Synthesis and superconducting properties of bulk CaC_6 GIC

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Among graphite intercalation compounds, the CaC_6 binary phase exhibits superconducting properties with the highest critical temperature of 11.5 K. The samples are synthesised using a liquid-solid method allowing the preparation of pure bulk samples, auspicious for crystallographic and magnetic measurements. The crystal structure of CaC_6 was entirely specified, this compound crystallises in the $R\bar{3}m$ space group. The magnetic properties of this phase were studied with a magnetic field successively applied parallel and perpendicular to the graphene sheets. The magnetic phase diagram indicates that the CaC_6 binary compound is a type II superconducting material slightly anisotropic in spite of its lamellar structure. The in-plane magnetic penetration depth measurements show a clear exponential behaviour at low temperature, consistent with an s-wave symmetry of the gap function, well fitted by the standard BCS theory in the dirty limit.

KEYWORDS : Graphite intercalation compound, Synthesis, X-ray diffraction, Superconductivity

1. Introduction

Recently, the discovery of superconductivity in two binary graphite intercalation compounds (GICs) : YbC_6 ¹⁾ and CaC_6 ^{1), 2)} and one ternary GIC $\text{Li}_3\text{Ca}_2\text{C}_6$ ³⁾ with surprisingly high critical temperatures renewed the interest in this family of lamellar materials. The GICs containing calcium exhibit critical temperatures of one order of magnitude higher than previous studied compounds⁴⁾. The first measurement of superconductivity in a graphite intercalation compound was made by Hannay *et al.*⁵⁾ in 1965 on the first stage KC_8 compound which exhibits a very low critical temperature : 0.14 K⁶⁾. A larger intercalated metal concentration allows to increase the critical temperature up to 3 K for KC_3 , 5 K for NaC_2 and 5.5 K for KC_4 ^{7), 8)}. These compounds were obtained by the means of high-pressure reactions but they become metastable under room conditions. However, several ternary graphite intercalation compounds promote superconductivity, for example, at 1.4 K for KHgC_8 ⁹⁾ or 2.7 K for $\text{KTl}_{1.5}\text{C}_4$ ¹⁰⁾. A review of all these compounds is given in¹¹⁾.

Among the superconducting GICs, the compounds exhibiting the highest T_c belong to the graphite-lithium-calcium system : CaC_6 and $\text{Li}_3\text{Ca}_2\text{C}_6$ with a respective critical temperature of 11.5 K and 11.15 K. This paper is a review of the synthesis, the crystal structure and the superconducting properties of CaC_6 binary compound.

2. Synthesis

It is well known that the intercalation into graphite of the alkaline earth metals by vapour phase is considerably more difficult than the one of the alkali metals. Furthermore, among these metals, barium and strontium intercalate rather easily, but, for calcium, the intercalation is strongly more difficult¹²⁾. Indeed, the reaction between calcium vapour and a platelet of pyrolytic graphite leads only to a very slight intercalation, that is extremely superficial. Moreover the reaction temperature has to remain sufficiently low, in order to avoid the formation of calcium acetylide. Consequently, bulk calcium-graphite samples had never been synthesised. For this reason, the study of the properties of the first stage graphite-calcium compound was not carried out during numerous years. The only known elements for this binary compound during 25 years are its colour, that is very pale yellow with the characteristic metallic brightness, the interlayer distance between graphene planes after intercalation, that reaches 454 pm, instead of 335 pm in pristine graphite, and its supposed chemical formula CaC_6 .

In 2004, we have succeeded in synthesising this compound in the bulk and almost pure, using a novel method consisting in plunging a pyrolytic graphite sample in a molten lithium-calcium alloy, whose composition is well defined¹³⁾. It is well established that three factors possess an essential effect relating to the reaction product : reaction temperature, alloy composition and reaction time.

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The reaction temperature appears as a crucial parameter. Indeed, it is firmly recommended to keep it below 400°C , to avoid the ruin of the graphene planes. The addition of lithium to calcium leads fortunately to a large decrease of the melting temperature from 839°C , that corresponds to pure calcium. Consequently, it is very easy to carry out the reaction below 400°C in a broad composition range.

