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**APLICAÇÃO DE FUNGOS DE MANGUEZAIS NA OBTENÇÃO DE  
NANOPARTÍCULAS DE PRATA COM AÇÃO ANTIMICROBIANA**

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## RESUMO

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Infecções hospitalares constituem um problema de saúde pública em países não desenvolvidos. Considerando a gravidade e consequências das infecções hospitalares, vestimentas hospitalares e materiais médicos que proporcionem a eliminação ou redução da presença de microrganismos têm sido estudados. A prata ( $\text{Ag}^+$ ) é um metal que apresenta ação antimicrobiana de amplo espectro e limitada toxicidade em humanos. Na forma de nanopartícula tem maior reatividade devido ao aumento da superfície de contato. Nanopartículas de prata (NP Ag) podem ser obtidas por métodos químicos e físicos, porém com uso de reagentes tóxicos e grande consumo de energia. Métodos biológicos representam uma alternativa para obter nanopartículas metálicas. Neste trabalho quatorze linhagens de fungos isolados de mangue foram avaliadas quanto ao potencial de síntese de NP Ag com atividade antimicrobiana. Os fungos foram cultivados sob agitação por 72 horas em meio líquido batata dextrose (BD). À biomassa foi adicionada água destilada estéril. Após 72 horas a suspensão foi filtrada. O filtrado fúngico (FF) foi utilizado para a síntese de NP Ag na presença de  $\text{AgNO}_3$  e dois fungos foram selecionadas para a continuidade do estudo. A caracterização físico-química das nanopartículas foi realizada por espectrofotometria, microscopia eletrônica de transmissão e espectroscopia de correlação de fótons. A banda de plasmon na região de 440 nm evidenciou a formação de NP variando entre 10-30 nm. O potencial zeta foi positivo para as NP Ag de MGE-201 e negativo para NP de L-2-2. A presença e identificação de proteínas na dispersão de nanopartículas foram feitas por eletroforese em gel de poliacrilamida – dodecil sulfato de sódio (SDS – PAGE) e cromatografia líquida acoplada à espectrometria de massas (LC/MS). A análise das proteínas presentes no FF e na dispersão de nanopartículas de L-2-2 em SDS-PAGE revelou a presença de três e quatro bandas com massa molecular na faixa de 25 a 174 Da, respectivamente. No FF e dispersão de NP Ag de MGE-201 foram encontradas quatro bandas com massa molecular de 75 a 328 Da. Nove proteínas foram detectadas por LC/MS na dispersão de NP de MGE-201. A ação antimicrobiana das nanopartículas foi avaliada em oito espécies de *Candida* e em quatro bactérias. As nanopartículas foram mais efetivas nas espécies de *C. guilhermondii*, *C. parapsilosis*, *P. aeruginosa* e *S. aureus* com concentrações inibitórias mínimas variando de 0,015 a 0,132  $\mu\text{g/mL}$ . A citotoxicidade foi avaliada em macrófagos J774 e em hepatócitos de ratos. NP Ag de L-2-2 e MGE-201 apresentaram  $\text{IC}_{50}$  de 5,5 e 26  $\mu\text{g/mL}$  em macrófagos e de 26 e 17  $\mu\text{g/mL}$  em hepatócitos, respectivamente. Tecidos de algodão e de poliéster foram impregnados com NP Ag e a porcentagem de impregnação determinada por plasma indutivamente acoplado (ICP) variou de 0,1 - 12,5%. A ação antifúngica dos tecidos impregnados foi testada em *C. albicans* ATCC 36802, *C. glabrata* IOC 4565 e *C. parapsilosis* IOC 4564 com inibição do crescimento dos patógenos na faixa de 68,41 – 97,91 %. Em *E. coli* e *S. aureus* a inibição do crescimento foi de 100% na concentração de 2,2  $\mu\text{g/mL}$ . Os fungos codificados como L-2-2 e MGE-201 foram identificados como *Bionectra ochroleuca* e *Aspergillus tubingensis*, respectivamente.

**Palavras-chave:** Fungos. Manguezal. Nanopartículas de prata. Atividade antibacteriana. Atividade antifúngica.

## ABSTRACT

RODRIGUES, A. G. **Application of mangrove fungi in obtaining silver nanoparticles with antimicrobial activity.** 2013. 106 p. Masters thesis (Biotechnology) – Instituto de Ciências Biomédicas, Universidade de São Paulo, São Paulo, 2013.

Hospital infections constitute a public health problem in undeveloped countries. Considering the severity and consequences of nosocomial infections, hospital clothing and medical devices that provide the elimination or reduction of microorganisms have been studied. Silver (Ag<sup>+</sup>) is a metal that has broad spectrum antimicrobial activity and limited toxicity in humans. In nanoparticles form silver has higher reactivity due to increased contact surface. Silver nanoparticles (Ag NP) can be obtained by chemical and physical methods, but with drawbacks such as the use of toxic reagents and large energy consumption. Biological methods represent an alternative to obtain metal nanoparticles. In this study fourteen strains of fungi isolated from the mangrove were evaluated regarding their capacity to synthesize Ag NP with antimicrobial activity. The fungi were cultivated for 72 hours in potato dextrose liquid medium (PD). Distilled sterile water was added to the biomass. After 72 h the suspension was filtered. The fungal filtrate (FF) was used to synthesize silver nanoparticles in the presence of AgNO<sub>3</sub> and two fungi were selected to continue the work. The physicochemical characterization was performed by spectrophotometry, transmission electron microscopy and photon correlation spectroscopy. The plasmon band in the region of 440 nm evidenced the formation of nanoparticles ranging from 10-30 nm. The zeta potential was positive for Ag NP of MGE-201, and negative for NP L-2-2. The presence and identification of the proteins in the nanoparticles dispersion were performed by sodium dodecyl sulfate - polyacrilamide gel electrophoresis (SDS - PAGE) and Liquid Chromatography - Mass Spectrometry (LC/MS) analysis. The analysis of the proteins in the FF and in the NP dispersion by SDS - PAGE revealed the presence of three and four bands with mass ranging from 25-174 Da, respectively. In the FF and Ag NP dispersion of MGE-201 four bands ranging from 75-328 Da were found. Nine proteins were detected by LC/MS in MGE-201 nanoparticles dispersion. The antimicrobial activity of the nanoparticles was evaluated against eight *Candida* species and four bacteria. The NP were more effective against the *C. guilhermondii*, *C. parapsilosis*, *P. aeruginosa* e *S. aureus* species with minimum inhibitory concentrations from 0.015 to 0.132 µg/mL (1.3 a 12 µM). The cytotoxicity was evaluated on J774 macrophages and rat hepatocytes. Ag NP presented IC<sub>50</sub> of 5.5 and 26 µg/mL in macrophages and of 26 e 17 µg/mL in hepatocytes, respectively. Cotton and polyester fabrics were impregnated with Ag NP for one, two and four times, and the percentage of impregnation was determined by *inductively coupled plasma* (ICP), varying from 0.1 - 12.5%. The antifungal activity of the fabrics impregnated with Ag NP was tested against *C. albicans* ATCC 36802, *C. glabrata* IOC 4565 and *C. parapsilosis* IOC 4564, presenting inhibition from 68.41 - 97.91 %. Against *E. coli* and *S. aureus* the growth inhibition was of 100% in the concentration of 2.2 µg/mL. The L-2-2 and MGE-201 coded fungi were identified as *Bionectra ochroleuca* and *Aspergillus tubingensis*, respectively.

