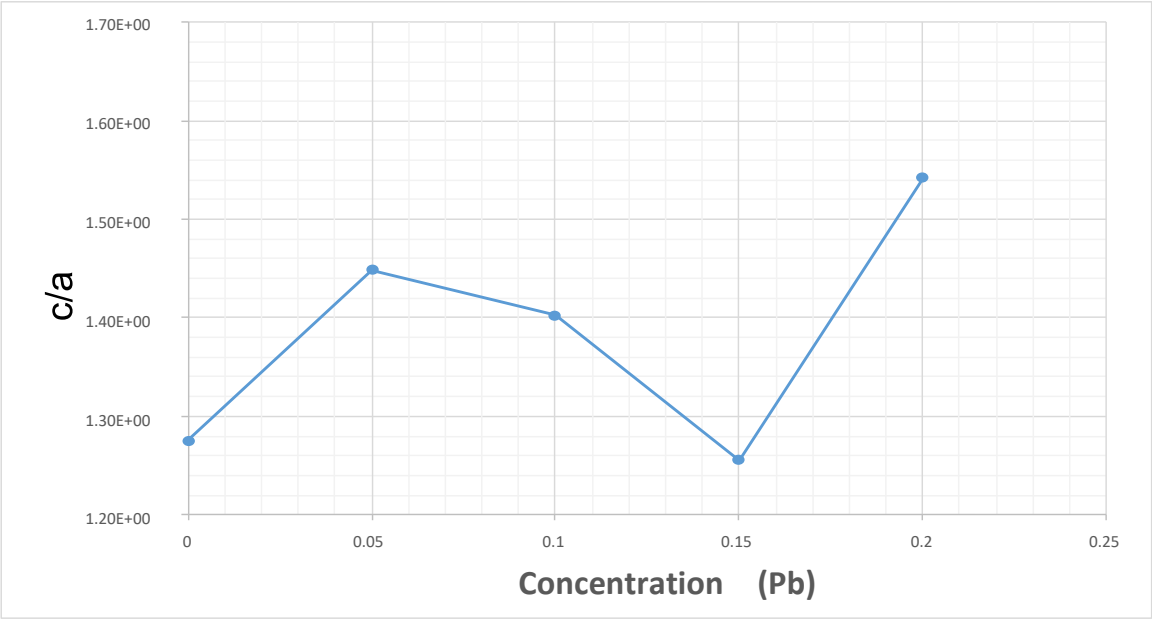

Figure 2. The (C/a) change as a function of the change in antimony (Pb) concentration

In figure 3, we note that all samples had metallic behavior in the region that precedes ($T_{c(onset)}$) Which then the material turns into a superconducting state, where all samples showed superconducting,

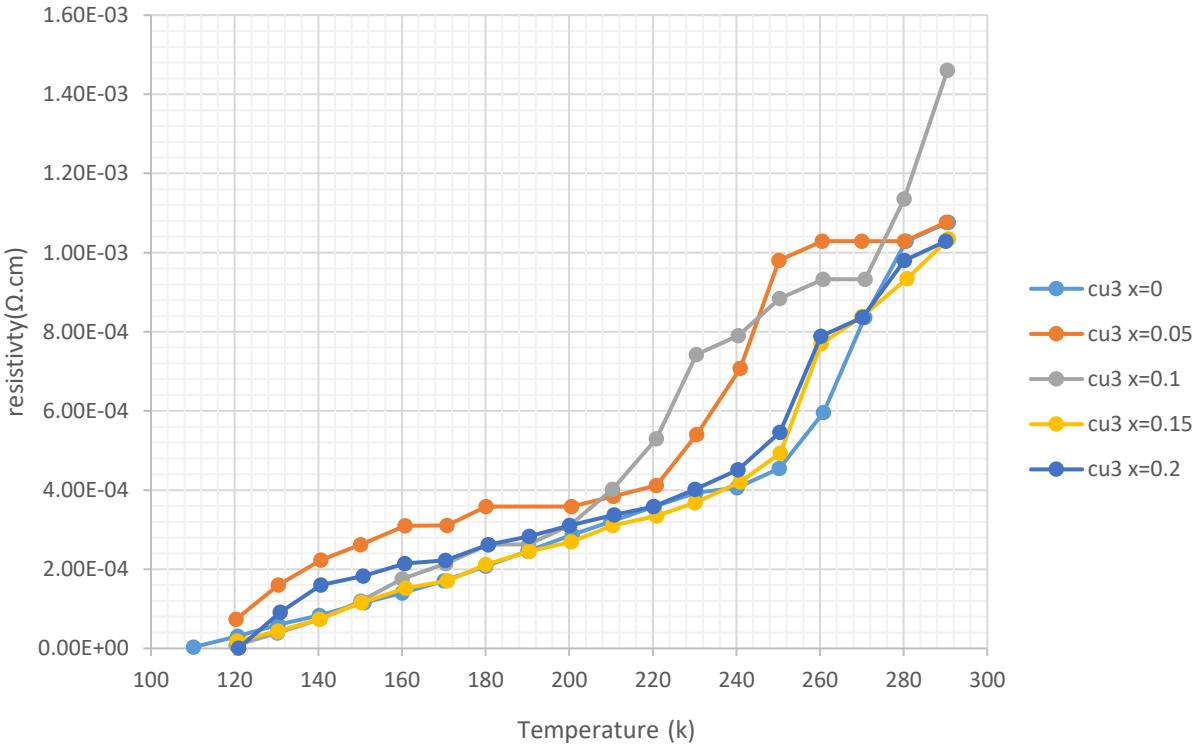

Figure 3 which represents the behavior of electrical resistance as a function of temperature in($Bi_{2-x}PbxBa_2Ca_{n-1}CunO_{10+\delta}$) which (x=0, , 0.05, 0.1, 0.15, 0.2)

Table 2 Shows the critical temperature, energy gap and concentration of gaps for the samples and concentration of gaps for the samples

X	الدرجة الحرجة	Tc(of) (K)	Tc(on) (K)	ΔT (K)	Tc(mid) (K)	Eg (eV)
0	109.2	109.2	120.7	11.5	114.95	0.0332
0.05	113.5	113.5	130.4	16.9	121.95	0.0345
0.1	118.7	118.7	130.2	11.5	124.45	0.0361
0.15	113.5	113.5	130.3	16.8	121.9	0.0345
0.2	120.9	120.9	130.9	10	125.9	0.0368

From (Table **2**) This behavior with a difference in critical transition temperatures increase T_C to T_C=120.9 K at x=0.2 and increasing of c axis because increase in the CuO layer [12], noting the increase in the width of the transition to the superconducting state, which is attributed to the presence of impurities and low phases, as well as to the generation of some internal distortions in the crystal structure Because of the replacement process.

4- Conclusion:

In our work prepared compound superconductor($Bi_{2-x}PbxBa_2Ca_{n-1}CunO_{10+\delta}$) where (x=0,0.05,0.1,0.15,0.2 (that's prepared by solid- state reaction method(SSR), The results of XRD diffraction test appeared that the compound had polycrystalline with a orthorhombic structure .

The transition temperature (Tc) of the grown samples up to x =0.2 have been have observe that maximum $Tc_{(on)}$ 130.9K at x=0.2, So we notice that the structure and electrical properties for (Bi-2223)were superconductor behavior When partial substitution of (Pb) instead of Bismuth (Bi) .

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