

ARTICLE

PRODUCTION OF CARBON NANODOTS IN THE DETECTION OF MICROBIAL AGENTS

Hamid Reza Saljooghi

Jiroft University of Medical Sciences and Health Services

ABSTRACT

Today, nanotechnology is one of the modern sciences and has affected all human life. This knowledge has been used in different fields such as the food industry. Since human beings are in dire need for food daily and permanently, any change in the food industry will have an important role in changing the quality of human life. One of the most useful tools in nanotechnology is the production of nano dots which are useful in different fields including the food industry in areas such as packing, molecular foods, labeling and monitoring, food additives, foods having a special releasing in body, and enzymes encrusting. Most researchers believe that nanotechnology is one of the foundations of the independence consolidation and national security of the country. Nanotechnology can be studied in two aspects of food safety and nutrition as well as overt and covert anti-hunger fighting. One of the most important different structures in nano-carbons is Dotty carbon clusters (carbon nano dots), and there are different ways to produce them. In this study, which has been conducted by the use of microwave method for producing carbon nano dots and then, it has used the Bioluminescence properties to verify microbial spoilage or destruct food vitamins in packed foods, the size of carbon nano dots in the nano dimension shows different qualities of light, and the survey found that the nano dots production by the mentioned methods can be useful in the visual detection of microbial contamination in food ingredients and vitamins or in labeling and monitoring in food additives and foods having a special emission in body and in enzymes encrusting.

INTRODUCTION

Carbons at the quantum level have passivizing surfaces that are very stable, and are highly regarded due to the properties of immune-reactivity before light, biocompatibility, low toxicity, cost-effectiveness and abundance of its raw materials in the nature. Carbon nano dots have a very good solubility in water because of the existence of a lot of carboxylic acid on their surfaces, and this has caused them to be functionalized by the use of organic, polymeric, inorganic, and biological materials. These nano-structures have attracted a considerable attention due to their very small dimensions and uniform structure, diversity of simple production methods, the ability to functionalize them, and specially the ability to replace them with toxic metal quantum dots. Carbon dots are a new generation of carbonic photoluminescents containing oxygen which are spherical and their size is less than 10 nm [1]. These nano dots were obtained by chance in 2004 when purifying single-walled carbon nanotubes via electrophoresis. Nano dots are special superior than organic pigments in terms of high solubility in water, bioavailability and biocompatibility properties, simplicity in surface functionalizing, low toxicity, the ability to fluorescence, and high stability against fading. Carbon dots are known as fluorescent carbons due to their strong fluorescence properties [2]. This characteristic of nano dots has led to complex catalyst systems based on carbon nano-dots in order to provide the cost-effective use of all sunlight spectrums. But it should be noted that in these nano dots, their less than 10 nm dimensions have a special optical catalyst, and their larger sizes have little or no optical activity [3]. Various materials including graphitic masses and carbonic materials such as nano diamonds [5], carbon nanotubes [11], soot [4], activated carbon [8], and graphite oxide [10] are used to produce these carbon nano dots by employing simple and inexpensive methods such as laser avulsion (Sonthanasamy, Ahmad et al. 2016), arc discharge [6], chemical oxidation [7], combustion oxidation [12], and microwaves and ultrasound [16].

METHODS

In this study, the synthesis of nanoparticles was made using the thermal effect of microwaves and a combination of polyethylene glycol and a sugar compound such as glucose or fructose. In this way, different amounts of polyethylene glycol and polysaccharide were solved in distilled water and the resulting clear solution was placed in a 500W microwave oven for 10 to 19 minutes, and after functionalizing agents and neutralizing to detect microbial agents cultured in TSI culture medium, it has been used.

RESULTS

With increasing the reaction and shelf life, the solution color was changed to yellow and finally to dark brown [Fig. 1].

Due to the reaction prolongation under microwave conditions, the generated nanoparticles become slightly larger and find the ability to have light emitting at higher wavelengths as well. In this way, after 5 to 10 minutes irradiation, microwave of carbon nano dotes with sizes from 2.65 nm to 2.75 nm were obtained. Finally, the generated nano dots were resulted after removal of ethylene glycol by using the flooded concentrated sulfuric acid, and the generated carbonic mass were resulted by using distillation in 2M citric acid, and then by neutralization through sodium carbonate and removal of salt by the use of dialysis bag of 5 nm carbon nano dots [12]. The nano dots were deactivated through reaction with 4, 7, and 10-trioxo, 1 and 3-tridecan ethylene diamine, olein amine, or polyethylene glycol (PEG) at 120oC for 72h under a

