# Antifungal effect of pegylated graphene oxide and silver nanoparticles against candida albicans

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Abstract

Due to the global concern over antimicrobial resistance,[1] advanced materials are being studied for their possible antimicrobial properties. Nanoparticles (NPs) have been shown to have antimicrobial effect against certain pathogens. In our study, an initial antimicrobial screening of 13 different NPs standard materials against a series of harmful micro-organisms was carried out. Along with Copper (Cu) and Silver (Ag) NPs, certain Graphene oxides NPs were found to effectively counteract a fungal species, called *Candida albicans*.[2] With an aim to improve colloidal stabilities of this Graphene oxides (GO), hence to provide better opportunities to microbial exposure, surface modification of GO NPs was performed. As shown in **Figure 1**, new PEGylated products GO-PEG was synthesised *via* amide bond formation after the coupling reaction of GO and 4-arm-PEG5K-$NH_2$ in the present of 1-ethyl-3- (3-dimethylaminopropyl)carbodiimide hypochlorite (EDC HCl).

The physiochemical properties of both GO and GO-PEG were investigated using pH, zeta potential and Nanoparticle Tracking Analysis (NTA).[3] During the initial antifungal screening, all treated *C. albicans* cultures were visualized using an inverted microscope with an aim to capture interactions between the cells and nanoparticles. Biological staining and fixation techniques were applied prior studying morphological changes of affected cells using Scanning Electron Microscopes (**Figure 2**).

MIC values were obtained using broth dilution method where each absorbance was measured at λ 490 nm (XTT) in 96 well plates. Four different ratios of GO-based and Ag NPs combinations were used to determine synergistic anti-fungal effects. The results obtained shown the antimicrobial effect depend of GO-based materials /different Ag NPs ratio.

In addition, Molecular Dynamic (MD) simulations of the adsorption of Ag clusters on pristine GO and GO-PEG surfaces were carried out. The calculated adsorption energies from these models demonstrated that the introduction of PEG chains on the GO NPs strengthens the interaction between the surface and the Ag cluster.

## References

[1] Marston, H.D., Dixon, D.M., Knisely, J.M., Palmore, T.N. & Fauci, A.S. 2016, "Antimicrobial Resistance", JAMA, 316,11, 1193-1204.

[2] A. Jeffery-Smith, S. K. Taori, C. S. Brown, et. al. (2018) Clinical Microbiology Review, 31 (1). DOI: 10.1128/CMR.00029-17

[3] Y.-K Cheong, M. P. Arce, A. Benito, D. Chen, N. L. Crisóstomo, L. Kerai, G. Rodríguez, J. L. Valverde, M. Vadalia, A. Cerpa, G. Ren. (2019) Synergistic antifungal study of PEGylated Graphene oxide and Copper nanoparticles against Candida albicans. Scientific Reports, submitted.

## Figures

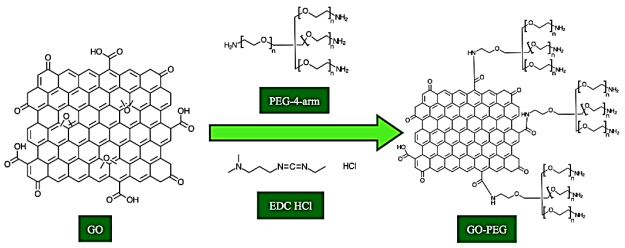


**Figure 1.** Synthesis of GO-PEG via coupling reaction

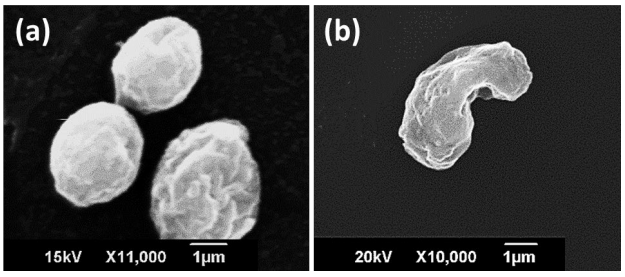


**Figure 2.** SEM images of (a) C. albicans control and (b) affected cell after NP treatment.