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قياسات الاشعة السينية و درجة الحرارة الانتقالية للمركب $Bi_2Sr_2La_2Cu_3O_{10+\delta}$ الفائق التوصيل المطعم بالكالسيوم

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ألخلاصه

درسنا تأثير التطعيم بالكالسيوم في خصائص مركب البزموث الفائقة التوصيل بإضافة كميات مختلفة من CaO إلى المركب $Bi_2Sr_2La_{2-x}Ca_xCu_3O_{10+\delta}$.وقد حصلنا على ثلاث نماذج هي A (x=0.4) ، و B (x=0.4) و C (x= 0.8) وقد حضرت النماذج بطريقة تفاعل الحالة الصلبة التقليدية في ظل الظروف المثليات. وأظهر تحليل عينات الأشعة السينية أن النماذج (AوB) ذو تراكيب رباعية الشكل بينما الانموذج (C) ذو تركيب معيني قائم مع انخفاض في قيمه ثابت الشبيكه c للعينات المطعمة بالكالسيوم بالمقارنة مع العينة الخالية منه. تم قيست ألمقاومية الكهربائية عند درجات حرارة مختلفة تحت المجالات المغناطيسية الصفرية و أظهرت تفسير البيانات أن العينة (A) ذو سلوك شبه موصل، و العينة (B) أظهرت سلوكا" معدنيا" بينما العينة (C) أظهرت بأنها موصل فائق التوصيل ذو درجة حرارة التحول عند المقاومة صفر تساوي 85 K.

الكلمات ألمفتاحيه:-ألمقاوميه الكهربائية ،درجة حرارة التحول ، تحليلات الأشعة السينية

X-ray Data and Transition Temperature Measurements of Ca Doped $Bi_2Sr_2La_2Cu_3O_{10+\delta}$ Superconductor

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Abstract

We studied the effect of Ca- doping on the properties of Bi-based superconductors by adding different amounts of CaO to the $Bi_2Sr_2La_{2-x}Ca_xCu_3O_{10+\delta}$ compound. consequently, we obtained three samples A,B and C with x=0.0, 0.4 and 0.8 respectively. The usual solid-state reaction method has been applied under optimum conditions. The x-ray diffraction analysis showed that the samples A and B have tetragonal structures conversely the sample C has an orthorhombic structure. In addition XRD analysis show that decreasing the c-axis lattice constant and thus decreasing the ratio c/a for samples A,B and C respectively. The X-ray florescence proved that the compositions of samples A,B and C with the ratio of Bi:Sr:La(Ca):Cu which were about 2:2:2:3. Resistivity were measured at different temperatures under zero magnetic fields and the data were interpreted. Sample A shows that semiconductor behavior, sample B showed a metal behavior *and* sample C showed a superconductor behaviors with transition temperature *at zero* resistance $T_{c(offset)}$ were 85 K .

Key words: Resistivity, transition temperature *and* x-ray diffraction analysis

Introduction

Superconductors Bi-base are very sensitive to synthesis conditions. They change from semiconductors to metal, from metal to superconductors, or from superconductors at low T_c to high T_c superconductors without losing their crystalline structuere(1). The high sensitivity of superconductors to partial replacement by elements have cations higher oxidation states and oxygen content. oxygen content is due to the apparent ease to which oxygen can move in and out of the atomic lattice(2,3). $Bi_2Sr_2Ca_2Cu_3O_{10+\delta}$ (2223) system is still difficult to synthesize in its pure form, the reason is that the formation of the (2223) phase is a very slow process taking place within a very limited temperature range, moreover, the weak bonding along the c-axis may also contribute to its stronger propensity to form intergrowth products(4) . To obtain a high quality 2223 monophase superconductor, the basic and significant knowledge needed is about the thermodynamic process of the Bi-system (5), the forming mechanisms and the inter relation of the two superconducting phases 2212 and 2223. The nucleation of (2223) can be formed, if additional layer of perovskite –like Cu-Ca-O is inserted into the (2212) matrix. This inserting process can occur under the sintering temperature through the fluctuation of component and energy (6).

In the present work, we have successfully to prepare $Bi_2Sr_2La_{2-x}Ca_xCu_3O_{10+\delta}$ bulk polycrystalline superconductor by using solid state reaction process, we analyze the structure and study the electrical properties of Ca-doped $Bi_2Sr_2La_2Cu_3O_{10+\delta}$ superconductor synthesized at the optimum conditions.