**Keywords:** Fungi. Mangrove. Silver nanoparticles. Antibacterial activity. Antifungal activity.

## 1 INTRODUÇÃO

As infecções hospitalares constituem um problema de saúde pública em países não desenvolvidos, com perda da qualidade de vida do paciente, e um custo adicional no procedimento hospitalar que pode variar de US\$ 146,00 a 131.276,00 (FUKUDA et al., 2011). No Brasil, estima-se que o número de óbitos causados por infecções hospitalares seja de 45.000 casos por ano (MALUCHE et al., 2008). Considerando a gravidade e consequências das infecções hospitalares, e a prevenção como ponto crucial para o melhor controle da mesma, o uso de vestimentas hospitalares e emprego de materiais médicos que proporcionem a eliminação ou redução da presença de microrganismos e, conseqüentemente, maior proteção ao paciente, tem sido uma alternativa estudada (BAKER et al., 2005; DURÁN et al., 2007; LUOMA, 2008; RAI et al., 2009).

Nanopartículas inorgânicas têm um papel importante em diferentes áreas, como na eletrônica e medicina, onde têm sido empregadas com grande sucesso (FARIA et al., 2010; PRABHUA et al., 2013). Dentre estas nanopartículas, as de prata possuem propriedades antimicrobianas relevantes e são usadas na preparação de materiais detentores de ação antimicrobiana, como produtos de higiene pessoal, eletrodomésticos, vestimentas e materiais de uso médico (JAIN; PRADEEP, 2005; KOKURA et al., 2010; LUBICK, 2008; PRABHUA et al., 2013). Devido aos inconvenientes decorrentes dos métodos físicos e químicos na síntese de nanopartículas de prata (NP Ag), pelo uso de reagentes tóxicos e possível contaminação ambiental, há grande interesse no uso de métodos biológicos com a aplicação de microrganismos (ARYA et al., 2010; DURÁN et al., 2007).

Nesse projeto, quatorze linhagens de fungos isolados de manguezais do estado de São Paulo foram avaliadas quanto a capacidade de síntese de NP Ag. Duas linhagens codificadas como L-2-2 e MGE-201 foram selecionadas para continuidade do estudo e foram identificadas taxonomicamente. A formação de nanopartículas foi monitorada pela presença da banda de ressonância plasmônica em espectrofotômetro a 440 nm e a caracterização foi realizada por técnicas físico-químicas como Microscopia Eletrônica de Transmissão e Espectroscopia de Correlação de Fótons. Para complementar o estudo, a análise de proteínas aderidas às NP Ag foi realizada por Cromatografia Líquida acoplada a Espectrometria de Massas (LC-MS), Emissão de Fluorescência e Espectroscopia de Infra-Vermelho Próximo (FIRT).

A ação antimicrobiana das NP Ag em dispersão, e impregnadas em tecidos de algodão e poliéster, foi avaliada em espécies de *Candida* sp, assim como em bactérias Gram-negativas e Gram-positivas frequentemente presentes em infecções hospitalares.

Tecidos de algodão e de poliéster foram impregnados com as NP Ag de L-2-2 e MGE-201 e avaliados em relação a sua ação antifúngica em *C. albicans* ATCC 36802, *C. glabrata* IOC 4565 e *C. parapsilosis* IOC 4564 e ação antibacteriana em *E. coli*, *S. aureus*, *P. aeruginosa* e *M. luteus*.

## 6 CONCLUSÕES

- Cinco linhagens de fungos foram eficazes na síntese de NP Ag e duas foram selecionados para continuidade do estudo;
- As NP Ag obtidas a partir de L-2-2, R-2BI-4 e MGE-201 foram caracterizadas por Microscopia Eletrônica de Transmissão, Espectroscopia de Correlação de Fótons e Espectrofotometria UV\Vis;
- As NP Ag obtidas a partir de L-2-2 e MGE-201 apresentam relativa uniformidade de tamanho, sendo as NP Ag L-2-2 as mais uniformes;
- Os dados de TEM, Espectroscopia de Correlação de Fótons e a análise do gel SDS-PAGE indicam a presença de proteínas na dispersão das NP Ag obtidas a partir do filtrado fúngico por L-2-2 e MGE-201;
- As NP Ag de L-2-2, R-2BI-4, MGE-201, MGE-202 e R-3BI-10 apresentaram ação antifúngica com CIMs de 1,2 a 44,6  $\mu\text{mol/L}$ , sendo a ação antifúngica das NP Ag de MGE-201 > R-2BI-4 > L-2-2 > MGE-202 > R-3BI-10;
- A ação antibacteriana das NP Ag de MGE-201 apresentou melhores resultados que L-2-2, ambas com ação antibacteriana acima de 65% na concentração de 1,1  $\mu\text{g/mL}$  e acima de 84% na concentração de 2,2  $\mu\text{g/mL}$ ;
- Foi possível identificar nove proteínas presentes no FF e na dispersão de NP preparadas a partir do fungo MGE-201 por LC-MS;
- Emissão de Fluorescência e FTIR mostrou a presença de proteínas, tendo espectros de aminoácidos como evidencia no FF e nas dispersões de NP Ag;
- A incorporação de NP Ag em tecidos de algodão e poliéster esteve na faixa de 0,1 a 12,5%, sendo que o tecido de algodão não apresentou proporção direta entre o número de impregnações e a porcentagem de incorporação de NP, enquanto que o tecido de poliéster mostrou resultados mais consistentes nesse aspecto;
- Em relação à impregnação das NP Ag de L-2-2 e MGE-201 em tecidos de algodão e poliéster não houve diferenças discrepantes entre o número de impregnações e a inibição de crescimento proporcionada, e que a impregnação de NP Ag em tecido de poliéster se mostra relativamente mais efetiva para inibir o crescimento de patógenos.

## REFERÊNCIAS

ACOSTA-TORRES, L. S.; LÓPEZ-MARÍN, L. M.; NÚÑEZ-ANITA, R. E.; HERNÁNDEZ-PADRÓN, G.; CASTAÑO, V. M. Biocompatible metal-oxide nanoparticles: nanotechnology improvement of conventional prosthetic acrylic resins. **Journal of Nanomaterials**, p. 1-8, 2011.

AGABEKOV, V.; IVANOVA, N.; DLOGUNOVICH, V.; VOSTCHULA, I. Optical properties of polyvinyl alcohol films modified with silver nanoparticles. **Journal of Nanomaterials**, v. 2012, p. 1-5, 2012.

AHAMED, M.; KARNS, M.; GOODSON, M.; ROWE, J.; HUSSAIN, S. M.; SCHLAGER, J. J.; HONG, Y. DNA damage response to different surface chemistry of silver nanoparticles in mammalian cells. **Toxicology and Applied Pharmacology**, v. 233, p. 404-410, 2008.

AHMAD, A.; MUKHERJEE, P.; SENAPATI, S.; MANDAL, D.; KHAN, M. I.; KUMAR, R.; SASTRY, M. Extracellular biosynthesis of silver nanoparticles using the fungus *Fusarium oxysporum*. **Colloids and Surfaces B: Biointerfaces**, v. 28, p. 313-318, 2003.

ALONGI, D. M. Carbon sequestration in mangrove forests. Review. **Carbon Management**, v. 3, n. 3, p. 313-322, 2012.

ALT, V.; BECHERTB, T.; STEINRÜCKEB, P.; WAGENERC, M.; SEIDELD, P.; DINGELDEIND, E.; DOMANNE, E.; SCHNETTLER, R. An *in vitro* assessment of the antibacterial properties and cytotoxicity of nanoparticulate silver bone cement. **Biomaterials**, v. 25, p. 4383-4391, 2004.

ANANDA, K.; SHRIDHAR, K. R. Diversity of filamentous fungi on decomposing leaf and woody litter of mangrove forests in the southwest coast of India. **Current Sci.**, v. 87, p. 1431-1438, 2004.

ANDERSEN, M. M. Silent innovation: corporate strategizing in early nanotechnology. In: DRUD conference, Copenhagen, 2011. **Anais...** Copenhagen, 2011.