KEY WORDS

Nanodot, microbial, photolytic, traditional medicine, *Mus musculus*, *Toxoplasmosis*

Published: 10 October 2016

*Corresponding Author
Email:
nahidyuk@gmail.com

nitrogen atmosphere, and finally, by creating a level agent binding to bacteria, they led to the nano dot binding to bacteria and finally, identifying the microbial agent. Infrared spectroscopy showed the Fourier transformation of a tensile band in the area of 1572 cm⁻¹ in accordance with carbon-carbon double bond and a vibratory band in the area of 1375 cm⁻¹ in accordance with carbon-hydrogen bond. From the images of Transmission Electron Microscopy (TEM), the existence of crystal structure consisted of a similar network space was demonstrated. Elemental analysis proved the existence of carbon nano dots rich of carbon and oxygen with 57 wt% carbon, 7.5 wt% hydrogen, 8.5 wt% nitrogen, and 27 wt% oxygen.

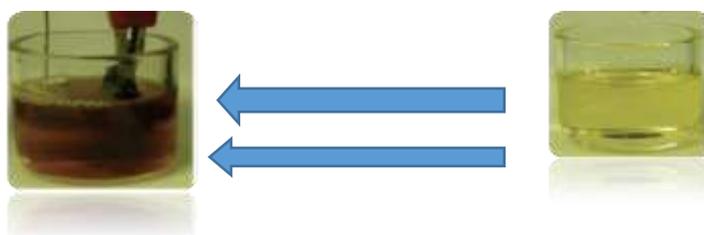


Fig. 1: The color change of the solution containing raw materials from yellow to dark brown with a higher irradiation time represents the generation of carbon nano dots.

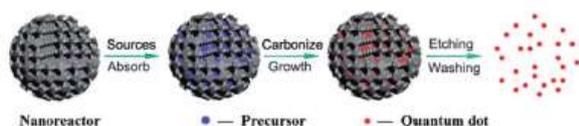


Fig. 2: Generation of carbon nano dots by absorbing microwave irradiation.

Nano dots generated in this way have absorption bands at about 320-260 nm. Carbon nano dots have an optical absorption with end stretching up to visible light range in the ultraviolet light range [Fig. 3].

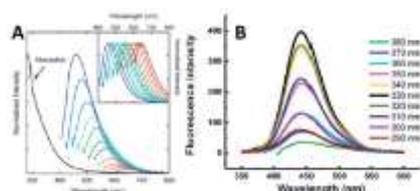


Fig. 3: The optical absorption on carbon nano dots in the visible to ultraviolet light spectrum.

Since the surface agents groups attached to nano dots are effective across absorption wave of nano dot, the nano dot absorption band increases into longer wavelengths after being functionalized with TTDDA or Organosilane (Gong, Hu et al. 2014). Two main optical characteristics of nano dots are based on the emission by surface energy traps and the effect of quantum size, so that the blue emission (shorter wavelengths) is resulted from the effect of quantum size and the green emission (longer wavelengths) is resulted from the effect of surface energy traps (Yang, Zhao et al. 2015). It should be noted that the exited optimal property of nanodots depends on the existence of the surface agents in the relevant nano dots and the nanodot size, so that according to the investigations conducted by Gang, Hu et al (2014), nanodots with a small size of 1.2 nm are dispersed in the ultraviolet area and nano dots with the size of 1.5-3 nm are dispersed in the area of visible light and the types with the size larger than 3.8 nm are dispersed in the area near infrared [Fig. 4 & 5] .

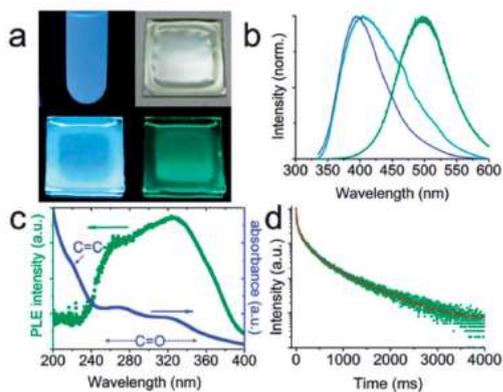


Fig. 4: Fluorescence property of carbon nano dots with absorbing the ultraviolet light.