Experimental

The $Bi_2Sr_2La_{2-x}Ca_xCu_3O_{10+\delta}$ samples with different Ca (x=0.0, 0.4, 0.8) were prepared by the standard solid state reaction method using mixed powder of BiO, Sr La_2O_3, CaO and CuO with a purity of 99.99%. The starting materials were carefully mixed and ground in a mortar. The powders were calcined in air at 800°C for 3 hours with several intermittent grindings, and furnace cooled. The composition of prepared samples was checked by the powder XRF analysis in order to find the actual Bi/Sr/Ca/La/Cu ratio .The powder was pressed into disc-shaped pellets (1.3 cm) in diameter and (0.2-0.3) cm thick, using hydraulic press under a pressure of 7 ton/cm^2 .The pellets were presintered in air at (855-860) ^{0}C for (12) hours with a rate of 250 ^{0}C/hr and then cooled to room temperature by same rate of heating.The presintered pellets were reground, repressed and resintered in the oxygen (oxygen rate 0.2 L/min) at the same range of temperature for further (6) hours and then cooled to (500) C and annealed in oxygent for (4) hours and then cooled to room temperature by same rate of heating. The exess of oxygen content (δ) as well as measuring the critical temperatures by the four - point technique have been described elsewhere (7). The X-ray diffractometer was used to confirm the resultant phase of the samples.

Results and Discussion

The variation of resistivity with temperature of as synthesized $Bi_2Sr_2La_{2-x}Ca_xCu_3O_{10+\delta}$ samples was measured by the standard four-probe technique. The normal state resistivity of all the samples showed semiconductors or metal behaviors with respect to temperature. The temperature dependence of the resistivity (ρ) samples with different Ca in $Bi_2Sr_2La_{2-x}Ca_xCu_3O_{10+\delta}$ for (x=0.0,0.4,0.8) is shown in figure (1). It is found from this figure that the behavior of resistivity (ρ) with the temperature for the sample A with x=0.0 is semiconductor behavior, sample B showed a metal behavior at x = 0.4, sample C showed a superconductor with transition temperature *at zero* resistance $T_{c(\text{offset})}$ were 85 K at x = 0.8. The compositions of the samples were determined by XRF analysis. The x-ray Florescence patterns of $Bi_2Sr_2La_{2-x}Ca_xCu_3O_{10+\delta}$ superconductors are shown in figures (2,3 and 4). The ratio of Bi:Sr:La(Ca):Cu were found to be about 2:2:2:3.

According to the X-ray diffraction data for the samples consisted of almost phase-pure polycrystalline Bi-2223 phase. Fig. (5) shows XRD patterns taken in x=0.0, 0.4, and 0.8, respectively. It shows that all our samples are consisted of a major 2223 phase and very small amounts of secondary phases such as SrBiO , Sr,La. Cu-O_δ Sr,Ca and CuO. The comparison between the relative intensities of XRD patterns for the samples with Ca = 0, 0.4 and 0.8, with the relative intensity of the same reflections of the sample with La =0.0 shows that High-T_c phase reflections of the free sample (Ca= 0) has lower intensity than samples have Ca. The lattice parameters have been estimated using d-values and (hkl) reflections of the observed x-ray diffraction pattern through the software program based on Cohen's least square method(8) , the parameters a, b, c and C/a are shown in table(1). Figure (6) shows decreasing c/a as comparable with the free sample, due to the substitution of Ca which has the ionic radius Ca^{+2} (2.23A^0) smaller than that of La^{+3}(2.74A^0) which render c-parameter to be smaller or get deformed.

Conclusions

In the present study, we have investigated the effect of simultaneous doping of Ca in La-O_{δ} layer of $Bi_2Sr_2La_{2-x}Ca_xCu_3O_{10+\delta}$. The substitution of Ca for La ions yields further holes thus they will modulate the structure by influencing the charge balance, oxygen distribution and relevant interactions process between the neighboring layers will lead to create more holes in the Cu-O layers. The transition temperature of as grown samples is found to be sensitive to the Ca concentrations it has been observed that maximum T_c (85 K) is achieved for $Bi_2Sr_2La_{1.2}Ca_{0.8}Cu_3O_{10.24}$.