ANDREOTE, F. D.; JIME'NEZ, D. J.; CHAVES, D.; DIAS, A. C. F.; LUVIZOTTO, D. M.; et al. The microbiome of brazilian mangrove sediments as revealed by metagenomics. **PLoS ONE**, v. 7, n. 6, p. 1-14, 2012.

ANGELESCU, D. G.; MAGNO, L. M.; STUBENRAUCH, C. Monte Carlo simulation of the size and composition of bimetallic nanoparticles synthesized in water in oil microemulsions. **J. Phys. Chem. C**, v. 114, n. 50, p. 22069-22078, 2010.

ANO BOM, A.; FREITAS, M.; MOREIRA, D.; SANCHES, D.; GOMES, A.; VALENTE, A.; CORDEIRO, Y.; SILVA, J. The p53 core domain is a molten globule at low pH functional implications of a partially unfolded structure. **The Journal of Biological Chemistry**, v. 285, p. 2857-2866, 2010.

\*De acordo com: ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. **NBR 6023**: informação e documentação: referências: elaboração. Rio de Janeiro, 2002.

ANTONY, J. J.; SIVALINGAM, P.; SIVA, D.; KAMALAKKANNAN, S.; ANBARASU, K.; SUKIRTHA R.; KRISHNAN, M.; ACHIRAMAN, S. Comparative evaluation of antibacterial activity of silver nanoparticles synthesized using *Rhizophora apiculata* and glucose. **Colloids Surf. B**, v. 88, p. 134-140, 2011.

ARAÚJO, W. L.; MACCHERONI, W. J.; AGUILAR-VILDOSO, C. I.; BARROSO, P. A. V.; SARIDAKIS, H. O.; AZEVEDO, J. L. Variability and interactions between endophytic bacteria and fungi isolated from leaf tissues of citrus rootstocks. **Canadian Journal of Microbiology**, v. 47, p. 229-236, 2001.

ARORA, S.; JAIN, J.; RAJWADE, J. M.; PAKNIKAR, K. M. Cellular responses induced by silver nanoparticles: *in vitro* studies. **Toxicol. Lett.**, v. 179, p. 93–100, 2008.

ARYA, V. Living system eco-friendly nano factories. **Digest. J. Nanomater. Biostruct.**, v. 5, p. 9-21, 2010.

ASHARANI, P. V.; WU, Y. L.; GONG, Z. Y.; VALIYAVEETIL, S. Toxicity of silver nanoparticles in zebrafish models. **Nanotechnology**, v. 19, p. 1-8, 2008.

ASHARANI, P. V.; MUN, G. L. K.; HANDE, M. P.; VALIYAVEETIL, S. Cytotoxicity and genotoxicity of silver nanoparticles in human cells. **ASCNANO**, v. 3, n. 2, p. 279-290, 2009.

BAKER, C.; PRADHAN, A.; PAKSTIS, L.; POCHAN, D. J.; SHAH, S. I. Synthesis and antibacterial properties of silver nanoparticles. **J. Nanosci. Nanotechnol.**, v. 5, p. 244-249, 2005.

BALAJI, D. S.; BASAVARAJA, S.; DESHPANDE, R.; BEDRE MAHESH, D.; PRABHAKAR, B. K.; VENKATARAMAN, A. Extracellular biosynthesis of functionalized silver nanoparticles by strains of *Cladosporium cladosporioides* fungus. **Colloids Surf. B**, v. 68, p. 88-92, 2009.

BALAN, L.; SCHNEIDER, R.; TURCK, C.; LOUGNOT, D.; MORLET-SAVARY, F. Photogenerating silver nanoparticles and polymer nanocomposites by direct activation in the near infrared. **Journal of Nanomaterials**, v. 2012, p. 1-6, 2012.

BHAINSA, K. C.; D'SOUZA S. F. Extracellular biosynthesis of silver nanoparticles using the fungus *Aspergillus fumigatus*. **Colloids Surf. B**, v. 47, p. 160-164, 2006.

BILBERG, K.; HOVGAARD, M. B. R.; BESENBACHER, F.; BAATRUP, E. *In vivo* toxicity of silver nanoparticles and silver ions in zebrafish (*Danio rerio*). **Journal of Toxicology**, v. 2012, p. 1-9, 2012.

BILBERG, K.; MALTE, H.; WANG, T.; BAATRUP, E. Silver nanoparticles and silver nitrate cause respiratory stress in eurasian perch (*Perca fluviatilis*). **Aquat. Toxicol.**, v. 96, n. 1, p. 159-165, 2010.



BIRGE, W.; ZUIDERVEEN, J. The comparative toxicity of silver to aquatic biota. Proceedings, 3rd Argentum International. In: Conference on the transport, fate, and effects of silver in the environment. **Anais...** Washington, DC, 1995.

BRADFORD, M. A. A rapid and sensitive method for the quantification of microgram quantities of protein utilizing the principles of protein-dye binding. **Analytical Biochemistry**, v. 72, p. 248-254, 1976.

BRASIL. Ministério da Saúde. **Conceitos e definições em saúde**. 1977. Disponível em: <<http://bvsmms.saude.gov.br/bvs/publicacoes/0117conceitos.pdf>>. Acesso em: 15 out. 2012.

BREATHNACH, A. S. Nosocomial infections. **Medicine**, v. 33, n. 3, p. 22-26, 2005.

BRUST, M.; WALKER, M.; BETHELL, D.; SCHIFFRIN, D. J.; WHYMAN, R. Synthesis of thiol-derivatised gold nanoparticles in a two-phase liquid-liquid system. **Chem. Commun.**, v. 7, p. 801-802, 1994.

BULET, P.; DINAMARQ, J. L.; HETRU, C.; LAGUEUX, M.; CHARLET, M.; HEGY, G.; DORSSELAER, A. V.; HOFFMANN, J. A. A novel inducible antibacterial peptide of *Drosophila* carries an o-glycosylated substitution. **J. Biol. Chem.**, v. 268, p. 14893-14897, 1993.

CASTELLANI, A. A maintenance and cultivation of the common pathogenic fungi of man in sterile distilled water. Further researches. **Jour. Trop. Med. Hyg.**, v. 70, p. 181-184, 1967.

CASTRO-LONGORIA, E.; VILCHIS-NESTOR, A. R.; AVALOS-BORJA, M. Biosynthesis of silver, gold and bimetallic nanoparticles using the filamentous fungus *Neurospora crassa*. **Colloids Surf. B.**, v. 83, p. 42-48, 2011.

CHEN, M.; GOODMAN, D. W. Catalytically active gold: from nanoparticles to ultrathin films. **Acc. Chem. Res.**, v. 39, p. 739-746, 2006.

CHEN, S.; TEMPLETON, A. C.; MURRAY, R. W. Monolayer-protected cluster growth dynamics. **Langmuir**, v. 16, p. 3543-3548, 2000.

CHEN, X.; LIU, L.; LIU, Z.; MARCUS, M. A.; WANG, WEI-CHENG.; OYLER, N. A.; GRASS, M. E.; MAO, B.; GLANS, PER-ANDERS.; YU, P. Y.; GUO, J.; MAO S. S. Properties of disorder-engineered black titanium dioxide nanoparticles through hydrogenation. **Nature**, v. 3, n. 1510, p. 1-7, 2013.

CHOI, O.; DENG K. K.; KIM, NAM-JUNG.; ROSS JR, L.; SURAMPALLI, R. Y.; HU, Z. The inhibitory effects of silver nanoparticles, silver ions, and silver chloride colloids on microbial growth. **Water Research**, v. 42, p. 3066-3074, 2008.

CHOI, O.; HU, Z. Q. Size dependent and reactive oxygen species related nanosilver toxicity to nitrifying bacteria. **Environ. Sci. Technol.**, v. 42, n. 458, p. 3-8, 2008.

CINGI, M. R.; DE ANGELIS, I.; FORTUNATI, E.; REGGIANI, D.; BIANCHI, V.; TIOZZO, R.; ZUCCO, F. Choice and standardization of test protocols in cytotoxicology: a multicentre approach. **Toxicol. In Vitro**, v. 5, n. 2, p. 119-125, 1991.