In order to carry out meticulous and reproducible reactions (Fig.1), it is strongly necessary to use metallic reagents absolutely pure. For this reason, the lithium metal has to be systematically purified in the glove box, by a melting up to 200°C , so that the impurities floating on the molten metal can be eliminated by a mechanical sweeping of its surface. Both lithium and calcium are

Fig.1 Schema of the successive steps of the solid-liquid method used for the synthesis of CaC_6 compound.

precisely weighed in the glove box with regard to the desired composition of the reactive alloy, which has to correspond to a Li/Ca ratio included between 3 and 4. The melting step occurs in a stainless steel tube placed in a tubular vertical furnace able to heat until $400\text{--}450^\circ\text{C}$. The alloy is then agitated to obtain a well homogeneous liquid.

The graphite platelet ($5\text{ mm} \times 15\text{ mm} \times 0.2\text{--}0.5\text{ mm}$) is then plunged in the molten alloy, the reactor is tightly closed under argon with a Swagelok top and the reaction is carried out for ten days at around 350°C . Finally, the sample is extracted from the reactor and its surface is cleaned by centrifugation at $300\text{--}350^\circ\text{C}$ or by cleavage. Its colour is then shiny silver with a strong metallic brightness.

The formation of pure first stage CaC_6 needs a rather precise reaction temperature close to 350°C . Indeed, if it is too low, the $\text{Li}_3\text{Ca}_2\text{C}_6$ ternary compound appears and can even become the unique reaction product. On the contrary, if the temperature is too high, a $\text{LiC}_6\text{--CaC}_6$ mixture is obtained. On the other hand, the same mixture is observed for too rich lithium binary alloys. And, if the lithium atomic contents are too low, the $\text{Li}_3\text{Ca}_2\text{C}_6$ ternary is obtained preferentially.

We have seen that the reactive alloy is very rich in lithium and poor in calcium (Li/Ca ratio included between 3 and 4). Nevertheless, at the end of the reaction, only the calcium is intercalated into graphite. Consequently, in spite of its dilution, the liquid calcium retains a sufficiently high thermodynamical activity in order to intercalate alone into graphite, although it is easier for lithium apparently to intercalate. In fact, the thermodynamics strongly favours the calcium intercalation to the detriment of lithium.

Fig.2 Intercalation mechanism of CaC_6 compound.

The study of the intercalation mechanisms leading to CaC_6 is followed by X-ray diffraction during the development of the reaction¹⁴). It shows clearly that the role of lithium is double. Of course, it serves as a flux for calcium, so that the liquid-solid reaction can be carry out at low temperature. But, it makes easier also the intercalation of calcium by pre-opening the graphitic galleries during the first step of the reaction. Indeed, the first hour of reaction leads to the successive formation of 5th, 4th, 3rd, 2nd and 1st stage binary lithium compounds. This staging mechanism is quite usual at the time of the intercalation into graphite of a pure metal. When the sample is entirely turned into quasi pure LiC_6 , the second mechanism begins and a slow and progressive substitution of lithium atoms by the calcium ones occurs, leading after several days to pure CaC_6 (**Fig.2**). During this substitution process, we emphasize that the sample contains simultaneously both LiC_6 and CaC_6 binaries (the segregation of both compounds is quite obvious).

3. Crystal structure

Thanks to this novel synthesis process, it becomes possible to study and to solve the crystal structure of this binary compound, using a bulk sample obtained from a pyrolytic graphite platelet.

It is well established that the first stage binary graphite-metal intercalation compounds possess a very well specific stoichiometry corresponding to MC_8 for the biggest metals and to MC_6 for the smallest ones. Indeed, when the repeat distance is higher than 530 pm, the first stoichiometry is observed (K, Rb, Cs) and the second one, when this distance is smaller than 530 pm (Li, Sr, Ba, Eu, Yb). Consequently, for calcium, the expected chemical formula is of course CaC_6 . This stoichiometry corresponds to an AAA... stacking for the successive graphene planes, so that all metal atoms are located in prismatic hexagonal sites : the adjacent graphene and metal planes are of course epitaxial. In each graphitic interval, one out of three prismatic sites is occupied by a metal atom, so that it appears three different manners able to receive a metal plane in a graphitic interval, which are denoted α , β and γ . Consequently, three different c-axis stacking can be thus considered :

$$A\alpha A\alpha A\alpha A\alpha A\alpha \dots$$
$$A\alpha A\beta A\alpha A\beta A\alpha \dots$$
$$A\alpha A\beta A\gamma A\alpha A\beta \dots$$

In the first case, the c parameter of the unit cell is obviously identical to the repeat distance ($c = d_i$). For the second stacking : $c = 2 d_i$, and for the third one : $c = 3 d_i$. The first and the second stackings lead to a hexagonal crystal symmetry, since the third one, on the contrary, corresponds to a rhomboedral symmetry.

