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ARTICLE

PRODUCTION OF CARBON NANODOTS IN THE DETECTION OF MICROBIAL AGENTS

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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 nanodots 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 nanodots), and there are different ways to produce them. In this study, which has been conducted by the use of microwave method for producing carbon nanodots and then, it has used the Bioluminescence properties to verify microbial spoilage or destruct food vitamins in packed foods, the size of carbon nanodots in the nano dimension shows different qualities of light, and the survey found that the nanodots 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.

KEY WORDS
Nanodot, microbial, photolytic

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INTRODUCTION

Carbons at the quantum level have passivating surfaces that are very stable, and are highly regarded due to the properties of immunoreactivity before light, biocompatibility, low toxicity, cost-effectiveness and abundance of its raw materials in the nature. Carbon nanodots 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 nanodots were obtained by chance in 2004 when purifying single-walled carbon nanotubes via electrophoresis. Nanodots 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 nanodots 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 nanodots, 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 nanodiamonds [4], carbon nanotubes [5], soot (Chen, Dou et al. 2016), activated carbon [4], and graphite oxide [10] are used to produce these carbon nanodots by employing simple and inexpensive methods such as laser avulsion (Sonthanasamy, Ahmad et al. 2016), arc discharge [6], chemical oxidation [7], combustion oxidation [17], 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].

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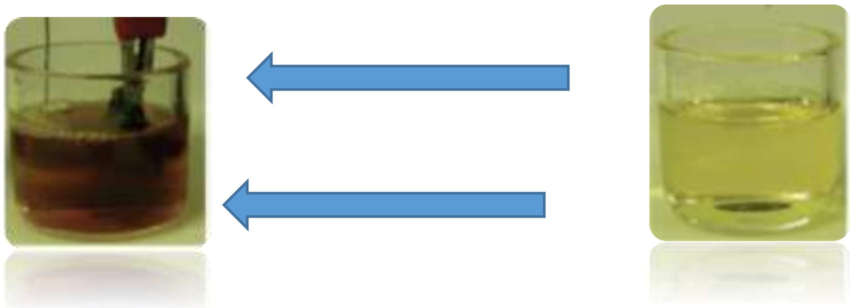

Fig. 1: The color change of the solution containing raw materials from yellow to dark brown with a higher irradiation time represents the generation of carbon nanodots.

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 nanodotes with sizes from 2.65 nm to 2.75 nm were obtained. Finally, the generated nanodots 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 nanodats [12]. The nanodots 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 doubled 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 nanodots rich of carbon and oxygen with 57 wt% carbon, 7.5 wt% hydrogen, 8.5 wt% nitrogen, and 27 wt% oxygen [Fig.2].

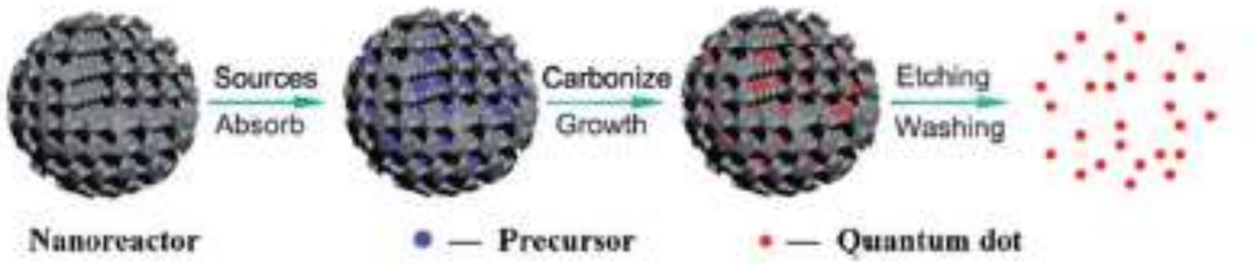

Fig. 2: Generation of carbon nanodots by absorbing microwave irradiation.

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

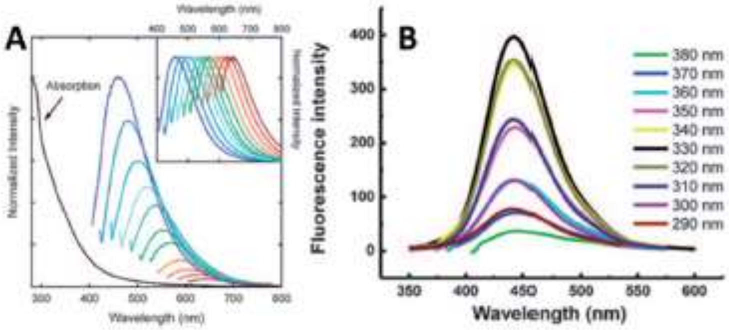

Fig. 3: The optical absorption on carbon nanodots in the visible to ultraviolet light spectrum.

Since the surface agents groups attached to nanodots are effective across absorption wave of nanodot, the nanodot absorption band increases into longer wavelengths after being functionalized with TTDDA or

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Organosilane [9]. Two main optical characteristics of nanodots 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 [15]. It should be noted that the exited optimal property of nanodots depends on the existence of the surface agents in the relevant nanodots 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 nanodots 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].