CLEARY, D. F. R.; SMALLA, K.; MENDONÇA-HAGLER, L. C. S.; GOMES, N. C. M. Assessment of variation in bacterial composition among microhabitats in a mangrove environment using DGGE fingerprints and barcoded pyrosequencing. **PLoS One**, v. 7, n. 1, p. 1-8, 2012

CLINICAL AND LABORATORY STANDARDS INSTITUTE (CLSI). **Norma M27-A2. Método de referência para testes de diluição em caldo para determinação da sensibilidade de leveduras a terapia antifúngica**. 2. ed. Pennsylvania/EUA: Edição Wayne, 2002. v. 22, n. 15, 45 p.

COSTA, I. P. M. W.; MAIA, L. C.; CAVALCANTI M. A. Diversity of leaf endophytic fungi in mangrove plants of northeast brazil. **Brazilian Journal of Microbiology**, p. 1165-1173, 2012.

COUTINHO, A. P. R.; DE MORAES, L. A.; BARATA, L. E.; DE SOUZA, A. O. Effects of the antimycobacterial compound 2-phenoxy-1-phenylethanone on rat hepatocytes and formation of metabolites. **Pharm. Biol.**, v. 50, n. 10, p. 1317-1325, 2012.

CROUSE, H. F.; DOUDT, A.; ZERBE, C.; BASU, S. Detection of quadruplex DNA by gold nanoparticles. **Journal of Analytical Methods in Chemistry**, v. 2012, n. 2012, p. 1-7, 2012.

CUENYA, B. R. Synthesis and catalytic properties of metal nanoparticles: Size, shape, support, composition, and oxidation state effects. **Thin Solid Films**, v. 518, p. 3127-3150, 2010.

DA LUZ C. F. P.; BARTH, O. M. Pollen analysis of honey and beebread derived from brazilian mangroves. **Brazilian Journal of Botany**, v. 35, n. 1, p. 79-85, 2012.

DAHL, J.; MADDUX, B. L. S.; HUTCHISON, J. E. "Toward greener nanosynthesis". **Chem. Rev.**, v. 107, p. 2228-2269, 2007.

DANIELS, J. K.; CHUMANOV, G. Spectroelectrochemical studies of plasmon coupled silver nanoparticles. **J. Electroanal. Chem.**, v. 575, p. 203-209, 2005.

DE LIMA, B.; GILMA, N.; GALVANI, E. Mangrove microclimate: a case study from southeastern Brazil. **Earth Interact.**, v. 17, p. 1-16, 2013.

DE LIMA, R.; SEABRA, A. B.; DURÁN, N. Silver nanoparticles: a brief review of cytotoxicity and genotoxicity of chemically and biogenically synthesized nanoparticles. **J. Appl. Toxicol.**, v. 32, n. 11, p. 867-879, 2012.

DE SOUZA, A. O.; PEDROSA, M. T.; ALDERETE, J. B.; CRUZ, A. F.; PRADO, M. A.; ALVES, R. B.; SILVA, C. L. Cytotoxicity, antitumoral and antimycobacterial activity of tetrazole and oxadiazole derivatives. **Pharmazie**, v. 60, p. 396-397, 2005.

DEBYE, P. Der Lichtdruck auf Kugeln von beliebigem Material. **Annalen der Physik**, Vierte Folge, v. 30, n. 1, p. 57-136, 1909.

DELABIE, J. H. C.; PAIM, V. R. L. M.; NASCIMENTO, I. C.; CAMPIOLO, S.; MARIANO, C. S. F. Ants as biological indicators of human impact in mangroves of the southeastern coast of Bahia, Brazil. **Neotropical Entomology**, v. 35, n. 5, p. 602-615, 2006.

DENIZOT, F.; LANG, R. Rapid colorimetric assay for cell growth and survival modifications to the tetrazolium dye procedure giving improved sensitivity and reliability. **Journal of Immunological Methods**, v. 89, p. 271-277, 1986.

DIAS, A. C. F.; ANDREOTE, F. D.; RIGONATO, J.; FIORE, M. F.; MELO, I. S.; ARAÚJO, W. L. The bacterial diversity in a Brazilian non-disturbed mangrove sediment. **Antonie van Leeuwenhoek (Gedrukt)**, v. 98, p. 541-551, 2010.

DISCH, S.; WETTERSKOG, E.; HERMANN, R. P.; KOROLKOV, D.; BUSCH, P.; BOESECKE, P.; LYON, O.; VAINIO, U.; SALAZAR-ALVAREZ, G.; BERGSTRÖM, L.; BRÜCKEL, T. Structural diversity in iron oxide nanoparticle assemblies as directed by particle morphology and orientation. **Nanoscale**, v. 5, n. 9, p. 3969-75, 2013.

DOURADO, M. N.; FERREIRA, A.; ARAÚJO, W. L.; AZEVEDO, J. L.; LACAVA, P. T. The diversity of endophytic methylotrophic bacteria in an oil-contaminated and an oil-free mangrove ecosystem and their tolerance to heavy metals. **Biotechnology Research International**, v. 2012, p. 1-8, 2012.

DURÁN, N.; MARCATO, P. D.; ALVES, O. L.; DE SOUZA, G. I. H. Cellular oxidoreductive proteins of *Chlamydomonas reinhardtii* control the biosynthesis of silver nanoparticles. **J. Nanopart.**, v. 3, p.1-7, 2005.

DURÁN, N.; MARCATO, P. D.; DE SOUZA, G. I. H.; ALVES, O. L.; ESPOSITO, E. Antibacterial effect of silver nanoparticles produced by fungal process on textile fabrics and their effluent treatment **J. Biomedicine Nanotechnol.**, v. 3, p. 203-208, 2007.

DURÁN, N.; MARCATO, P. D.; INGLE, A.; GADE, A.; RAI, M. Fungi-mediated synthesis of silver nanoparticles: characterization processes and applications. **Prog. Mycol.**, p. 425-449, 2010.

EDISON, T. J. I.; SETHURAMAN, M. G. Instant green synthesis of silver nanoparticles using *Terminalia chebula* fruit extract and evaluation of their catalytic activity on reduction of methylene blue. **Process Biochemistry**, v. 47, p. 1351-1357, 2012.

EFTINK, M. R.; GHIRON, C. A. Fluorescence quenching studies with proteins. **Analytical Biochemistry**, v. 114, p. 199-227. 1981.

EISLER, R. **Silver hazards to fish, wildlife, and invertebrates: A synoptic review.** Contaminant Hazard Reviews, Report 32, Pautuxent Wildlife Research Center. US Geological Survey, Reston VA, 63, 1996. p. 1-44.

EKLUND, S. E.; CLIFFEL, D. E. Synthesis and catalytic properties of soluble platinum nanoparticles protected by a thiol monolayer. **Langmuir**, v. 20, n. 14, p. 6012-6018, 2004.

EL-NOUR, K. M. M. A.; EFTAIHA, A.; AL-WARTHAN, A.; AMMAR, R. A. A. Synthesis and applications of silver nanoparticles. **J. Chem.**, v. 3, p. 135-140, 2010.

EL-RAFIE, M. H.; MOHAMED, A. A.; SHAHEEN, TH. I.; HEBEISH, A. Antimicrobial effect of silver nanoparticles produced by fungal process on cotton fabrics. **Carbohydr. Polym.**, v. 80, p.779-782, 2010.

EVANOFF JR. D. D.; CHUMANOV, G. Synthesis and optical properties of silver nanoparticles and arrays. **ChemPhyChem.**, v. 6, p. 1221-1231, 2005.