The first stacking has been observed only for LiC_6 ¹⁵⁾. And the other known MC_6 compounds (SrC_6 , BaC_6 , EuC_6 , SmC_6 and YbC_6)^{12), 16), 17)} select all the second stacking. Consequently, all

Fig.3 00l X-Ray diffraction pattern of CaC_6 compound. Reflexions are indexed with respect to the interplanar distance.

Fig.4 1D c-axis electronic density profiles of CaC_6 : experiment (—) and model (▨).

these binary compounds exhibit systematically a hexagonal crystal structure. We show in the following report that CaC_6 is different, since its symmetry is rhomboedral according to the third stacking.

The X-ray diagram of the $00l$ reflections (**Fig.3**) of the compound gives directly the value of its repeat distance, which is equal to 452.4 pm. Using their structure factors, the intensities of these reflections allow besides to draw the **c**-axis electronic density (**Fig.4**) profile of the compound, which is able to give directly its composition, according to the previously supposed CaC_6 chemical formula. At last, this latter stoichiometry has been confirmed with precision by means of nuclear microprobe^{18), 19)}.

The study of the $hk0$ and hkl reflections of the compound has to confirm its particular stoichiometry. Indeed, if we consider the projection of the calcium atoms plane on the adjacent graphene plane, the MC_6 formula leads to a characteristic 2D hexagonal unit cell, whose a parameter is close to $a_G\sqrt{3}$ (with $a_G = 246$ pm), if we ignore the dilation of the graphene plane caused by the electron transfer from the calcium atoms to the carbon sheets. An other and frequently

used notation for this 2D cell is the following : $\sqrt{3} \cdot \sqrt{3} R 30^\circ$, that reveals the shift of 30° between the 2D graphene cell and the MC_6 one. In order to know the value of this a parameter, a particularly interesting way consists in carrying out a diffraction pattern by the rotating crystal method. The horizontal strata are easily identified and numbered. And we observe, in the perpendicular direction, the $[\text{hk}]$ rows, whose first one corresponds to $[10]$ with the reticular distance of a $\sqrt{3}/2$. The calculation of a gives the value of approximately 433 pm, that is very close to $a_G \sqrt{3}$. Consequently, this result appears as an additional confirmation of the CaC_6 stoichiometry. The positions of the following $[\text{hk}]$ rows are in good agreement with this previous 2D hexagonal unit cell.

A detailed analysis of the $[10]$ row of the diffraction pattern shows clearly that the reticular distance corresponding to the space between two successive strata reaches the value of 1357.2 pm. It is obviously the value of the c parameter of the 3D hexagonal unit cell of the compound. Consequently, this parameter is three times as much as the repeat distance ($1357.2 = 3 \times 452.4$). This result can obviously be attributed to the $\text{A}\alpha\text{A}\beta\text{A}\gamma\text{A}\alpha\text{A}\beta\dots$ specific stacking. But other observations have to confirm this interpretation.

Along this same $[10]$ row, there is no reflection on the zero stratum, and similarly, the reflections are lacking on the 3 and 6 strata. These specific lacks are very characteristic of the previous stacking, since they appear as systematic extinctions in this system. On the whole, the hkl reflections of the diffraction pattern obey the general diffraction condition : $-h + k + l = 3n$. This result is a good confirmation of the proposed model for the c-axis calcium planes stacking.

We have seen that, with such a stacking, the symmetry of the crystal is not hexagonal but rhomboedral. The corresponding specific symmetries lead to the $\text{R}\bar{3}\text{m}$ space group for the CaC_6 crystal⁽²⁰⁾.

The value of the a parameter is three times as high as the carbon-carbon distance in the graphene planes of the compound. This distance is equal to 144.4 pm, so that its dilation after intercalation reaches 2.4 pm, that is to say 1.69 %. Using the Pietronero-Strässler formula⁽²¹⁾, it is possible to calculate the charge transfer resulting from the intercalation of calcium into the graphitic galleries. Reduced to one carbon atom, this electron transfer reaches 0.103. We have to point out that, among all the MC_6 compounds, the previous carbon-carbon distance dilation and charge transfer are the highest ones.