X-ray diffraction(XRD) analysis showed tetragonal structure (samples A and B) and an orthorhombic structure (sample C) with decrease of the c-axis lattice constant for the samples doped with calcium as compared with this has no calcium content . It was found that the change of the Ca concentrations of all our samples produce a change in the C/a and lattice parameters.

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Table(1): Values of lattice parameter a,b, C/a, oxygen content (δ) and T_c for samples with different composition of $Bi_2Sr_2La_{2-x}Ca_xCu_3O_{10+\delta}$

X	$T_{c(OFF)}$(K)	*δ(o_2)*	*a*(A^0)	*b*(A^0)	*c*(A^0)	*C/a*
0.0	------	--------	5.402	5.421	37.78	6.99

0.4	------	--------	5.414	5.414	37.63	6.95
0.8	85	*0.24*	5.423	5. 423	37.32	6.80

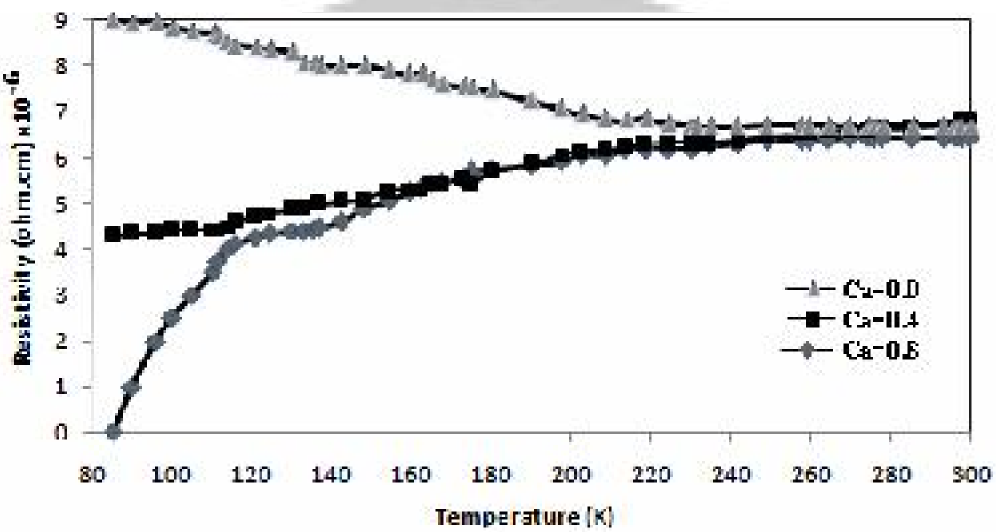

Fig. (1): The resistivity dependence on Temperature for $Bi_2Sr_2La_{2-x}Ca_xCu_3O_{10+\delta}$ at indicated values of (Ca) at x =0.00, 0.4 and 0.8