FABREGA, J.; LUOMA, S. N.; TYLER, C. R.; GALLOWAY, T. S.; LEAD, J. R. Silver nanoparticles: behaviour and effects in the aquatic environment. **Environment International**, v. 37, p. 517-531, 2011.

FARADAY, M. The bakerian lecture: experimental relations of gold (and other metals) to light. **Philos. Trans. R. Soc. London**, v. 147, p. 145-181, 1857.

FARIA, A. F.; MARTINEZ, D. S. F. T.; MORAES, A. C. M.; DA COSTA, M. E. H. M.; BARROS, E. B., FILHO, A. G. S.; PAULA, A. J.; ALVES O. L. Unveiling the role of oxidation debris on the surface chemistry of graphene through the anchoring of Ag nanoparticles. **Chem. Mater.**, v. 24, p. 4080-4087, 2012.

FERREIRA, T. O.; OTERO, X. L.; SOUZA-JUNIOR, V. S.; VIDAL-TORRADO, P.; MACÍAS, F.; ET AL. Spatial patterns of soil attributes and components in a mangrove system in Southeast Brazil (São Paulo). **J. Soils. Sed.**, v. 10, n. 6, p. 995-1006, 2010.

FEYNMAN, R. There's plenty of room at the bottom. **Engineering and Science**, v. 23, p. 22-36, 1960.

FOLDBJERG, R.; DANG, D. A.; AUTRUP, H. Cytotoxicity and genotoxicity of silver nanoparticles in the human lung cancer cell line, A549. **Arch.Toxicol.**, v. 85, p. 743-750, 2011.

FUKUDA, H.; LEE, J.; IMANAKA, Y. J. Variations in analytical methodology for estimating costs of hospital-acquired infections: a systematic review. **Hospital Infection**. v. 77, p. 93-105, 2011.

GADE, A.; BONDE, P.; INGLE, A. P.; MARCATO, P. D.; DURÁN, N.; RAI, M. K. Exploitation of *Aspergillus niger* for Synthesis of Silver Nanoparticles. **J. Biobases Mat. Bioenerg.**, v. 2, p. 243-247, 2008.

GAJBHIYE, M.; KESHARWANI, J.; INGLE, A.; GADE, A.; RAI, M. Fungus-mediated synthesis of silver nanoparticles and their activity against pathogenic fungi in combination with fluconazole. **Nanomed.**, v. 5, p. 382-386, 2009.

GARCÍA, C. P.; SUMBAYEV, V.; GILLILAND, D.; YASINSKA, I. M.; GIBBS B. F.; MEHN, D.; CALZOLAI, L.; ROSSI F. Microscopic analysis of the interaction of gold nanoparticles with cells of the innate immune system. **Nature**, v. 3, n. 1326, p. 1-7, 2013.

GASPAR, D.; PIMENTEL, A. C.; MATEUS, T.; LEITÃO, J. P.; SOARES, J.; FALCÃO, B. P.; ARAÚJO, A.; VICENTE, A.; FILONOVICH, S. A.; AGUAS, H.; MARTINS, R.; FERREIRA, I. Influence of the layer thickness in plasmonic gold nanoparticles produced by thermal evaporation. **Sci. Rep.**, v. 3, n. 3, p. 1-5, 2013.

GATTER, N.; KOHNEN, W.; JANSEN, B. *In vitro* efficacy of a hydrophilic central venous catheter loaded with silver to prevent microbial colonization. **Zent. bl. Bakteriol.**, v. 287, p. 157-169, 1998.

GAYATHRI, S.; SARAVANAN, D.; RADHAKRISHNAN, M.; BALAGURUNATHAN, R.; KATHERISAN, K. Bioprospecting potential of fast growing endophytic bacteria from leaves of mangrove and salt-marsh plant species. **Indian Journal of Biotechnology**, v. 9, p. 379-402, 2010.

GIBBONS, B.; WARNAR, L. The role of antimicrobial silver nanotechnology. **Medical Device and Diagnostic Industry Magazine**. Aug 2005. Disponível em: <<http://www.devicelink.com/>>. Acesso em: 10 mar. 2013.

GOHARSHADI, E. K.; AZIZI-TOUPKANLOO, H. Silver colloid nanoparticles: ultrasound-assisted synthesis, electrical and rheological properties. **Powder Technology**, p. 1-29, 2012.

GOLE, A.; DASH, C.; RAMAKRISHNAN, V.; SAINKAR, S. R.; MANDALE, A. B.; RAO, M.; SASTRY, M. Pepsin-gold colloid conjugates: preparation, characterization, and enzymatic activity. **Langmuir**, v. 17, p. 1674-1679, 2001.

GOMES-FILHO, J. E.; SILVA, F. O.; WATANABE, S.; CINTRA, L. T. A.; TENDORO, K. V.; DALTO, L. G.; PACANARO, S. V.; LODI, C. S.; DE MELO, F. F. F. Tissue reaction to silver nanoparticles dispersion as an alternative irrigating solution. **JOE**, v. 36, n. 10, p. 1698-1702, 2010.

GOMES, A. M. A.; MARIANO, R. L. R.; MICHEREFF, S. J.; SILVEIRA, E. B.; ASSIS, S. M. P. Isolamento de bactérias para testes de antagonismo. In: MARIANO, R. L. R.; SILVEIRA, E. B. (Ed.). **Manual de práticas em fitobacteriologia**. 2. ed. Recife: Universidade Federal Rural de Pernambuco, 2005. p. 119-125.

GONZÁLEZ-MENDOZA, D.; ARGUMEDO-DELIRA, R.; MORALES-TREJO, A.; PULIDOHERRERA, A.; CERVANTES-DÍAZ, L.; GRIMALDO-JUAREZ, O.; ALARCÓN, A. A rapid method for isolation of total DNA from pathogenic filamentous plant fungi. **Genet. Mol. Res.**, v. 9, p. 162-166, 2010.

GREEN, M. A.; PILLAI, S. Harnessing plasmonics for solar cells. **Nature Photonics**. v. 6, p. 130-131, 2012.

GROSELL, M.; DE BOECK, G.; JOHANNSSON, O.; WOOD, C. M. The effects of silver on intestinal ion and acid-base regulation in the marine teleost fish, *Papophrys vetulus*. **Comp Biochem Physiol C. Toxicol. Pharmacol.**, v. 124, n. 2, p. 59-70, 1999.

GULRAJANI, M. L.; GUPTA, D.; PERIYASAMY, S.; MUTHU, S. G. Preparation and application of silver nanoparticles on silk for imparting antimicrobial properties. **J. Appl. Polym. Sci.**, v. 108, p. 614-623, 2007.

GUU, JR.; JU, Y. M.; HSIEH, H. J. Bionectriaceous fungi collected from forests in Taiwan. **Botanical Studies**, v. 51, p. 61-74, 2010.

HACKENBERG, S.; SCHERZED, A.; KESSLER, M.; HUMMEL, S.; TECHNAN, A.; FROELICH, K.; GINZKEY, C.; KOEHLER, C.; HAGEN, R.; KLEINSASSER, N. Silver nanoparticles: evaluation of DNA damage, toxicity and functional impairment in human mesenchymal stem cells. **Toxicology Letters**, v. 201, p. 27-33, 2011.

HANSON, J. R. **The chemistry of fungi**. Brighton: RSC Publishing, 2008. p. 1.

HARUTA, M. Size- and support-dependency in the catalysis of gold. **Catal. Today**, v. 36 p. 153-166, 1997.

HEATH, J. R. Size dependent surface-plasmon resonances of bare silver particles. **Physical Review**, v. 40, n. 4, p. 9982-9985, 1989.

HERZING, A. A.; KIELY, C. J.; CARLEY, A. F.; LANDON, P.; HUTCHINGS, G. J. Identification of active gold nanoclusters on iron oxide supports for CO oxidation. **Science**, v. 321, p. 1331-1335, 2008.

