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Bio-functionalization of phytogenic Ag and ZnO nanobactericides onto cellulose films for bactericidal activity against multiple drug resistant pathogens

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ABSTRACT

The present study describes the synthesis of silver and zinc oxide nanobactericides from the phytogenic source *Bupleurum aureum.* The synthesized nanobactericides were characterized and evaluated for bio-functionalization onto bacterial cellulose membrane which was synthesized by *Komagataeibacterxylinus* B-12068 culture strain. The synthesis of nanobacterides were initially confirmed using UV–Visible spectroscopy which indicated localized surface resonance (LSPR) peaks at 415 nm for silver nanobactericides and 280 nm for zinc nanobactericides. The nature of the capping agent for synthesized nanobactericides was predicted using FTIR which confirmed the presence of functional moieties. XRD analysis revealed their crystalline nature while morphological characteristics were studied using TEM which confirmed the polydispersity of nanobactericides with the average size in the range of 20–25 nm. The nanobactericides were tested for their antimicrobial activity against seven multi-drug resistant pathogens which were clinically isolated from patients suffering from a myriad of microbial infections. The tested pathogens had antimicrobial resistance to ten different antibiotics and have been reported to be the major cause of nosocomial infections. The nanobactericides displayed significant activity against the test pathogens. Silver nanobactericides showed the highest activity against *Escherichia coli* strain 55 with a 24 mm zone of inhibition while zinc oxide nanobactericides displayed the highest activity against *methicillin-resistant Staphylococcus aureus* (MRSA) with a 20 mm inhibition zone. The bio- functionalized cellulose films (BCF) were characterized using SEM along with physicochemical analysis. The BCF's were evaluated for antibacterial activity against test pathogens which resulted in marked antimicrobial potential against multi-drug resistant bacteria and therefore has the potential to be utilized as an efficient alternative to counter drug resistant pathogens.

1. Introduction

Nanotechnology is a branch of applied science which deals with manipulating materials at the nanoscale (Syed et al., 2016a). In recent years, the use of nanomaterials in the biomedical sector has rapidly flourished especially in the areas of drug delivery, bio-diagnostics and as potent antimicrobial agents. The rapid expansion of multi-drug resistant pathogens has influenced the global economy with the depletion of effective antibiotics to counter infections from drug-resistant pathogens (Ventola, 2015; Khan et al., 2016; Lobanovska and Pilla, 2017). The magnitude of resistance has created considerable impact on both terrestrial and aquatic living organisms (Fair and Tor, 2014). Ever since the first antibiotic was discovered, there has been a steady rise in the rate of antibiotic resistance against antimicrobial agents (Ventola, 2015). According to WHO, developing new and safe antimicrobial agents is one of the top priorities by 2020 (Baker et al., 2013; Syed et al., 2016b; Reinhardt and Neundorf, 2016; Navya and Daima, 2015). Use of functionalized nanomaterials against the treatment of microbial

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