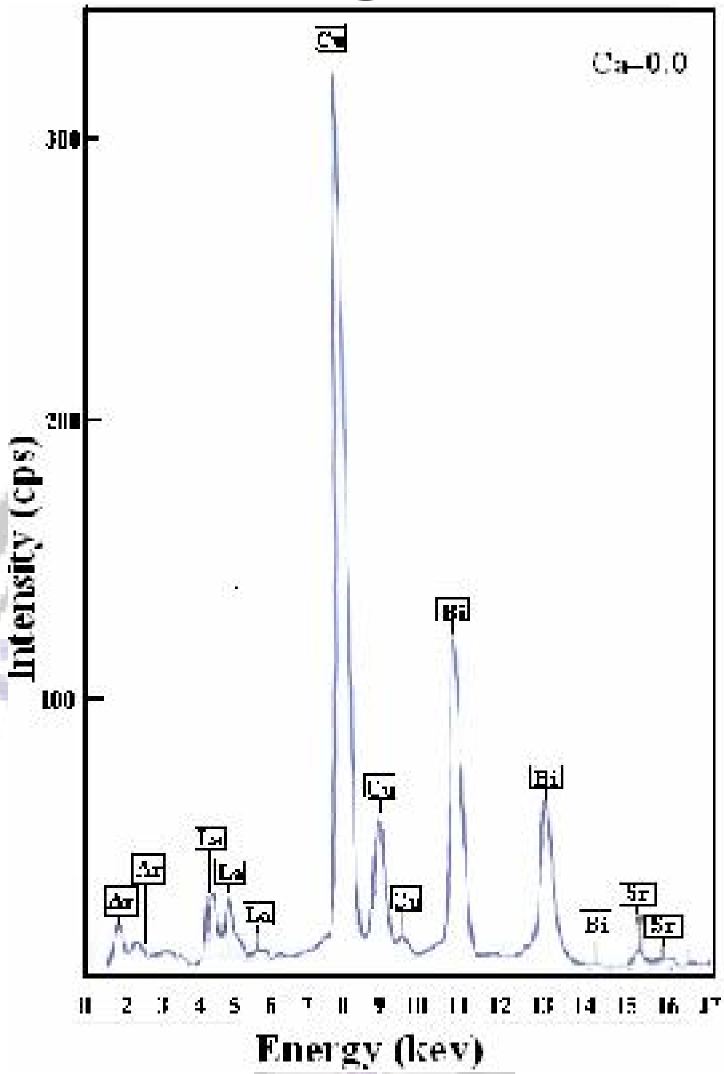

Fig.(2) :XRF Patterns for the sample $Bi_2Sr_2La_{2-x}Ca_xCu_3O_{10+\delta}$ for x=0.0

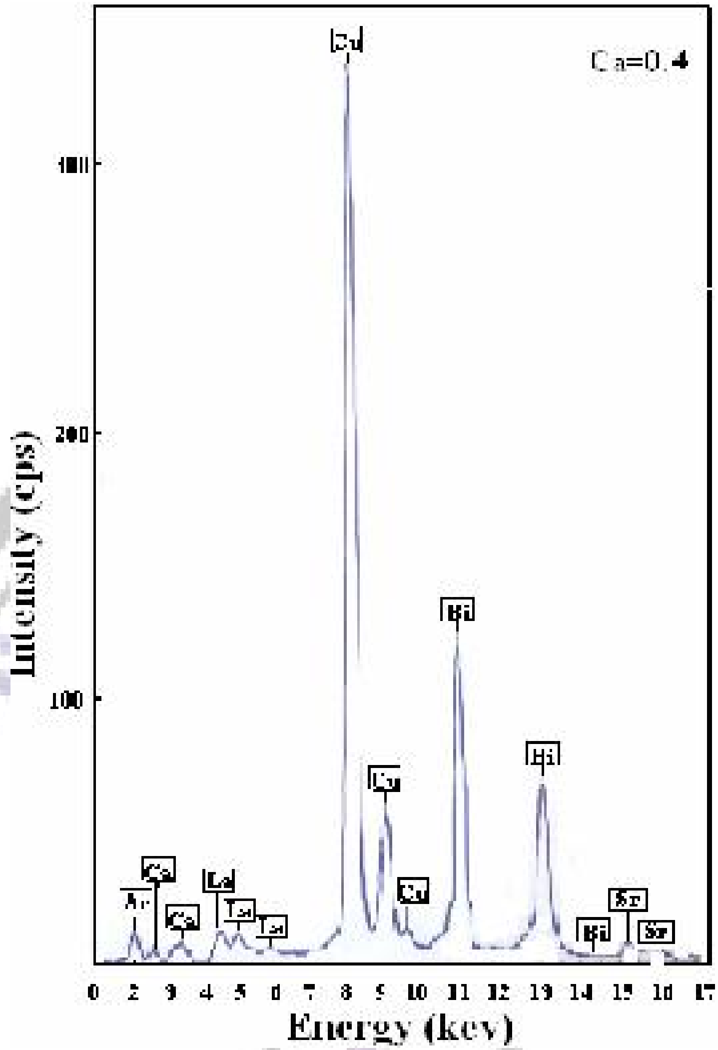

Fig.(3): XRF Patterns for the sample $Bi_2Sr_2La_{2-x}Ca_xCu_3O_{10+\delta}$ for x=0. 4