HOLGUIN, G.; VAZQUEZ, P.; BASHAN, Y. The role of sediment microorganisms in the productivity, conservation, and rehabilitation of the mangrove ecosystems: an overview. **Biol. Fertil. Soils**, v. 33, p. 265-278, 2001.

HUANG, H. B.; XIAO, Z. E.; FENG, X. J.; HUANG, C. H.; ZHU, X.; JU, J. H.; LI, M. F.; LIN, Y. C.; LIU, L.; SHE, Z. G. Cytotoxic naphtho-g-pyrones from the mangrove endophytic fungus *Aspergillus tubingensis* (GX1-5E). **Helv. Chim. Acta**, v. 94, p.1732–1740, 2011a.

INGLE, A.; GADE, A.; BAWASKAR M.; RAI, M. *Fusarium solani*: A novel biological agent for the extracellular synthesis of silver nanoparticles, **Journal of Nanoparticle Research**, v. 11, p. 2079–2085, 2009.

INTELLECTUAL PROPERTY OFFICE (IPO). **UK innovation nanotechnology patent landscape analysis**. 2009.

JAIN, P.; PRADEEP, T. Potential of silver nanoparticle-coated polyurethane foam as an antibacterial water filter. **Biotechnology and Bioengineering**, v. 90, n. 1, p. 59-63, 2005.

JANA, N. R.; GEARHEART, L.; MURPHY, C. J. Seed-mediated growth approach for shape-controlled synthesis of spheroidal and rod-like gold nanoparticles using a surfactant template. **Adv. Mater.**, v. 13, n. 18, p. 1389-1393, 2001.

JEBALI, A.; RAMEZANI, F.; KAZEMI, B. Biosynthesis of silver nanoparticles by *Geotricum* sp. **J. Cluster Sci.**, v. 22, p. 225-232, 2011.

JEYARAJ, M.; RAJESHA, M.; ARUNB, R.; ALIC, D. M.; SATHISHKUMARA, G.; SIVANANDHANA, G.; DEVA, G. K.; MANICKAVASAGAMA, M.; PREMKUMARB, K.; THAJUDDINC, N.; GANAPATHIA, A. An investigation on the cytotoxicity and caspase-mediated apoptotic effect of biologically synthesized silver nanoparticles using Podophyllum hexandrum on human cervical carcinoma cells. **Colloids and Surfaces B: Biointerfaces**, v. 102 p. 708-717, 2013.

JIANG, H.; MANOLACHE, S.; WONG, A. C. L.; DENES, F. S. Plasma-enhanced deposition of silver nanoparticles onto polymer and metal surfaces for the generation of antimicrobial characteristics. **Journal of Applied Polymer Science**, v. 93, p. 1411-1422, 2004.

JIANG, W.; MASHAYEKHI, H.; XING, B. Bacteria toxicity comparison between nano- and micro-scaled oxide particles. **Environ. Pollut.**, v. 157, p. 1619-1625, 2009.

JORDAN, C. C.; KAISER, I. N.; MOORE, V. C. Nanotechnology patent survey: who will be the leaders in the fifth technology revolution?. **Nanotechnology Law & Business**, p. 122-132, 2012.

KABASHIN, A. V.; DELAPORTE, A. P.; GROJO, D.; TORRES R.; SENTIS, T. S. M. Nanofabrication with pulsed lasers. **Nanoscale Research Letters** , v. 5, p. 454-463, 2010

KAEGI, R.; SINNET, B.; ZULEEG, S.; HAGENDORFER, H.; MUELLER, E.; VONBANK, R.; BOLLER, M.; BURKHARDT, M. Release of silver nanoparticles from outdoor facades. **Environmental Pollution**, v. 158, p. 2900-2905, 2010.

KANG, S. W.; CHAR, K.; K.; KANG, Y. S. Novel application of partially positively charged silver nanoparticles for facilitated transport in olefin/paraffin separation membranes. **Chem. Mater.**, v. 20, p. 1308-1311, 2008.

KATHIRESAN, K.; ALIKUNHI, N. M.; PATHMANABAN, S.; NABIKHAN, A.; KANDASAMY, S. Analysis of antimicrobial silver nanoparticles synthe-sized by coastal strains of *Escherichia coli* and *Aspergillus niger*. **Can. J. Microbiol.**, v. 56, p. 1050–1059, 2010.

KATHIRESAN, K.; BINGHAM, B. L. Biology of mangroves and mangrove ecosystems. **Advances in Marine Biology**, v. 40, p. 81-251, 2001.

KATHIRESAN, K.; MANIVANNAN, S.; NABEEL, M. A.; DHIVYA B. Studies on silver nanoparticles synthesized by a marine fungus, *Penicillium fellutanum* isolated from coastal mangrove sediment. **Colloids Surf. B.**, v. 71, p. 133-137, 2009.

KERKER, M. **The scattering of light and other electromagnetic radiation**. London: Academic Press, 1969.

KHAN, S. S.; MUKHERJEE, A.; CHANDRASEKARAN, N. Studies on interaction of colloidal silver nanoparticles (SNPs) with five different bacterial species. **Colloids Surf. B Biointerfaces**, v. 87, p. 129-138, 2011.

KIM, J. S.; KUK, E.; YU, K. N.; KIM, J. H.; PARK, S. J.; LEE, H. J. Antimicrobial effects of silver nanoparticles. **Nanomed. Nanotechnol. Biol. Med.**, v. 3, p. 95-101, 2007.

KIM, Y. S.; SONG, M. Y.; PARK, J. D.; SONG, K. S.; RYU, H. R.; CHUNG, Y. H.; CHANG, H. K.; LEE, J. H.; OH, K. H.; KELMAN, B. J.; HWANG, I. K.; YU, I. J. Subchronic oral toxicity of silver nanoparticles. **Particle and Fibre Toxicology**, v. 7, n. 20, p. 1-11, 2010.

KIM, Y.; SUH, H. S.; CHA, H. J.; KIM, S. H.; JEONG, K. S.; KIM, D. H. A case of generalized argyria after ingestion of colloidal silver solution. **Am. J. Ind. Med.**, v. 52, p. 246-250, 2009.

KIMURA, M. A simple method for estimating evolutionary rates of base substitutions through comparative studies of nucleotide sequences. **J. Mol. Evol.**, v. 16, p. 111-120, 1980.

KLASEN, H. J. Historical review of the use of silver in the treatment of burns. I. Early uses. **Burns.**, v. 26, p. 117-130, 2000.

KOKURA, S.; HANDA, O.; TAKAGI, T.; ISHIKAWA, T.; NAITO, Y.; YOSHIKAWA, T. Silver nanoparticles as a safe preservative for use in cosmetics. **Nanomedicine: Nanotechnology, Biology, and Medicine**, v. 6, p. 570-574, 2010.

KOMIYAMA, A.; ONG, J. E.; POUNGPARN, S. Allometry, biomass and productivity of mangrove forests: a review. **Aquatic Botany**, v. 89, n. 2, p. 128-137, 2008.

KOWSHIK, M.; ASHTAPUTRE, S.; KHARRAZI, S.; VOGEL, W.; URBAN, J.; KULKARANI, S. K.; PAKNIKAR, K. M. Extracellular synthesis of silver nanoparticles by a silver-tolerant yeast strain MKY3. **Nanotechnology**, v. 14, p. 95-100, 2003.

KREIBIG, U.; SCHMITZ, B.; BREUER, H. D. Separation of plasmon-polariton modes of small metal particles. **Physical Review B**, v. 36, n. 9, 1987.

KREIBIG, U.; VOLLMER, M. *Optical Properties of Metal Clusters*. Springer: New York, Chapter 2, 1995.

KRUTYAKOV, Y. A.; KUDRINSKIY, A. A.; OLENIN, A. Y.; LISICHKIN, G. V. Synthesis and properties of silver nanoparticles: advances and prospects. **Russian Chemical Reviews**, v. 77, n. 3, p. 233-257, 2008.

