The arc sputtering of the graphite in liquids

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Introduction

The well-known method of fullerenes synthesis by W. Kratschmer [1] is the process of electric arc sputtering of the graphite in the gaseous medium under lower pressure. In so doing, the chemical nature of the gas phase can essentially change the composition of the sputtering products. The composition of products of gas-phase sputtering of graphite or composite materials on its basis is intensively studied during last 15-20 years.

At the same time, it is possible to carry out graphite sputtering in liquids. This report at the first time deals with our experiments on graphite sputtering in water, toluene and alcohol. The task statement assumed to obtain the new products both in the solid and in the liquid phase.

Discussion

The method and facility for arc synthesis of the materials is described by A.G. Dubovoy [2].

In the course of graphite arc sputtering in liquids, it is necessary to take into account both processes taking place in the arc and, also, the interaction of the arc-sputtering products with liquid medium. In the first case the high temperature of product evaporation plays a special role. On the contrary, the product, being a mixture of the evaporated carbon, vapours and decomposition products of the liquid medium, undergoes the processes of the immediate quenching with the rate of 10^{10} to 10^{14} degrees per second.

As a result of the synthesis, the product is formed in two phases: the solid (nanostructural carbon in the various modifications) and the liquid, as a solution of the products of carbon interaction with the liquid.

The synthesis in water results in the formation of the highly-dispersed carbon where some quantity of hydrogen- and oxygen-containing groups formed in the course of water decomposition presents.

When water is replaced with an alcohol the content of hydrogen in the solid phase essentially increases.

The graphite sputtering in toluene results in the formation of both fractal carbon clusters and the soluble products. The liquid-phase products are the mixture of different hydrocarbons which is similar, as to its colour, to the extract of fullerenes mixture in toluene.

To identify the fullerenes in the liquid-phase products, the analysis of the obtained solutions by optical spectroscopy in the range 340 to 600 nm was carried out. The SF-26 spectrophotometer with digital data output was used for these measurements.

The spectrum of the starting solution contains the single wide adsorpotion band with flat maximum in the region about 340 nm. The position of the maximum is shifted to long-wave region when the concentration of the solution increases. The characteristic adsorption bands for the C_{60} and C_{70} were not observed in the spectra.

Using the chromatographic column with activated graphite, d = 4 cm, l = 100 cm, the starting solution has been separated to 17 fractions. Two peaks related to the fractions VII and XII are visibly found in the chromatogram.

The spectroscopic study of the solutions from the fraction VII showed that their spectra are identical to the spectra of the starting solution. The two adsorption bands in the wavelength regions of 365 nm and 383 nm have appeared in the spectra of the solution from the fraction XII. The positions of the bands are closed to ones for C_{70} fullerene.

At the same time, the solid phase contains the order of magnitude more hydrogen than the one obtained in water.

Conclusion

1. The electric arc sputtering of the graphite in liquids is a new original method for obtaining the nanostructural carbon materials.

2. The electric arc sputtering of the graphite in hydrocarbons results, apart from the formation of modified carbon materials, in the appearance of soluble products that is accompanied by the change in colour and optical density.

3. The proposed method can yield the wide spectrum of new materials and become one of the ways to synthesize the carbon nanostructures.

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Дуговое распыление графита в жидкостях

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Введение

Широко известный метод получения фуллеренов (метод В. Кретчмера [1]) представляет собой процесс электродугового распыления графита в газовой среде при пониженном давлении. При этом химическая природа газовой фазы существенным образом может изменить состав продуктов распыления. Исследования состава продуктов распыления графита или композиционных материалов на основе графита в газовой фазе активно проводятся в течении последних 15-20 лет.

Вместе с тем возможно проведение распыления графита в жидкостях. В настоящем докладе мы впервые приводим описание наших экспериментов по распылению графита в воде, толуоле и спирте. При постановке нашей работы мы предполагали получить новые продукты как в твердой так и в жидких фазах.

Обсуждение

Метод и установка по синтезу материалов дуговым методом описаны в работе А.Г. Дубового [2].

При дуговом распылении графита в жидкостях необходимо учитывать как процессы, протекающие в дуге, так и взаимодействие продуктов дугового распыления с жидкой средой. Если в первом случае особую роль играет высокая температура испарения продукта, то во втором случае продукт, представляя смесь испаряемого углерода, паров и продуктов разложения жидкой среды, претерпевает процессы мгновенной закалки со скоростью 10^{10}-10^{14} град./с.

В результате синтеза продукт образуется в виде двух фаз – твердой (наноструктурный углерод в различных модификациях) и жидкой (в виде раствора продуктов взаимодействия углерода с жидкой фазой).

Синтез в воде приводит к образованию высокодисперсного углерода, содержащего некоторое количество водород- и кислород-содержащих групп, образующихся при разложении воды.

При замене воды на спирт содержание водорода в твердой фазе значительно увеличивается.

Распыление графита в толуоле приводит к образованию как фрактальных кластеров углерода, так и растворимых продуктов. Жидкофазные продукты представляют собой смесь различных углеводородов, по цвету похожих на экстракт смеси фуллеренов в толуоле.

С целью идентификации фуллеренов в жидкофазных продуктах проведен анализ полученных растворов методом оптической спектроскопии в диапазоне 340-600 нм. Использовался спектрофотометр СФ-26 с цифровым выводом данных.

Спектр исходного раствора представляет одну широкую полосу поглощения с пологим максимумом в области 340 нм, положение которого с увеличением концентрации раствора сдвигается в длинноволновую область. Характерных полос поглощения для C_{60} и C_{70} на спектрах не наблюдается.

Хроматографичеки (колонка с активированным графитом, *d*=4 см, *l*=100 см) исходный раствор был разделен на 17 фракций. На хроматограмме заметно прослеживаются два пика, относящиеся к фракциям VII и XII.

Спектроскопическое исследование растворов из фракции VII показало, что их спектры идентичны спектрам исходного раствора. На спектрах раствора из фракции XII появились две полосы поглощения в области длин волн 365 нм и 383 нм, близкие по своему положению к положению полос поглощения фуллерена C_{70}.

Твердая фаза при этом содержит водорода на порядок больше, чем полученная в воде.

Выводы

1. Электродуговое распыление графита в жидкостях является новым оригинальным

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способом получения наноструктурных углеродных материалов.

2. Электродуговое распыление графита в углеводородах приводит, наряду с образованием модифицированных углеродных наноматериалов, появлению растворимых продуктов, что сопровождается изменением окраски и оптической плотности.

3. Предложенный метод может дать большой спектр новых материалов и стать одним из способов синтеза углеродных наноструктур.

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