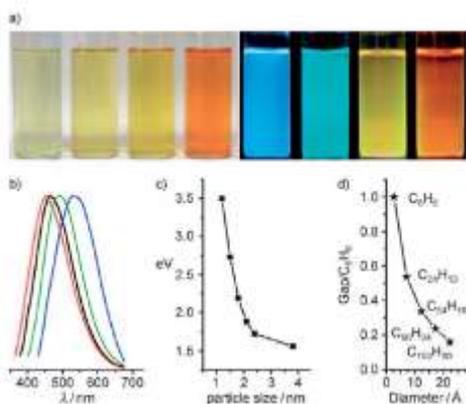


Fig. 5: Different emission spectrums of nano dots with different sizes.

Since agent groups have different energy levels, which can lead to produce a group of emission traps, when a light at a special wavelength is provoked, it causes the brightness of carbon nano dot, and in this case, the surface state of emission traps will determine the dispersion; now if the related carbon nano dot surface is neutralized through oxidation and other reactions of surface modification by the use of specified organic groups, then the light emission will simply be seen through shifting into red. Usually, surface-counteractive materials are agents having amine groups or polymers such as octadecylamine and/or polyethylene glycol. Research shows that different oxidation of nano dots surfaces leads to the emission of different optical colors (Shi, Li et al. 2016). In the investigations, it was indicated that carbon nano dots are used due to their unique light induction properties and the excellent ability of electron diffraction as a choice for photovoltaic and optimal catalyst applications. Therefore, by creating targeted surface agents on these nano dots and then by oxidation of the relevant surface agents through oxidizing agents that are created in bacteria – considered as agents of food spoilage – or oxidizing agents that are created as a result of physical destruction of nutrients including vitamins, carbon nano dots can be dispersed, and accordingly, by the use of optical imaging process from such a excited nano dots in the mentioned state, the contaminated food sample can be immediately identified, and even if the surface-oxidizing agent can be designed in such a way that it is exclusively produced by a special bacteria, a novel method for the detection of the relevant bacteria can be conducted. In this study, exclusively by creating surface agents bonding to bacterial antigens, the ability of optical identification of bacteria has been gained [Fig. 6.a & b].

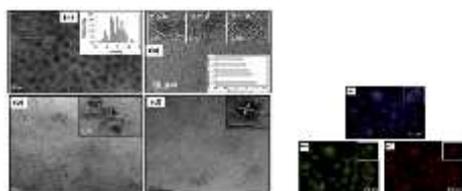


Fig. 6: a) different images of transversal electron microscope from generated carbon nano dots; b) fluorescence property of carbon nano dots employed in the detection of bacterial samples and vitamin agents or animal food agents.

CONCLUSION AND DISCUSSION

As expressed, due to the prolongation of the reaction under microwave conditions, the generated nano dots become slightly larger and gain the ability to have optical dispersion across longer wavelengths. In this way, after 5-10 min irradiation, carbon nano dots microwave waves in the size of 2.65-2.75 nm are resulted. This process in Liu & He experiments showed that 5 nm carbon nano dots have photoluminescence strength. Also, as expressed, the nano dots were deactivated through reaction with 4, 7, and 10-trioxo, 1 and 3-tridecan ethylene diamine, olein amine, or polyethylene glycol (PEG) at 120°C for 72h under a nitrogen atmosphere, and finally, by creating a level agent binding to bacteria, they led to the nanodot binding to bacteria and finally, identifying the microbial agent. Infrared spectroscopy showed the Fourier transformation of a tensile band in the area of 1572 cm⁻¹ in accordance with carbon-carbon double bond and a vibratory band in the area of 1375 cm⁻¹ in accordance with carbon-hydrogen bond. The existence of longer wavelengths after functionalizing carbon nano dots according to Gang experiments was completely clear. In the investigations, it was indicated that carbon nano dots are used due to their unique light induction properties and the excellent ability of electron diffraction as a choice for photovoltaic and optimal catalyst applications. Therefore, by creation of targeted surface agents on these nano dots and then by oxidation of the relevant surface agents through oxidizing agents that are created in bacteria – considered as agents of food spoilage – or oxidizing agents that are created as a result of physical destruction of nutrients including vitamins, carbon nano dots can be dispersed, and accordingly, by the use of optical imaging process from such a exited nano dots in the mentioned state, the contaminated food sample can be immediately identified, and even if the surface-oxidizing agent can be designed in such a way that it is exclusively produced by a special bacteria, a novel method for the detection of the relevant bacteria can be conducted. In this study, exclusively by creating surface agents bonding to bacterial antigens, the ability of optical identification of bacteria has been gained.

