A Brief Review: Antibacterial Activity of Quinone Derivatives

Patitapaban Mohanty Subhasmita Sahoo 1, Sunita Behera 1, Rubi Behura 1, Anantjyoti Acharya 1, Debajyoti Biswal 1, Sameer Kumar Suna 1, Rojalin Sahoo 1, Ram Chandra Soren 1, Bigyan Ranjan Jali 1,*
1 Department of Chemistry, Veer Surendra Sai University of Technology, Burla, Sambalpur-768018, Odisha, India
* Correspondence: bigyan.Jali7@gmail.com (B.R.J.);

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Abstract: Quinones and their derivatives play an important role in pharmaceutical, medicinal, and environmental applications. The biological activities of quinone derivatives against various gram-positive and negative bacteria and pathogens show strategies for discovering new drug efficiency and various physio-chemical properties. This review discusses the antibacterial activities of various notable quinones and their derivatives against various bacteria and pathogens. A wide literature survey is done on the database PubMed, Scopus, and Google scholars by using code word antibacterial activity of quinone derivatives and the role of various quinone derivatives to discover new potent pharmaceutical applications. Herein, we wish to discuss various quinone derivatives used as potent drug molecules for antibacterial activity against various gram-positive and negative bacteria and pathogens. Proper health care systems are essential for newly develop methodologies to fight against unexpected bacteria and pathogens. The antibacterial activities of various quinone derivatives deliver notable supervision for additional design and synthesis of quinone derivatives and examine the pharmaceutical, industrial and medicinal applications.

Keywords: quinone; naphthoquinone; anthraquinone, anti-bacteria; activity; drug; bacteria.

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1. Introduction

Due to their unique physical and chemical properties, quinones and their derivatives play a vital role in chemical, environmental, and pharmaceutical applications [1-7]. Quinones and their derivatives are biologically active compounds and spectacle a significant role in electron-transfer and photochemical processes [8-12]. They are widely present in nature [13]. They are mainly obtained from plants, animals, bacteria, and fungi in the direct way or in-indirect way [14,15]. Quinone derivatives ascribe an important role in various fields such as chemosensor, MOF, catalyst, ROS, polymorphs, dyes, batteries, energy storage, electron transfer, etc. [16-25]. Apart from that, the natural or synthetic quinone derivatives are prominent members of viable or potential drug molecules in the medicinal and pharmaceutical industry [27-29]. Due to their sole pharmaceutical applications are widely used as anticancer, anti-oxidant, anti-malaria, antimicrobial, anti-inflammatory agents [30,31]. Quinone derivatives arouse many clinical and pharmaceutical applications such as phylloquinone, β-lapachone, lapachol, lawsone, plumbagin, juglomycin A, menadione, etc. (Figure 1). It is well documented that quinone moiety in the vitamin K1 and K2 is chiefly responsible for various biological activities [32-34]. Due to their assorted utilities and clinical applications, quinone
derivatives are widely used to develop novel antibacterial drug molecules. Herein reported the systematic evaluation of various quinone derivatives and their antibacterial activity against various bacteria and pathogens using different methods.

