Lasers in Medical Science
https://doi.org/10.1007/s10103-018-2677-4

ORIGINAL ARTICLE

The antifungal agent of silver nanoparticles activated by diode laser as light source to reduce *C. albicans* biofilms: an in vitro study

Suryani D. Astuti[1,2] · Putri S. Puspita[3] · Alfian P. Putra[4] · Andi H. Zaidan[1] · Mochamad Z. Fahmi[5] · Ardiyansyah Syahrom[6,7] · Suhariningsih[1]

Received: 21 May 2018 / Accepted: 30 October 2018

Abstract

Candida albicans is a normal flora caused fungal infections and has the ability to form biofilms. The aim of this study was to improve the antifungal effect of silver nanoparticles (AgNPs) and the light source for reducing the biofilm survival of *C. albicans*. AgNPs were prepared by silver nitrate ($AgNO_3$) and trisodium citrate ($Na_3C_6H_5O_7$). To determine the antifungal effect of treatments on *C. albicans* biofilm, samples were distributed into four groups; L + P+ was treatment with laser irradiation and AgNPs; L + P− was treatment with laser irradiation only; L − P+ was treatment with AgNPs only (control positive); L − P− was no treatment with laser irradiation or AgNPs (control negative). The growth of fungi had been monitored by measuring the optical density at 405 nm with ELISA reader. The particle size of AgNPs was measured by using (particle size analyzer) and the zeta potential of AgNPs was measured by using Malvern zetasizer. The PSA test showed that the particle size of AgNPs was distributed between 7.531–5559.644 nm. The zeta potentials were found lower than − 30 mV with pH of 7, 9 or 11. The reduction percentage was analyzed by ANOVA test. The highest reduction difference was given at a lower level irradiation because irradiation with a density energy of 6.13 ± 0.002 J/cm^2 resulted in the biofilm reduction of 7.07 ± 0.23% for the sample without AgNPs compared to the sample with AgNPs that increased the biofilm reduction of 64.48 ± 0.07%. The irradiation with a 450-nm light source had a significant fungicidal effect on *C. albicans* biofilm. The combination of light source and AgNPs provides an increase of biofilm reduction compared to the light source itself.

Keywords AgNPs · Lasers diode · *Candida albicans* · Antifungal effect · Biofilm

✉ Suryani D. Astuti
suryanidyah@fst.unair.ac.id

[1] Department of Physics, Faculty Science and Technology, Universitas Airlangga, Surabaya 60115, Indonesia

[2] Biomedical Engineering Master Program, Post Graduate School, Universitas Airlangga, Surabaya 60115, Indonesia

[3] Magister of Physics Engineering, Institute of Technology Sepuluh Nopember, Surabaya 60111, Indonesia

[4] Biomedical Engineering Study Program, Department of Physics, Faculty of Sciences and Technology, Universitas Airlangga, Surabaya 60115, Indonesia

[5] Department of Chemistry, Faculty of Sciences and Technology, Universitas Airlangga, Surabaya 60115, Indonesia

[6] Department of Applied Mechanics and Design, Faculty of Mechanical Engineering, Universiti Teknologi Malaysia, 81310 Johor Bahru, Malaysia

[7] Sports Innovation and Technology Centre (SITC), Institute of Human Centred and Engineering (IHCE), Universiti Teknologi Malaysia, 81310 Johor Bahru, Malaysia

Introduction

Invasive candidiasis (IC) is a form of serious infection caused by the fungal species called *Candida albicans* (*C. albicans*). The infection manifests on several matters, such as candidemia, disseminated candidiasis, endocarditis, meningitis, and endophthalmitis. A previous report related to IC in some countries shows that the infections caused by fungal are still high and tend to increase every year [1–3]. Other studies on IC case reported with a similar problem such as high mortality rate, needing a long-term treatment, and being costly [4–6]. Moreover, one of the difficulties of these treatments is the characteristic of *C. albicans* being resistance to antifungal drugs, including amphotericin B, nystatin, clotrimazole, and fluconazole. Drug susceptibility studies have revealed that biofilms of *C. albicans* are up to 2000 times more resistant compared to planktonic cells [7, 8]. This resistance occurs by layer protector is called extracellular polymeric substance (EPS). EPS biofilm of mature *C. albicans* has a

Published online: 09 November 2018