The characteristic parameters of the rhomboedral unit cell are $a = 517$ pm and $\alpha = 49.55^\circ$, and the Wyckoff's atomic positions are the following ones :

Carbon : 6 atoms 6g (1/6 5/6 1/2)

Calcium : 1 atom 1a (0 0 0)

This unit cell is primitive, centrosymmetrical and belongs to the holodry of the rhomboedral system (Fig.5).

Fig.5 (a) Rhomboedral unit cell of CaC_6 and (b) set of joined unit cells.

Fig.6 Crystal structures of (a) calcium and (b) CaC_6 . Rhomboedra are represented in red.

Among the known first stage MC_6 graphite intercalation compounds, CaC_6 is only to possess this $\text{R}\bar{3}\text{m}$ rhomboedral structure. Each of them exhibits the $\text{P6}_3/\text{mmc}$ hexagonal structure except LiC_6 , whose crystal symmetry is hexagonal too, but with the $\text{P6}/\text{mmm}$ space group.

Metallic calcium that crystallises in a cubic face-centered structure with an a parameter of 558.8 pm can be represented by a specific rhombohedron with $\alpha = 60^\circ$ and $a = 395$ pm which contains only one calcium atom. We can compare this structure with that of CaC_6 (Fig.6) : the rhomboedral unit cell of CaC_6 is obtained from the calcium rhombohedron, thanks to an elongation along its ternary axis and a dilation of its a parameter, so that in CaC_6 , calcium "remembers" its previous structure.

For almost all MC_6 compounds, the interactions between the successive intercalated cations planes lead to the $\text{A}\alpha\text{A}\beta\text{A}\alpha\dots$ stacking, because the interaction is exerted on a rather great distance (as far as the second intercalated plane). A comparable phenomenon appears with CaC_6 , but since its repeat distance is shorter, this

interaction can be exerted as far as the third intercalated plane (1357 pm).

On the other hand, LiC_6 appears as an exception. Indeed, its strongly short repeat distance (370 pm) due to the very small size of lithium would of course be favourable to the same rhomboedral stacking as for CaC_6 . But we observe exactly the opposite, since the lithium atoms are strictly superimposed along the *c*-axis, according to the $P6/mmm$ space group, so that the metal-metal distance along this axis appears as extremely short. Consequently, a covalent attractive interaction between lithium atoms turns up, and strongly weakens the cationic repulsive interaction. Simultaneously, the ionic character of intercalated metal decreases considerably. In LiC_6 , the electron transfer reaches 0.07 only, while its value is 0.103 in CaC_6 (approximately 0.5 time higher).

4. Superconducting properties

According to the magnetisation measurements of CaC_6 , the saturation of the diamagnetic response is reached after a sharp transition at 11.5 K²⁾ (**Fig.7**). Various magnetisation experiments²¹⁾⁻²³⁾ versus field were performed by several groups in order to determine the critical fields and then, to observe if the magnetic behaviour is highly anisotropic as it can be expected, due to the lamellar structure of this kind of compound. In this way, magnetic measurements were carried out with the external applied field parallel ($H_{//ab}$) or perpendicular ($H_{//c}$) to the graphene sheets. At 2K, the $H_{c2//ab}$ and $H_{c2//c}$ upper critical fields reach 9500 Oe and 5000 Oe respectively⁴⁾ (**Fig.8**). According to the previous papers^{4), 22)}, the anisotropic ratio $H_{c2//ab}/H_{c2//c}$ is estimated at a value close to 2. For Xie *et al.*, this ratio is slightly higher but estimated from measurements obtained with a sample prepared by vapour phase reaction, whose $T_{c \text{ onset}}$ reaches only 11.3 K²³⁾. These rather low values of anisotropic ratio indicate that, in spite of the lamellar structure of CaC_6 , its magnetic behaviour is more 3D than it can be expected (for example, this ratio reaches 4.7-6.2 for KC_8 ⁶⁾, 11 for KHgC_4 ²⁴⁾ or 30 in KHgC_8 ²⁵⁾).

Rapidly, various theories have been developed using two different points of view. In one hand, a conventional electron-phonon pairing mechanism is sufficient to explain the superconductivity of CaC_6 ²⁶⁾⁻²⁸⁾ and on the other hand, unconventional mechanism are pointed out such as plasmonic or excitonic pairing mechanism²⁹⁾. In order to confirm one of these theories, experimental effort was done on CaC_6 .