2. Result and Discussions

In the field of the clinical world, consideration of retardation of pathogenic bacteria towards the available antibiotic is becoming a major worldwide problem as many bacterial pathogens have already established resistance against them [35-37]. To achieve a new effective scaffold for an efficient fight against bacteria. The research on the development of a new antimicrobial agent has mainly focused on two aspects like (i) increasing potent bacterial antigens and (ii) appearance of new bacteria pathogen. The main aspect of synthesizing effective drugs is their structural characteristic and the rate of activity. In this regard, quinones and their derivatives play an essential role in developing a novel-anti-bacterial drug against various bacteria and pathogens. It is found that quinone derivatives displayed powerful antibacterial activity, and also these derivatives were used for various pharmaceutical and clinical applications [38-40]. In this regard, Gawali et al. reported two novel 1,4-naphthoquinone derivatives (1-2) and examined their antibacterial activity against various pathogens. From the experimental data, it is observed that probe 1 exhibited potent antibacterial activity against S. aureus NCIM 2079 and P. aeruginosa MTCC 2297. On the other hand, probe 2 showed better antibacterial activity against all pathogens with MIC values in the range of 32-512 μg/ml. Due to their differential structural activity, both derivatives ascribed better activity compared to the reference antibiotics [41]. Antibacterial activities of a series of novel 1,4-benzoquinones derivatives (3-4a-h) were demonstrated against various gram-positive and negative bacteria using the micro broth dilutions method. The authors
suggested that 3a-b displayed better antibacterial activity against S. epidermidis and Amikacin with MIC values of 4.88 μg/mL and 78.12 μg/mL as compared to Cefuroxime as a reference drug molecule. On the other hand, the other derivatives remain silent towards the various bacteria [42]. Similarly, Kijja et al. reported a series of 1,3-Dioxepine and spiropyran derivatives (5-7) and determined the antibacterial activity against various pathogens. The experimental data found that 5-7 show better antibacterial activity against gram-positive bacteria, including Staphylococcus aureus ATCC 29213, Enterococcus faecalis ATCC 29212, and environmental isolates S. aureus with reference strains [43]. A series of novel 1,4-naphthoquinone derivatives (8-11) was designed and evaluated against raw cell line's antibacterial activity. From the above data, it is found that 8 and 9 showed the highest antibacterial activities against raw cell lines with IC50 values of 483.5-2044. 8 M [44]. Antibacterial activities of ortho-quinone derivative (12) against some medicinal plants were demonstrated. The authors suggested that 12 ascribe potent antibacterial activity against gram-positive bacteria, including Staphylococcus aureus, S. epidermidis, Enterococcus faecalis, and Micrococcus luteus [45]. A series of novel diaziridinyl quinone isoxazole hybrids (13a-j) was reported by Yennam et al. All the synthesized derivatives were used to detect the antibacterial activity against A549 and PC3 Cell lines. It was observed that 13h show the highest antibacterial activity towards Staphylococcus aureus MTCC 96, S. aureus MLS-16 MTCC 2940, Bacillus subtilis MTCC 121, and Klebsiella planticola MTCC 530 [46]. 1,4-Napthoquinone derivatives (14a-e) showed antibacterial activity against multi-resistant bacterial strains. The authors found that 14b-d shows the highest antibacterial activity against gram-positive bacteria (Staphylococcus aureus) and negative bacteria (Pseudomonas aeruginosa, Escherichia coli I, Escherichia coli 12 and Klebsiella pneumonia) with MIC value 0.30 mg/mL and 1.05 mg/mL [47]. Antibacterial activities of a series of novel quinone derivatives (15a-h) were demonstrated against several bacterial strains and fungi. The authors suggested that 15a shows the highest antibacterial activity against gram-positive and negative bacteria towards S.aureus (MIC = 39.06 μg/mL) [48]. A series of NH or S-substituted 1,4-quinones (16-23) was demonstrated and estimated their antibacterial activity against gram-positive and gram-negative bacteria. The experimental data shows that 22-23 show the potent antibacterial activity against E.Coli, Staphylococcus aureus, Microsporum canis, and Trichophyton mentagrophytes [49].