KVITEK, L.; VANICKOVA, M.; PANACEK, A.; SOUKUPOVA, J.; DITTRICH, M.; VALENTOVA, E. Initial study on the toxicity of silver nanoparticles (nps) against *Paramecium caudatum*. **J. Phys. Chem. C.**, v. 113, n. 4, p. 296-300, 2009.

LAKOWICZ, J. R. **Principles of fluorescence spectroscopy**. New York: Plenum Press, 1983. 510 p.

LANKVELD, D. P. K.; OOMENB, A. G.; KRYSTEK, P.; NEIGH, A.; DE JONG, A. T.; NOORLANDER, C.W.; VAN EIJKEREN, J. C. H.; GEERTSMA, R. E.; DE JONG, W.H.



The kinetics of the tissue distribution of silver nanoparticles of different sizes. **Biomaterials**, v. 31, p. 8350-8361, 2010.

LEE, HYO-JEOUNG.; SONG, J. Y.; KIM, B. S. Biological synthesis of copper nanoparticles using *Magnolia kobus* leaf extract and their antibacterial activity. **Journal of Chemical Technology and Biotechnology**, n. 88, p. 1971-1977, 2013.

LESLIE, J. F.; K. K. KLEIN. Female fertility and mating-type effects on effective population size and evolution in filamentous fungi. **Genetics**, v. 144, p. 557-567, 1996.

LI, G. Q.; HUANG, H. C.; KOKKO, E. G.; ACHARYA, S. N. Ultrastructural study of mycoparasitism of *Gliocladium roseum* on *Botrytis cinerea*. **Botanical Bulletin of Academia Sinica**, Taiwan, v. 43, n. 2, p. 211-218, 2002.

LI, W.; XIAO, Y.; WANG, C.; DANG, J.; CHEN, C.; GAO, L.; BATZER, J. C.; SUN, G.; GLEASON, M. L. A new species of *Devriesia* causing sooty blotch and flyspeck on Rubber Trees in China. **Mycol. Progress**, p. 1-6, 2013.

LIU, Q.; XU, Z.; FINCH, J. A.; EGERTON, R. A novel two-step silica-coating process for engineering magnetic nanocomposites. **Chem. Mater.**, v. 10, p. 3936-3940, 1998.

LIU, S. H.; ZHANG, Z. H.; HAN, M. Y. Gram-scale synthesis and biofunctionalization of silica-coated silver nanoparticles for fast colorimetric DNA detection. **Anal. Chem.**, v. 77, p. 2595-2600, 2005.

LIU, Y. J.; WHELEN, S.; HALL, B. D. Phylogenetic relationships among ascomycetes: evidence from an RNA polymerase II subunit. **Mol. Biol. Evol.**, v. 16, n. 12, p. 1799-1808, 1999.

LORENZ, L. Sur la lumière réfléchiée et réfractée par une sphère (surface) transparente. in Oeuvres scientifiques de L. Lorenz. revues et annotées par H. Valentiner. Tome Premier. **Librairie Lehmann & Stage**, Copenhague, p. 403-529, 1898.

LOWRY, O. H.; ROSEBROUGH, N. J.; FARR, A. L.; RANDALL, R. Protein measurement with the folin-phenol reagents. **J. Biol. Chem.**, v. 193, p. 265-275, 1951.

LUBICK, N. Ceramic filter makes water treatment easy. **Environmental Science and Technology**, v. 42, p. 649-650, 2008.

LUOMA, S. N. Silver nanotechnologies and the environment: old problems or new challenges?. Woodrow **Wilson International Center for Scholars**, p. 9-66, 2008.

MAALI, A.; CARDINAL, T.; TREGUER-DELAPIERRE, M. Intrinsic fluorescence from individual silver nanoparticles. **Physica E**, v. 17, p. 559-560, 2003.

MACDONALD, I. D. G, SMITH, W. E. Orientation of cytochrome c adsorbed on a citrate-reduced silver colloid surface. **Langmuir**, v. 12, p. 706-713. 1996.

MACHADO, A.; FERRAZ, A. A. B.; FERRAZ, E.; ARRUDA, E.; NOBRE, J.; KONKEWICZ, L. R.; PIMENTEL, M. L.; LEÃO, M. T. C.; TRABASSO, P.; GRIMBAUM, R. **Prevenção da infecção hospitalar**. Sociedade Brasileira de Infectologia, 2001. Disponível

em: <[http://www.bibliomed.com.br/diretrizes/pdf/infeccao\\_hospitalar.pdf](http://www.bibliomed.com.br/diretrizes/pdf/infeccao_hospitalar.pdf)>. Acesso em: 15 out. 2011.

MALUCHE, M. E.; SANTOS, J. I. *Candida sp.* and nosocomial infections: epidemiological and laboratory aspects. **Rev. Bras. Anál. Clín.**, v. 40, p. 65-67, 2008.

MANDAL, S.; PHADTARE, S.; SASTRY, M. Interfacing biology nanoparticles. **Current Applied Physics**, v. 5, p. 118-127, 2005.

MARTINS, P. T. A.; COUTO, E. C. G.; DELABIE, J. H. C. Phytosociology of the cururupe river mangrove (Ilhéus, Bahia State, Brazil). **Journal of Integrated Coastal Zone Management**, v. 11, n. 2, p. 163-169, 2011.

MAYFIELD, D. A.; KARAKAYA, A.; BATZER, J. C.; BLASER, J. M.; GLEASON, M. L. Diversity of sooty blotch and flyspeck fungi from apples in northeastern Turkey. **Eur. J. Plant. Pathol.**, v. 135, p. 805-815, 2012.

MERIN, D. D.; PRAKASH, S.; BHIMBA, B. V. Antibacterial screening of silver nanoparticles synthesized by marine micro algae. **Asi. Pac. Trop. Med.**, p. 797-799, 2010.

MENDES, L. W.; TAKETANI, R. G.; NAVARRETE, A. A.; TSAI S. M. Shifts in phylogenetic diversity of archaeal communities in mangrove sediments at different sites and depths in southeastern Brazil. **Research in Microbiology**, v. 163, p. 366-377, 2012.

MIAO, A-J.; SCHWEHR, K. A.; XU, C.; ZHANG, S-J.; LUO, Z.; QUIGG, A. The algal toxicity of silver engineered nanoparticles and detoxification by exopolymeric substances. **Environ. Pollut.**, v. 157, n. 30, p. 34-41, 2009.

MICHELSON, E. S. Globalization at the nano frontier: the future of nanotechnology policy in the United States, China, and India. **Technology in Society**, v. 30, p. 405-410, 2008.

MIE, G. Beiträge zur Optik trüber Medien, speziell kolloidaler Metallösungen. **Annalen der Physik**, Vierte Folge, v. 25, p. 377-445, 1908.

MONTEIRO, D. R.; GORUP, L. F.; TAKAMIYA, A. S.; RUVOLLO-FILHO, A. C.; DE CAMARGO, E. R.; BARBOSA, D. B. The growing importance of materials that prevent microbial adhesion: antimicrobial effect of medical devices containing silver. **International Journal of Antimicrobial Agents**, v. 34, p. 103-110, 2009.

MOORES, A.; GOETTMANN, F. The plasmon band in noble metal nanoparticles: an introduction to theory and applications. **New J. Chem.**, v. 30, p. 1121-1132, 2006.

MORONES, J. R.; ELECHIGUERRA, J. L.; CAMACHO, A.; HOLT, K.; KOURI, J. B.; RAMIREZ, J. T.; YACAMAN, M. J. The bactericidal effect of silver nanoparticles. **Nanotechnology**, v. 16, p. 2346-2353, 2005.

NARAYANAN, K. B.; SHAKTIVEL, N. Biological synthesis of metal nanoparticles by microbes. **Adv. Colloid Interf. Sci.**, v. 156, p. 1-13, 2010.

