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Antibacterial Activities of Carbon Quantum Dots Derived From Lemon Juice

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Abstract. Carbon Quantum Dots (CQDs) were synthesized by a simple, effective, high yield and low cost hydrothermal technique which was used to prepare the introduced carbon quantum dots powder from Lemon juice. The Carbon Quantum Dots (CQDs) were characterized by *Transmission electron microscopy* (*TEM*), Fourier transform infrared spectroscopy (FT-IR), ultraviolet-visible spectroscopy (UV-vis), and were used to study the morphology, chemical composition, and spectroscopy properties. Herein, we described a study of the immobilization of an antibacterial agent and its interaction with different types of bacterial colonies. The CQDs displayed good antibacterial activity against a number of positive & negative bacteria. The results showed that CQDs exhibited better antibacterial efficiency against Kokuria Kristina (approximately 35 mm) comparing to other bacterial. The aim of the study is to assess the applicability of the CQDs in antibacterial filtration and various biomedical applications.

INTRODUCTION

Carbon quantum dots (CQDs) as an emerging class of quantum dots (QDs), which is a new class of carbon-based nanomaterial normally with the spatial size less than 20 nm, which was discovered by Xu et al. in 2004 [**1**]. Carbon quantum dots (CQDs) have received considerable attention in biomedicine, versatile sensor, water pollutants, hematin, drugs, vitamins,and photodetection, because of their highly biocompatibility, luminescent properties, and sphere-shaped nanoparticles, easy synthesis routes, economical synthesis, cheap starting materials, water-solubility, low levels of toxicity, chemical stability, and easy functionalization [**2-3**]. Nowadays, many efforts have been made on the development of new strategies for synthesis and doping of CQDs. Different physical and chemical methods, such as hydrothermal treatment, laser ablation, electrochemical oxidation and microwave treatment, have been presented in the literature [**4-7**]. In general, the hydrothermal approach has been employed in many studies for CQDs formation using various natural resources, such as leaves, fruits, grains, seeds, and even beverages such as beer, coffee, milk, and tea [**8 -10**]. Green synthesis for CQDs from natural resources by hydrothermal technique has great advantages in different application because, it is simple, repeatable, environment friendly, and cost-effective.

EXPERIMENTAL PART

Prapering Carbon Quantum Dots

In a typical experiment, 40mL of extract lemon juice (ivorywhite solution) was put into a Teflon-lined stainless steel autoclave for hydrothermal treatment at 120 to 280◦C for 12 h. After the reaction, the autoclave was naturally cooled to room temperature. During this hydrothermal process, ivorywhite solution changed to dark brown solution, indicating the formation of C-dots. -ese carbon dots were then purified to remove the larger nanoparticles by 2 μmfilter paper. -e microstructure and particles size distribution of the C-dots were determined by using high-resolution transmission electron microscope, HRTEM (JEM 2100, JEOL Techniques, Tokyo, Japan), and dynamic light

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scattering (DLS, Malvern, England), respectively. Chemical bonding of the C-dots were measured with Fourier transform infrared spectroscopy (FTIR using a Perkin–Elmer Spectrum BX spectrometer) using KBr pellets and X-ray photoelectron spectrometer (XPS, Multilab 2000, -ermo Fisher Scientific, USA). Optical absorption and room temperature PL of the C-dots were performed using a Cary 500 spectrophotometer and a NANO LOG spectrofluorometer (Horiba, Edison, NJ, USA) equipped with a 450W xenon arc lamp.

Antibacterial Properties

The antibacterial effectiveness of CQDs was studied against Gram's positive bacterial such as Staphylococcus aureus, and Gram's Negative bacterial such as Escherichia coli, using an agar well diffusion style in the Natthan at el procedure [**11**], in a clean aseptic room. 20 mL of Muller-Hinton was poured in sterile Petri dishes before culturing. Stock cultures of bacterial species were collected using a sterile wire loop. After the organisms were cultured, by prepared bacterial inoculums were swabbed throughout the surface of the nutrient agar medium (growth medium) using a sterilized cotton swab to maintain uniform distribution of the bacteria across the plate surface, wells with diameter of 6 mm were bored on the agar plates by using a sterile tip.carbon quantum dots were placed into the well and incubated for 24 h at 37 °C. Successively, the inhibition zone (mm) formed in the Petri dish was observed