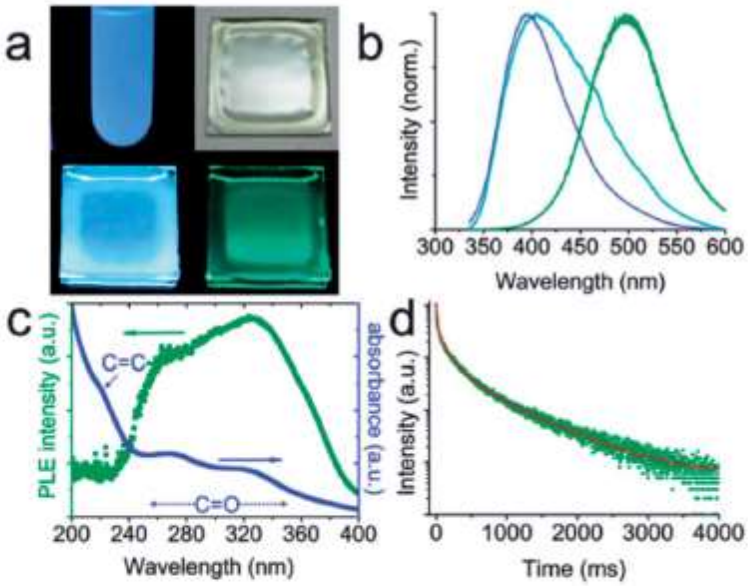

Fig. 4: Fluorescence property of carbon nanodots with absorbing the ultraviolet light .

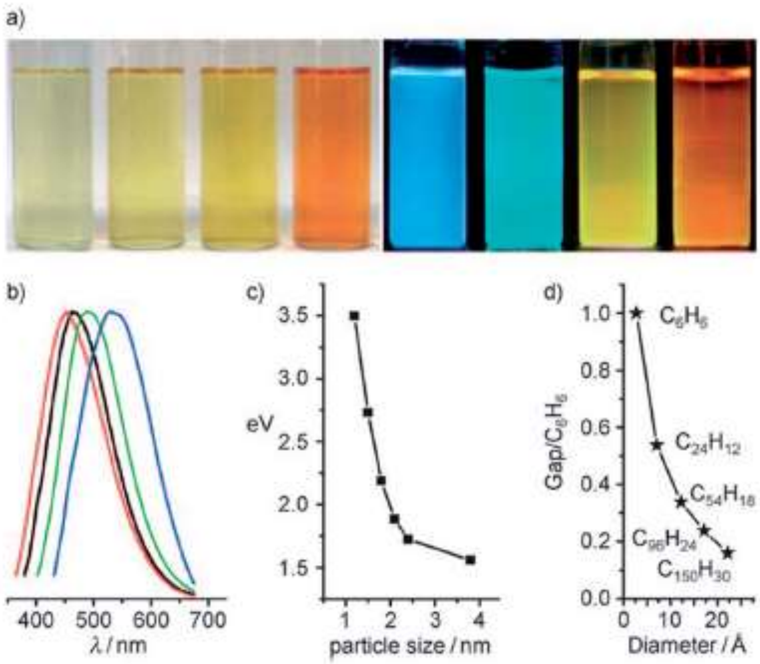

Fig. 5: Different emission spectrums of nanodots with different sizes.

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 nanodot, and in this case, the surface state of emission traps will determine the dispersion; now if the related carbon nanodot 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 nanodots surfaces leads to the emission of different optical colors [13]. In the investigations, it was indicated that carbon nanodots 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 nanodots 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 nanodots can be dispersed, and accordingly, by the use of optical imaging process from such a exited nanodots 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).

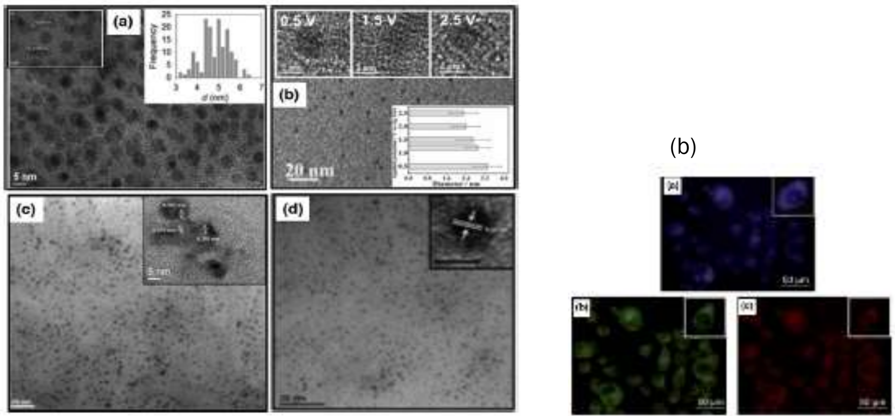

Fig. 6(a): different images of transversal electron microscope from generated carbon nanodots; **(b)** fluorescence property of carbon nanodots employed in the detection of bacterial samples and vitamin agents or animal food agents.

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DISCUSSION AND CONCLUSION

As expressed, due to the prolongation of the reaction under microwave conditions, the generated nanodots become slightly larger and gain the ability to have optical dispersion across longer wavelengths. In this way, after 5-10 min irradiation, carbon nanodots microwave waves in the size of 2.65-2.75 nm are resulted. This process in Liu & He experiments showed that 5 nm carbon nanodots have photoluminescence strength. Also, as expressed, the nanodots 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 doubled 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 nanodots according to Gang experiments was completely clear. In the investigations, it was indicated that carbon nanodots 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 nanodots 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 nanodots can be dispersed, and accordingly, by the use of optical imaging process from such a exited nanodots 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.

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FINANCIAL DISCLOSURE
None

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