CONFLICT OF INTEREST

There is no conflict of interest.

ACKNOWLEDGEMENTS

None

FINANCIAL DISCLOSURE

None

REFERENCES

- [1] Arcudi FL, Dordevic M, Prato. [2016] Synthesis, Separation, and Characterization of Small and Highly Fluorescent Nitrogen-Doped Carbon Nano Dots. *Angew Chem Int Ed Engl.* 55(6):2107-2112.
- [2] Castro HP, Souza VS, Scholten JD, Dias JH, et al. [2016] Synthesis and Characterisation of Fluorescent Carbon Nano dots Produced in Ionic Liquids by Laser Ablation. *Chemistry.* 22(1):138-143.
- [3] Cayuela A, Soriano ML, Carrillo-Carrion C, Valcarcel M. [2016] Semiconductor and carbon-based fluorescent nano dots: the need for consistency. *Chem Commun (Camb).* 52(7):1311-1326.
- [4] Chen J, Dou R, Yang Z, Wang X, Mao c, Gao X, Wang L. [2016] The effect and fate of water-soluble carbon nano dots in maize (*Zea mays* L.). *Nano toxicology:* 1-11.
- [5] Chen S, Zheng H, Wang J, Hou J. [2013] Carbon nano dots as a matrix for the analysis of low-molecular-weight molecules in both positive- and negative-ion matrix-assisted laser desorption/ionization time-of-flight mass spectrometry and quantification of glucose and uric acid in real samples. *Anal Chem.* 85(14):6646-6652.
- [6] Chizhik AM, Stein S, Dekaliuk MO. [2016] Super-Resolution Optical Fluctuation Bio-Imaging with Dual-Color Carbon Nano dots. *Nano Lett.* 16(1): 237-242.
- [7] Deng J, Lu Q, Mi N, Li H. [2014] Electro chemical synthesis of carbon nano dots directly from alcohols. *Chemistry.* 20(17):4993-4999.
- [8] Dou X, Lin Z, Chen H, Zheng Y. [2013] Production of superoxide anion radicals as evidence for carbon nano dots acting as electron donors by the chemiluminescence method. *Chem Commun (Camb).* 49(52):5871-5873.
- [9] Gong X, Hu Q, Paa MC. [2014] High-performance liquid chromatographic and mass spectrometric analysis of fluorescent carbon nano dots. *Talanta* 129: 529-538.
- [10] Gude V. [2014] Synthesis of hydrophobic photoluminescent carbon nano dots by using L-tyrosine and citric acid through a thermal oxidation route. *Beilstein J Nano technol.* 5:1513-1522.
- [11] Guo DY, Shan CX, Liu KK, Lou Q, Shen DZ. [2015] Surface plasmon effect of carbon nano dots *Nanoscale.* 7(45):18908-18913.
- [12] Liu H, He Z, Jiang LP, Zhu JJ. [2015] Microwave-assisted synthesis of wavelength-tunable photoluminescent carbon nano dots and their potential applications. *ACS Appl Mater Interfaces.* 7(8):4913-4920.
- [13] Shi L, Li Y, Li X, Zhao B, et al. [2016] Controllable synthesis of green and blue fluorescent carbon nano dots for pH and Cu(2+) sensing in living cells. *Biosens Bio electron.* 77:598-602.
- [14] Sonthanasamy RS, Ahmad WY, Fazry S, Hassan NI, Lazim AM. [2016] Transformation of crystalline starch nanoparticles into highly luminescent carbon nano dots: Toxicity studies and their applications *Carbohydr Polym.* 137:488-496.
- [15] Yang P, Zhao J, Wang J, Cui H, Li L, et al. [2015] Multifunctional Nitrogen-Doped Carbon Nanodots for Photoluminescence, Sensor, and Visible-Light-Induced H₂ Production. *Chemphyschem.* 16(14):3058-3063.
- [16] Youn DH, Seol M, Kim JY, Jang JW, et al. [2013] TiN nanoparticles on CNT-graphene hybrid support as noble-metal-free counter electrode for quantum-dot-sensitized solar cells. *Chem Sus Chem.* 6(2):261-267.
- [17] Zhu A, Luo Z, Ding C, Li B, et al. [2014] A two-photon "turn-on" fluorescent probe based on carbon nano dots for imaging and selective bio sensing of hydrogen sulfide in live cells and tissues. *Analyst.* 139(8):1945-1952.