The first experiment concerning the symmetry of the gap function was performed by Lamura *et al.*³⁰⁾. Using a high-resolution mutual inductance technique, the variation versus temperature of the magnetic penetration depth along the *c*-axis in the superconducting state, λ_{ab} , was measured and indicates a thermal activated behaviour, i.e. an exponential increase with the temperature of $\Delta\lambda_{ab}$

Fig.7 Magnetisation (ZFC : Zero Field Cooling and FC : Field Cooling) versus temperature of CaC_6 with a field of 5 Oe applied parallel to the graphene sheets.

Fig.8 Superconducting phase diagram of CaC_6 compiled from $M(H)$ measurements at given temperatures. $M(H)$ data were collected with the external field applied parallel to the *c*-axis (H_{c1c} , H_{c2c}) and in the perpendicular plane (H_{c1ab} , H_{c2ab}), the inset corresponds to H_{c1c} and H_{c1ab} with an expanded field scale.

(**Fig.9**). As it is shown in the following figure (**Fig.10**) from Lamura³¹⁾, this clear behavior can be related to a fully gap without knot with a *s*-symmetry. This “*s*-wave” symmetry of the gap function remains compatible with the standard BCS theory. The fit of $\Delta\lambda_{ab}(T)$ for $T < T_c/2$ leads to $\lambda_{ab}(0) = 72 \pm 8$ nm and a zero-

Fig.9 Variation of the in-plane magnetic penetration depth λ_{ab} of CaC_6 versus temperature before (Δ) and after (O) the cleavage of the sample. The inset corresponds to an expanded scale before 5.5 K.

Fig.10 Expected evolution of the magnetic penetration depth versus temperature for a s-wave and a d-wave symmetry of the gap function. The thermal activated behaviour (exponential evolution versus temperature) clearly indicates a fully gaped superconductor. A d-wave symmetry systematically leads to a linear evolution of λ .

temperature superconducting gap of $\Delta(0) = 1.79 \pm 0.08$ meV. In this case, the ratio $2\Delta(0)/k_B T_c$ is estimated at 3.6 ± 0.2 , which is very close to the BCS value of 3.52. Moreover, this result is in good agreement with the calculation of Calandra and Mauri²⁶⁾ since the expected ratio reaches 3.69³²⁾ using the predicted value of electron-phonon coupling $\lambda = 0.83$ and the logarithmic average phonon frequency $\omega_{ln} = 24.7$ meV. Since it was believed that graphite intercalation compounds can be possible examples of two-band gap superconductor³⁴⁾, fit measurements with a two-band model³⁵⁾ were attempted. However, no additional information was obtained, simply because a single-gap analysis is fully capable to describe the experimental data³⁰⁾. By the means of surface resist-

Fig.11 Evolution of the superconducting gap energy of CaC_6 versus T/T_c (open circle) compared to the BCS theory (solid line).

ance measurements in the microwave regime, Andreone *et al.*³³⁾ report a gap amplitude of $\Delta(0) = 1.5 \pm 0.3$ meV. This slightly depressed value is related by the authors to the sensitivity of the microwave impedance measurement. Indeed, since CaC_6 is highly air-sensitive, some traces of oxide or hydroxide can be present on the sample surface; measurements of $\Delta\lambda_{ab}$ on an aged surface of CaC_6 have lead to a gap value 30 % lower than the one obtained from measurements done on freshly cleaved sample³⁰⁾ and then, support this suggestion (Fig.9).

An anomaly observed in the specific heat experiments performed by Kim *et al.*²⁷⁾ have suggested also an isotropic s-wave gap with $2\Delta(0)/k_B T_c = 3.552$. However, Mazin *et al.*³⁶⁾ pointed out that the theories mentioned above don't fit the specific heat measurements. The calculations done by Sanna *et al.*³⁷⁾ solve this point. Using a method developed to describe superconductivity in elemental metals, their calculations lead to a moderately anisotropic gap function, which gives to a perfect match of the specific heat measurement.

