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# Enhanced Photodynamic inactivation of Staphylococcus Aureus with Schiff base substituted Zinc phthalocyanines through conjugation to silver nanoparticles

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ABSTRACT

We present the preparation of Schiff base substituted neutral phthalocyanines derived from aldehyde-substituted phthalocyanine which are conjugated to silver nanoparticles through covalent-like strong interactions. The photophysicochemical properties of the nanoconjugates and the Pcs alone were studied comparatively. The photodynamic antimicrobial chemotherapy (PACT) activities. of prepared photosensitizers was investigated against Gram-positive bacterium (*Staphylococcus aureus*). Unlike Pcs alone, conjugated phthalocyanines to silver nanoparticles showed excellent photodynamic antimicrobial activity with the 100% reduction percentage upon illumination.





## 1. Introduction

The worldwide worrying increase in antibiotic resistance among microbial pathogens requires research into new antimicrobial techniques [1]. In addition to ineffectiveness of antibiotics for drug-resistant bacteria, the traditional methods for providing disinfection of surfaces and foods such as ultraviolet (UV) irradiation and thermotherapy require excess energy [2,3]. In order to overcome these drawbacks, it has become imperative to develop new antimicrobial reagents or methods that act more efficiently and faster than existing antibiotics or antimicrobial strategies [4].

Photodynamic antimicrobial therapy (PACT) has emerged as an effective alternative to current applications [5]. There are studies showing that photodynamic antibacterial chemotherapy is a powerful tool to kill microorganisms as *in vivo* and *in vitro* [6,7]

PACT uses photosensitizers (PSs), which are initially activated by absorbing visible light to reach the excited singlet state, and then may undergo intersystem crossing to the long-lived excited triplet state ($^3PS^*$) where they carry out the photochemical reactions by performing the transfer its energy to molecular oxygen to form singlet oxygen that can destroy pathogenic bacteria [8]. This is an important factor in the application of PSs to drug-resistant bacteria.

Most of the PSs used in PACT are phthalocyanines (Pcs) which are based on the tetrapyrrole backbone [9-11]. Pcs are known to meet the expectations to be ideal PS since they show absorption in the visible region, have high triplet-state quantum yields and accordingly, high production of singlet oxygen upon illumination [12]. Another important point for PSs used in PACT is accumulation inside the cells or binding to the bacterial cell envelope [13].

The syntheses of new selectively designed photosensitizers have become important to be able to provide the enhanced physicochemical properties for antimicrobial PDT effectiveness via chemical modifications [14,15]. Choosing the right substituents and appropriate metal ion allows the design of Pc molecules suitable for photodynamic therapy applications [16]. The increasing importance and use of Schiff bases in pharmacology such as antitumour, antioxidant, anti-bacterial, antifungal have prompted us to place them on Pc ring to give four imine group in one molecule [17,18]. For this aim, the aldehyde substituted ZnPc was reacted with different aromatic amine compounds to obtain Schiff bases substituted ZnPc containing N, O heteroatoms in order to evaluate the effect of heteroatoms on PACT.

Although Pcs have appropriate properties, their low solubility or high aggregation tendency prevents them from showing a good therapeutic antimicrobial effect. Several types of solutions

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