![Chemical Structures](https://biointerfaceresearch.com/3249)
Figure 2. Various quinone derivatives used for antibacterial studies.
A series of novel 1,4-Napthaquinone derivatives (24-25) were reported by Pisoschi et al. The antibacterial activity of these derivatives was examined against various bacteria. It is observed that all compounds display better antibacterial activity against gram-positive bacteria by diffusion method [50]. Cunha et al. reported a series of novel derivatives (26a-d) and evaluated the antibacterial properties against some pathogenic strains. The authors found that 26d shows potent antibacterial activity against gram-negative bacteria towards E. coli and P. aeruginosa. The MIC value was calculated and found to be 1-2 μg mL⁻¹ [51]. A series of novel 2,3-Disubstituted-1,4-naphtoquinone derivatives (27-30) was demonstrated by Yildirim et al. and estimated they are in vitro antibacterial activity against several bacterial strains and yeast. The experimental analysis revealed that the derivatives 27b and 28b show excellent antibacterial activity against various human-originated pathogens with MIC values 4.88 and 2.44 μg/mL compared to reference drug molecules such as Cefuroxime [52]. Antibacterial activities of a few naphthoquinones derivatives were demonstrated against various pathogens and bacteria. The antibacterial data found that the derivatives (31-33) show excellent activity against various pathogens [53]. Two novels 1,2-naphthoquinone derivatives (34-35), were reported and synthesized by Duan et al. The antibacterial activity was demonstrated against various gram-positive and negative bacteria. Both derivatives display excellent antibacterial activity against gram-positive bacteria [54]. Antibacterial activities of a series of various quinone derivatives were demonstrated against various bacterial. The authors found that 3'-methyl-6-(methylthio)-[1,1'-biphenyl]-2,5-dione (36) ascribe potent antibacterial activity [55]. A series of novel quinone derivatives (37a-l) were demonstrated antibacterial activity against various gram-positive and negative bacteria. From the antibacterial analysis, it is observed that ten derivatives envisage the potent antibacterial activity against various gram-negative bacteria with MIC values 4.00 to 64 μg/mL [56]. Antibacterial activities of a series of novel naphthoquinone derivatives (38-45) were demonstrated against various gram-positive and negative bacteria. The antibacterial studied shows that the derivative (38) displays strong antibacterial activity, and MIC value is calculated and found to be 200 to 400 μg/mL.

On the other hand, the authors suggested that 41 envisaged moderate antibacterial activity. The MIC value is found to be 25 μg/mL. The other compounds remain silent towards bacteria [57].
24a-d

24a = \text{NS}
24b = \text{-Phenol}
24c = \text{Phenol-COOH}
24d = \text{Phenylamine}

25a-d

25a = \text{Thiazole-NH2}
25b = \text{-Phenol}
25c = \text{-Phenol-COOH}
25d = \text{Phenylamine}

26a-d

26a = R_1=R_2=R_3=H
26b = R_1=OMe, R_2=R_3=H
26c = R_1=R_2=H, R_3=OMe
26d = R_1=R_2=H, R_3=Cl
27a, R1 = CF3, R2 = R3 = H  
28a, R1 = CF3, R2 = R3 = H  
29a, R1 = CF3, R2 = R3 = H  
30a, R1 = CF3, R2 = R3 = H  

27b, R2 = CF3, R1 = R3 = H  
28b, R2 = CF3, R1 = R3 = H  
29b, R2 = CF3, R1 = R3 = H  
30b, R2 = CF3, R1 = R3 = H  

27c, R3 = CF3, R2 = R1 = H  
28c, R3 = CF3, R2 = R1 = H  
29c, R3 = CF3, R2 = R1 = H  
30c, R3 = CF3, R2 = R1 = H  

a, R = C6H5; b, R = 2-CH3C6H4; c, R = 3-CH3C6H4; d, R = 4-CH3C6H4; e, R = 4-CIC6H4; f, R = 4-FC6H4; g, R = 4-NO2C6H4; h, R = Propyl; i, R = naphthyl; j, R = 4-CH3OC6H4; k, R = 4-CH3SC6H4; l, R = 4-OHC6H4
3. Conclusions and perspectives

In this review, the antibacterial activities of various novel quinone derivatives such as naphthoquinones, benzoquinones, and anthraquinones are designated. The antibacterial activity of quinone derivatives was enhanced due to the polarity of the substituents: the stronger polarity, the excellent antibacterial activity against various gram-positive and negative bacteria and pathogens. Various novel quinones have excellent bio-medical applications and wide-ranging arcade diagnoses. It is well known that investigation of various quinones and their derivatives possess significant biological activities, so it is of great interest to design and synthesize numerous novel quinones and their derivatives and examine their biological applications as a source of inspiration for upcoming therapeutic enlargement. This summary and review of antibacterial activities of various quinone derivatives deliver notable supervision for additional design and synthesis of quinone derivatives and their related drugs.

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Conflict of interest

The authors have declared that no competing interests exist.

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