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Short Communication

Synthesis and Characterization of Carbyne

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Abstract

Carbyne is an alkyl carbynes (R=H, phenyl, methyl). Carbyne have occurrence in interstellar medium as well as in earth. It has certain occurrence in biological objects. It is also prepare in special gas and space environment. First, in our review, we study the carbynes in the different fields by using its outstanding properties. Thereafter, we study the carbyne in different fields by literature survey. Secondly, represents details of synthesis of carbyne. There is a big dispute on its existence because of stability difficulties in the laboratory synthesis. The most promising objects of modern nanotechnology are the carbon-based materials. Finally, we reported the methodology used for synthesis of carbyne. Overall our review gives the systematic report for synthesis, properties and used of carbyne in different fields.

Keywords: Carbyne, Synthesis, Property.

Introduction

Andre Geim and Konstantin Novoselov won the Nobel Prize in Physics in 2010 at the University of Manchester for ground breaking experiments of two-dimensional material, graphene. During this period, least well known materials are discovered. The carbyne is sp hybridized carbon atom contains one-dimensional chain of carbon[1]. Generally, carbyne is also called hypothetical carbon allotrope[2]. The carbyne represents the hexagonal structure with lattice parameter a = 5.78 Å, b = 5.78 Å, c = 9.92 Å, $\alpha = 90°$, $\beta = 90°$, $\gamma = 120°$ [13]. The carbyne have effective surface area of about 11000 m^2g^{-1}. [3] It is presents in interstellar dust and meteorites[4]. The one of the major problem is the preparation of single crystal carbyne and it is not identified by proper characterization[5]. It is the linear chain of carbon atom which is the composed of either successive double bonds $(=C=C=)_n$ or repeating single and triple bonds $(-C\equiv C-)_n$ over the chain corresponding to the cumulene and polyyne, respectively[6]. The polyyne phase of carbyne possesses the semiconducting properties. Another phase of carbyne, cumulene, shows the metallic behavior and has lack of stability[7]. In the present article, we are focused on the preparation method, properties of carbyne and its application.

Review of Literature

Cannella et al. in 2015[8] have reported the mechanism for the carbyne ring structure from graphite sample heated at high temperature using pulse laser. Wesolowski et al. in 2011[9] have prepared the carbon nanoparticles containing polyyne chains by irradiating Ti:Sapphire tabletop laser on liquid phase of benzene. In their preparation method, the laser beam incident on the liquid benzene. After irradiation of laser for 20 minutes, it is observed that the brown color precipitates is produced. The carbon nanoparticles are analyzed by atomic force microscopy (AFM) and surface enhanced Raman spectroscopy (SERS). AFM revealed that the shapes of nanoparticles are spherical, prolate and toroidal. The amorphous structure of carbon is observed found from SERS.

Xue et al. in[10] have prepared the linear carbon chain containing polycumulenes structure from the potato starch pyrolysis process. The mixture of potato starch and iron nitrate aqueous solution is taken in tube furnace. By passing the mixture of Ar/H_2 stream on the tube furnace and controlled the temperature and reaction pressure at 0.2 MPa. The reactions proceed at temperature 500°C, 800°C and cooled at room temperature. After whole process, only Ar gas stream is passed at 800°C for the period of 6 hours in reactor. The final product is purified by using hydrochloric acid for the removal of Fe catalyst. The advantage of such method is to obtain a fine structure of linear carbon chain. The Raman spectrum of carbon atom wire is observed at absorption peak of 971, 999.5, 1077.5 and 1506 cm^{-1} which is related to the polycumulenes structure.

Kavan at al. in[11] have reported the polyyne phase of carbyne prepared via the electrochemical carbonization process. Liu et al.[12] prepared the carbyne using oxidative poly-condensation of acetylene. In their work, preparation is made in aqueous and benzene phase. The stock solution of calcium carbide (CaC_2), ammonium hydroxide ($NH_3.H_2O$), silver nitrate ($AgNO_3$), Perchloric acid ($HClO_4$) is composed in distilled water. Silver nitrate and ammonium hydroxide solution are magnetically stirred until the formation of homogeneous mixture. Calcium carbide solution mixed up in mixture of silver nitrate and ammonium hydroxide and then Perchloric acid added at temperature 35 °C for 8 hour under constant stirring. Fourier transform infrared (FTIR) revealed that the black residues

appeared at 2105.89 cm^{-1}, 1944.20 cm^{-1} which indicated the α-carbyne and β-carbyne forms of carbyne, respectively and also at 815.32 cm^{-1} peak due to presence of silver ions (Ag). In the second stage, preparation is made by replacing distilled water with benzene phase. In this case, it is achieved the higher purity with longer linear carbon chain. The polycondensation method is controlled process, mild reaction condition and good quality product.

Properties of Carbyne

The well known carbon allotropes are the diamond, graphite, fullerenes nanotubes, graphene, lonsdaleite and C_8 which shows very interesting properties. All these allotropic forms of carbon composed of sp^2 and sp^3 hybridized carbon atom. The absence of sp bonded carbon allotrope is carbyne. Carbyne shows the strong purple-blue fluorescence spectrum[13]. The band gap of carbyne is approximately 2.56 eV[14]. The one dimensional carbyne chain composed of cumulenes or polyynes forms. The C-C double bonded structure of carbyne form shows the conducting response which related to cumulenes phase. The polyynes phase of carbyne composed of single and triple bond subunit corresponding to the insulator[15]. The cumulene phase is converted into the polyyne phase according to the study of peierls transition induced strain[16]. Electron spin resonance data, the evaluated g-factor of carbyne about 2.0044 ± (3) which is larger than values of graphite (2.0036) and diamond (2.0027)[17].

Conclusion

According to the literature survey of carbyne materials, least number of research papers are presented. Carbyne is the least well known materials up to date. It is the basic structure of all the allotropic form of carbon with the sp bonded carbon atom. It is difficult to synthesize at normal condition. The sp bonded carbon atom, carbyne, shows the excellent properties due to the effective surface area. Carbyne is the most potential applicable materials. The carbyne and carbyne materials is used in era of energy storage system due to large surface area such as hydrogen storage[18], battery[19] and so on.

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