RESULT AND DISCUSSION

Structure Characterization of Carbon Quantum Dots

Figures 1 shows the TEM image of CQDs synthesized at 250°C for 8h**.** The morphology and size of prepared CQDs were observed by TEM. It shows that CQDs are nearly spherical and exhibit nearly uniform dispersion with diameter around 8 – 12 nm. TEM image does not show discernible lattice structures of C-dots on the higher magnification, suggesting that C-dots are amorphous dots. Although many scientists have demonstrated the existence of a sp2 crystal carbon, most of the C-dots have weak crystallinity [**12-13**]. Similar to natural source-derived C-dots, lemon juice-derived C-dots also have amorphous nature in this study. The surface functional groups of CDs obtained from different precursors were identified by FTIR spectroscopy. As shown in Fig. 2, the peaks at 3401 cm^{-1} were attributed to stretching vibrations of O-H [**14**]. The adsorption peaks at 1395 and 2944 cm^{-1} indicate the existence of the C-H bond. The peak of 1712 cm^{-1} corresponds to the characteristic amplitude C-O. Peaks at 1360 cm−1are thought to be related to the vibration of the COOH group [**15**]. The existence of this peak is attributed to the presence of acids in C-dots when the temperature varies between 150 and 200°C [**16**].e peak of 1024- 1195 cm^{-1} corresponds to the stretching mode of the C-O-C bond [**17**]. The optical properties of the synthesized CQDs are presented in fig.3. The UV-Vis absorption spectrum has no background absorption in the visible area. This result demonstrated that there are no other forms of nanocarbon produced during the partial carbonization of precursors which are usually absorbed at longer wavelengths [**18**].