The first STM/STS measurements³⁸⁾ indicate a gap value of $\Delta(0) = 1.6 \pm 0.2$ meV, with an evolution with the temperature in good agreement with the BCS theory (Fig.11). The *ab* plane coherence length extracted from zero-bias conductance of a vortex reaches 33 nm, according to the value obtained from the magnetic measurement²⁾. No evidence of two-gap superconductivity is given. However, Kurter *et al.*³⁹⁾ have suggested the possibility of strong coupling superconductivity, since they reported a $\Delta(0)$ of 2.3 meV. From directional point contact spectroscopy, Gonnelli *et al.*⁴⁰⁾ confirmed the first STM measurements and clearly showed that the gap function is anisotropic, according to the previous theory³⁷⁾. But, the gap is included between 1.36 and 1.7 meV and the anisotropy is probably greater than it was proposed from first-principles calculations. From this experiment, two-gap superconductivity is not excluded. And it is interesting to note that the idea of two-band superconductivity in graphite intercalation compounds

Fig.12 (a) Electrical resistivity of CaC_6 at 300 K ($\rho_{300\text{K}}$) and electrical resistivity at the critical temperature in the normal state (ρ_0) - (b) Evolution of the critical temperature versus pressure.

was suggested in 1992⁴¹⁾.

Phonon modes were studied by micro-Raman scattering technique by Hlinka *et al.*⁴²⁾. Spectra on cleaved surfaces systematically show two bands at 1500 cm^{-1} and 450 cm^{-1} assigned to Raman-active E_g modes corresponding respectively to the in-plane bond-stretching mode and the out-of-plane puckering mode of the graphene planes. No significative change is observed on these two modes above and below the critical temperature. According to the theory, these modes are not involved in the mechanism responsive of the CaC_6 superconductivity. In order to obtain information about one of the phonons involved, i.e. the in-plane Ca mode, IR measurements like far-IR absorption techniques are required.

Many high pressure measurements were done, since it can be a powerful tool to increase the critical temperature. For CaC_6 , a pressure of 8 GPa leads to an increase of 3.6 K, with a T_c of 15.1 K (Fig.12). The pressure dependence of T_c is linear, with a coefficient of approximately 0.5 K/GPa ⁴³⁾⁻⁴⁵⁾. The resistivity curves $\rho(T)$ at $T > T_c$ were fitted by the generalized Bloch-Grüneisen formula with two phonons modes. The phonon energies and the weights of these two modes are consistent with the calculation of Calandra and Mauri²⁶⁾ at atmospheric pressure. Indeed, the low and the high energy modes were attributed to in-plane Ca and out-of-plane C modes respectively.

For pressure included between 8 and 10 GPa, the critical temperature dramatically falls to 5 K⁴³⁾. This phenomenon was attributed to the softening of the in-plane Ca phonon mode, leading to structural instability. It is interesting to note that in YbC_6 , the critical temperature increases linearly in a first time and, like in the case of CaC_6 , for a pressure higher than 2 GPa, it falls⁴⁵⁾.

In order to confirm this assumption, X-ray diffraction measurements under pressure up to 13 GPa were performed⁴⁶⁾. No space group change is observed in this range of pressure. Below 9 GPa, using a linear regression, the isothermal compressibility coefficients reach $da/dP = -0.38\text{ pm/GPa}$ and $dc/dP = 8.1\text{ pm/GPa}$. At 9 GPa, the compressibility of CaC_6 suddenly increases and becomes approximately 3 times higher than the previous one. In addition, a large increase of the Full Width at Half Maximum of the diffraction reflexion is observed for pressure higher than 9 GPa, supporting disorder induced by the pressure. According to Csányi *et al.*⁴⁷⁾, small displacement of the calcium atoms can be responsible for the structural transition. These variations of calcium position may be generated by a reduction of symmetry and then, a modification of the space group. However, the X-ray diffraction patterns don't allow the identification of low intensity extra reflexions due to such a modification.

Conclusions

The highest critical temperature among graphite intercalation compounds has been reached in the lithium-calcium-graphite system with the binary CaC_6 compound. This phase was synthesised using a solid-liquid method leading to pure bulk samples. CaC_6 appears as a well crystallised graphite intercalation compound with a $R\bar{3}m$ crystal structure. Magnetic measurements reveal that CaC_6 appears as a type II superconducting material with a weak anisotropy of its critical fields. The electrodynamics characterisation of CaC_6 shows the first experimental evidence of a conventional pairing mechanism with a s-wave superconducting gap. These results are well corroborated with those obtained by several other methods such as microwave surface resistance measurements, scanning tunnelling spectroscopy, ... The application of a high pressure such as 8 GPa increases the critical temperature of this compound up to 15.1 K.

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