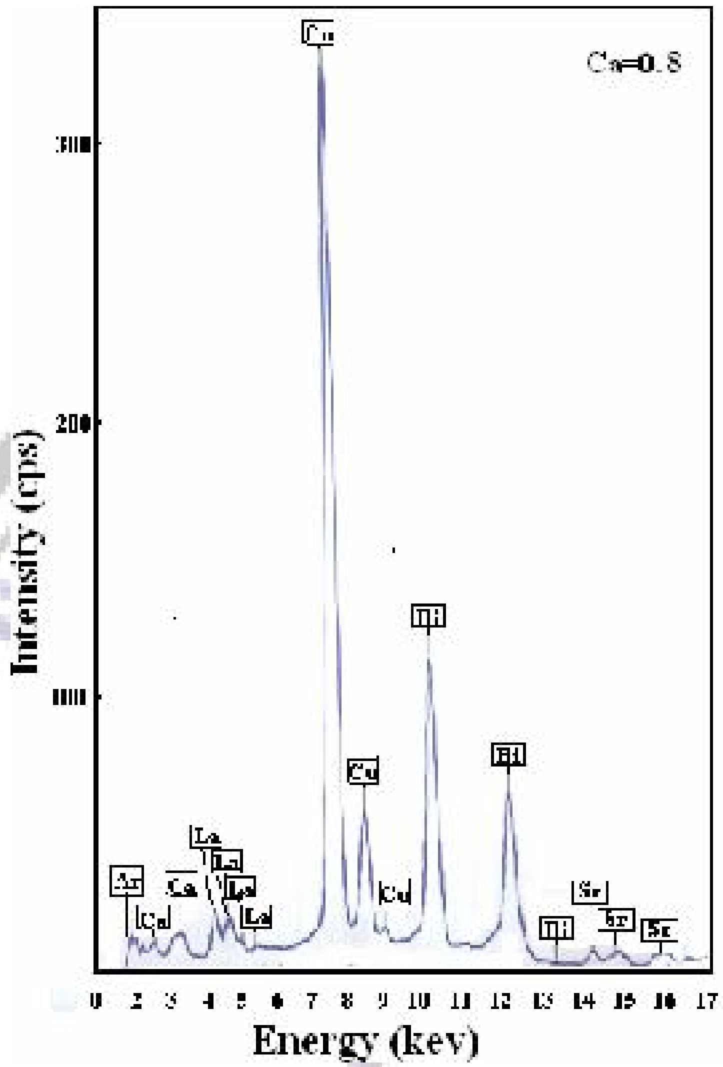

Fig.(4): XRF Patterns for the sample $Bi_2Sr_2La_{2-x}Ca_xCu_3O_{10+\delta}$ for x= 0.8