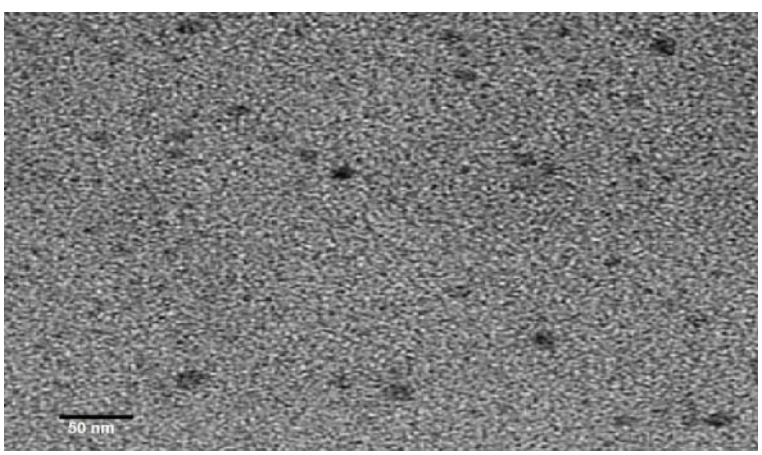

FIGURE 1. TEM image of CQDs

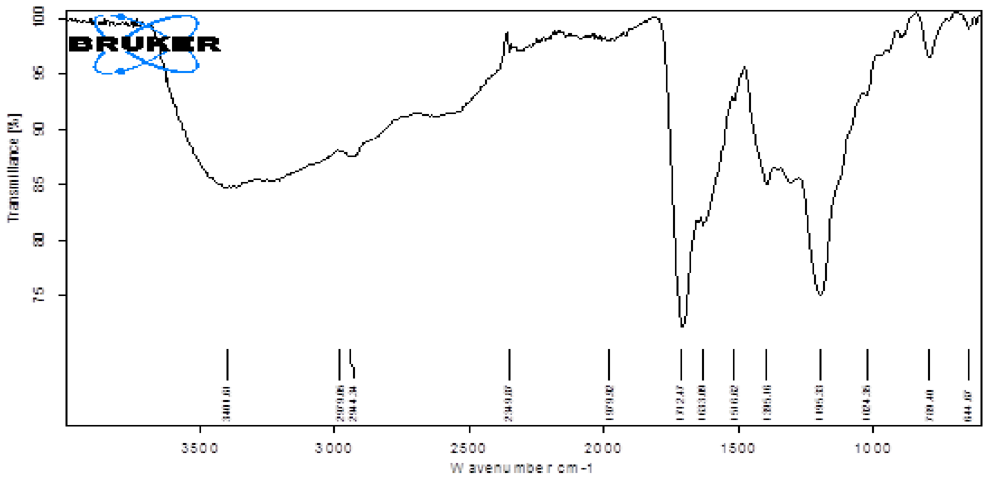

FIGURE 2. RTIR spectrum of CQDs

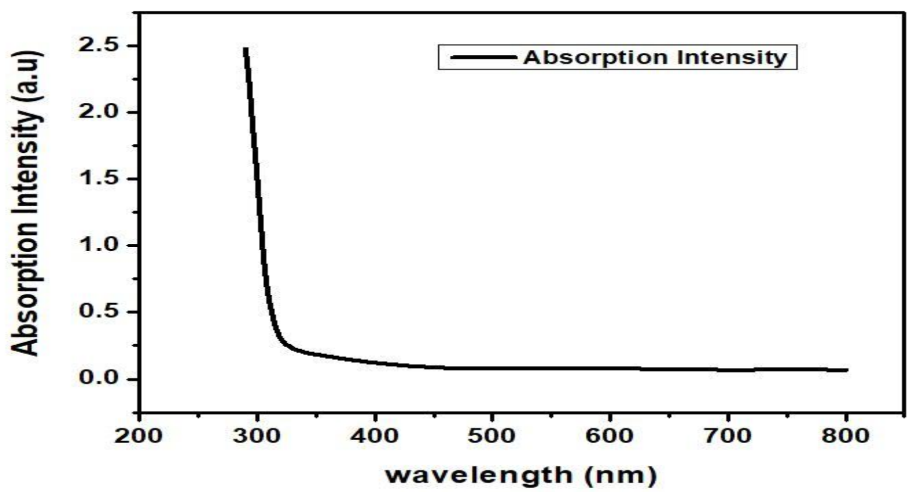

FIGURE 3. UV-vis spectrum of CQDs

Antibacterial Properties

CQDs are generally known as benign and nontoxic in vitro and in vivo. However, with their effective light-harvesting over a very broad spectral range from UV to near -IR, CQDs have exhibited strong photodynamic effects, with relevant uses in cancer therapy reported. Similarly, photoexcited CQDs are capable of producing reactive oxygen species (ROS), which are known to kill/inhibit microorganisms. According to existing research results, the major processes responsible for the antimicrobial effects of CDots are likely associated with the generation of ROS [procedure [**11**]. The antibacterial ability of the samples contained CQDs were determined in terms of the inhibition zone created on agar around the paper discs against different positive and negative gram as shown in fig.4. the diameter (D) of the inhibition zone for different bacterial were shown in table 1. Kokerocous Kristina had stronger antibacterial more than others. Results show that CQDs have antibacterial ability against Gram-positive bacteria comparing to Gram-negtive bacteria.

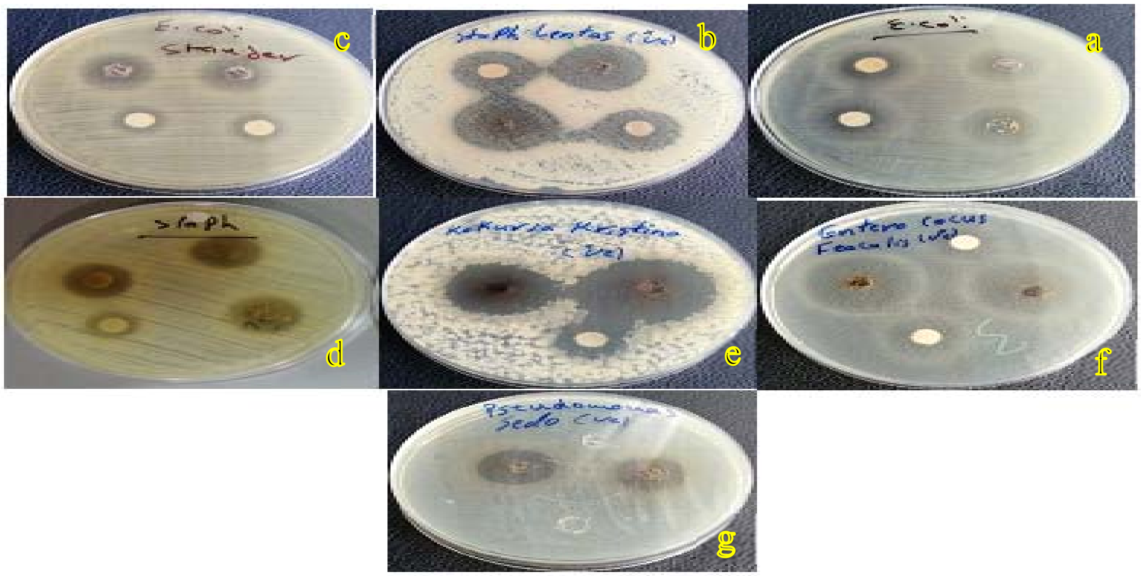

FIGURE 4. Antibacterial efficacy of CQDs against (a) E.coli, (b) Staph lentus, (c) Escherichia coli, (d) Staphylocour arease , (e) Kokerocous Kristina , (f) Enterocous feacalis , and (g) Sedo.

TABLE 1.: Diameter of the inhibition zone for different bacterial **of CQDs**

Tested organism	Gram reaction	Inhibition zone (mm)
E.coli stander	**-Ve**	**17**
Escherichia coli	**-Ve**	**18**
Sedo	**-Ve**	**21**
Staph lentus	**+Ve**	**28**
Enterocous feacalis	**+Ve**	**25**
Kokerocous Kristina	**+Ve**	**35**
Staphylocour arease	**+Ve**	**22**

CONCLUSION

This study shows that CQDs could inhibitor the growth of micro- organisms noteworthy and exhibit higher antibacterial activity Kokerocous Kristina more than all others bacterial. Also, The results show CQDs more effective for positive gram. These biodegradable, biocompatible and antibacterial of CQDs have promising potential for use as effective biomedical materials, and low cost membrane.

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