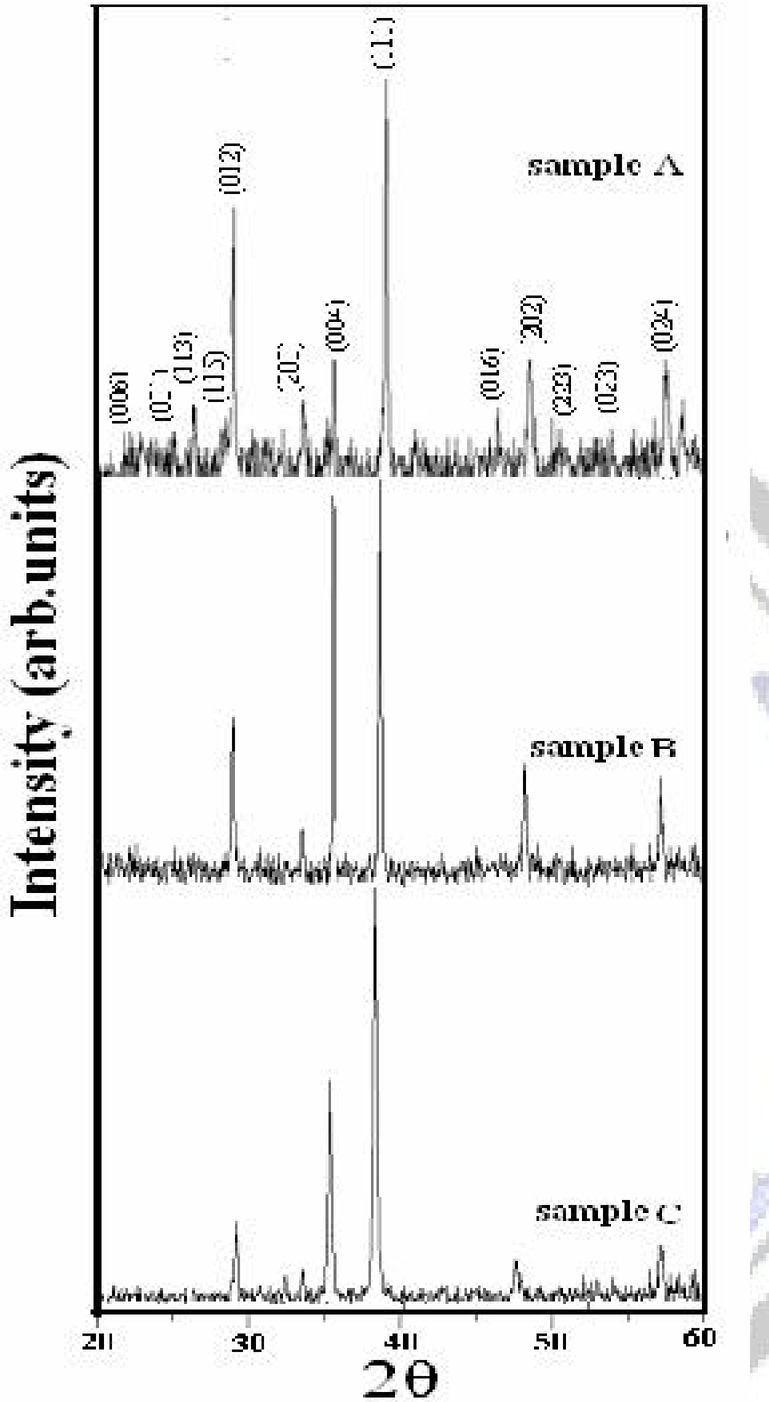

Fig.(5): XRD Patterns for the sample $Bi_2Sr_2La_{2-x}Ca_xCu_3O_{10+\delta}$ for A (x=0.0), B(x=0.4) and C (x=0.8)

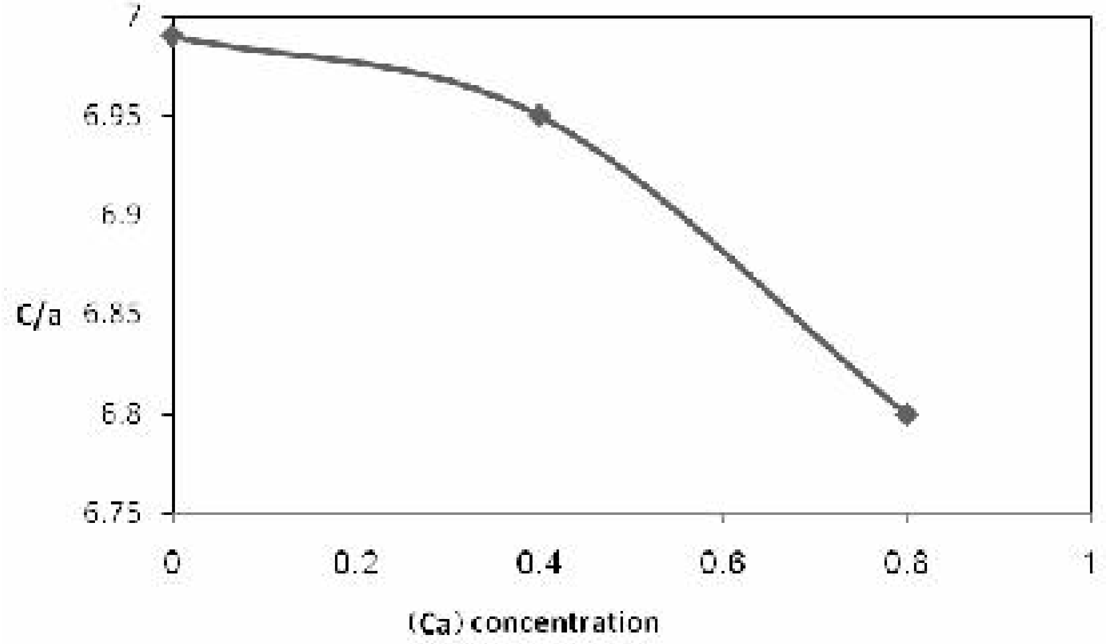

Fig.(6): C/a as function of different Ca for $Bi_2Sr_2La_{2-x}Ca_xCu_3O_{10+\delta}$