NAVARRO, E.; PICCAPIETRA, F.; WAGNER, B.; MARCONI, F.; KAEGI, R.; ODZAK, N. Toxicity of silver nanoparticles to *Chlamydomonas reinhardtii*. **Environ Sci Technol.**, v. 42, n. 89, p. 59-64, 2008b.

NIOSI, J.; REID, S. E. Biotechnology and nanotechnology: science-based enabling technologies as windows of opportunity for LDCs?. **World Development**, v. 35, n. 3, p. 426-438, 2007.

ONO, L. K.; ROLDÁN-CUENYA, B. Effect of interparticle interaction on the low temperature oxidation of CO over size - selected Au nanocatalysts supported on ultrathin TiC films. **Catalysis Letters**, v. 113, n. 3-4, p. 86-94, 2007.

OSONO, T. Endophytic and epiphytic phyllosphere fungi of *Camellia japonica*: seasonal and leaf age-dependent variations. **Mycologia**, v. 100, n. 3, p. 387-391, 2008.

OSONO, T.; FUKASAWA, Y.; TAKEDA, H. Role of diverse fungi in larch needle litter decomposition. **Mycologia**, v. 95, p. 820-826, 2003.

ÖZYÜREK, M.; GÜNGÖR, N.; BAKI, S.; GÜÇLÜ, K.; APAK, R. Development of a silver nanoparticle-based method for the antioxidant capacity measurement of polyphenols. **Anal. Chem.**, v.84, p. 8052-8059, 2012.

PALOMINO, J. C.; MARTIN, A.; CAMACHO, M.; GUERRA, H.; SWINGS, J.; PORTAELS, F. Resazurin microtiter assay plate: simple and inexpensive method for detection of drug resistance in *Mycobacterium tuberculosis*. **Antimicrob. Agents Chemother.**, v. 46, p. 2720-2722, 2002.

PANÁČEK, A.; KOLÁŘ, M.; VEČEŘOVÁ, R.; PRUCEK, R.; SOUKUPOVÁ, J.; KRYŠTOF, V.; HAMAL, P.; ZBOŘIL, P.; KVÍTEK, L. Antifungal activity of silver nanoparticles against *Candida spp.* **Biomaterials**, v. 3, p. 6333-6340, 2009.

PANYALA, N. R.; PEÑA-MÉNDEZ, E. M.; HAVEL, J. Silver or silver nanoparticles: a hazardous threat to the environment and human health?. **Applied Biomedicine**, v. 6, p. 117-129, 2008.

PARK, EUN-JUNG.; Y. I, J.; KIM, Y.; CHOI, K.; PARK, K. Silver nanoparticles induce cytotoxicity by a trojan-horse type mechanism. **Toxicology in Vitro**, v. 24, p. 872-878, 2010.

PEIXOTO, R.; CHAER, G. M.; CARMO, F. L.; ARAÚJO, F. V.; PAES, J. E.; VOLPON, A.; SANTIAGO, G. A.; ROSADO, A. S. Bacterial communities reflect the spatial variation in pollutant levels in Brazilian mangrove sediment. **Antonie Van Leeuwenhoek**, v. 99, n. 2, p. 341-54, 2011.

PEREIRA, G. H.; MULLER, P. R.; SZESZS, M. W.; LEVIN, A. S.; MELHEM, M. S. Five-year evaluation of bloodstream yeast infections in a tertiary hospital: the predominance of non-*C. albicans Candida* species. **Medical Mycology**, v. 48, p. 839-842, 2010.

PEREIRA, M. K. **Ressonância de plasmon de superfície localizado e espalhamento raman em soluções coloidais de ouro.** 2009. 107 f. Dissertação (Mestrado em Física) – Universidade Federal do Rio Grande do Sul, 2009.

PETRYAYEVA, E.; KRULL, U. J. Localized surface plasmon resonance: nanostructures, bioassays and biosensing-a review. **Analytica Chimica Acta**, v. 706, p. 8-24, 2011.

PRABHUA, D.; ARULVASUA, C.; BABUA, G.; MANIKANDANB, R.; SRINIVASAN, P. Biologically synthesized green silver nanoparticles from leaf extract of *Vitex negundo L.* induce growth-inhibitory effect on human colon cancer cell line HCT15. **Process Biochemistry**, v. 48, n. 2 p. 317-324, 2013.

PRESCHITSCHKEK, N; DOMINIC, B. Nanotechnology patenting in China and Germany - a comparison of patent landscapes by bibliographic analyses. **Journal of Business Chemistry**, 7, v. 1, p. 3-13, 2010.

PRIETO, G.; ZECEVIC, J.; FRIEDRICH, H.; DE JONG, K. P.; DE JONGH, P. E. Towards stable catalysts by controlling collective properties of supported metal nanoparticles. **Nature Materials**, p. 34-39, 2012.

PUURUNEN, K.; VASARA, P. Opportunities for utilising nanotechnology in reaching near-zero emissions in the paper industry. **Journal of Cleaner Production**, v. 15 p. 1287-1294, 2007.

RAEDER, U.; BRODA, P. Rapid preparation of DNA from filamentous fungi. **Lett. Appl. Microbiol.**, v. 1, p. 17-20, 1985.

RAI, M.; YADAV, A.; GADE, A. Silver nanoparticles as a new generation of antimicrobials. **Biotechnology Advances**. v. 27, p. 76-83, 2009.

RANI, P. U., RAJASEKHARREDDY, P. Green synthesis of silver-protein (core-shell) nanoparticles using *Piper betle L.* leaf extract and its ecotoxicological studies on *Daphnia magna*. **Colloids and Surface A: Physicochemical and Engineering Aspects**, v. 389, p. 188-194, 2011.

RAVINDRA, S.; MOHAN, Y. M.; REDDY, N. N.; RAJU, K. M. Fabrication of antibacterial cotton fibres loaded with silver nanoparticles via “Green Approach”. **Colloids Surf. A**, v. 367, p. 31-40, 2010.

RENUGADEVI, K.; ASWINI, R.V. Microwave irradiation assisted synthesis of silver nanoparticle using *Azadirachta indica* leaf extract as a reducing agent and *in vitro* evaluation of its antibacterial and anticancer activity. **International Journal of Nanomaterials and Biostructures**, v. 2, n. 2, p. 5-10, 2012.

RIGONATO, J.; KENT, A. D.; ALVARENGA, D. O.; ANDREOTE, F. D.; BEIRIGO, R. M.; VIDAL-TORRADO, P.; FIORE, M. F. Drivers of cyanobacterial diversity and community composition in mangrove soils in south-east Brazil. **Environmental Microbiology**, v. 15, p. 1103-1114, 2013.

RODRIGUES, A. G.; PING L. Y.; MARCATO, P. D.; ALVES, O. L.; SILVA, M. C. P.; RUIZ, R. C.; MELO, I. S.; TASIC, L.; DE SOUZA, A. O. Biogenic antimicrobial silver nanoparticles produced by fungi. **Appl. Microbiol. Biotechnol.**, v. 97, p. 775-782, 2013

RODRIGUEZ, R. J.; JR, J. F. W.; ARNOLD, A. E.; REDMAN, R. S. Fungal endophytes: diversity and functional roles. **New Phytologist**, p. 1-17, 2009.

RULKA, E. L.; LIMA, M.; NEVES, E. B. Perfil das publicações científicas sobre a infecção hospitalar na base de dados SciELO. **J. Health Sci. Inst.**, v. 30, n. 2, p. 161-165, 2012.

RUPARELIA, J. P.; CHATTERJEE A. K.; DUTTAGUPTA, S. P.; MUKHERJI, S. Strain specificity in antimicrobial activity of silver and copper nanoparticles. **Acta Biomater.**, v. 4, n. 70, p. 707-716, 2008.

SAITOU, N.; NEI, M. The neighbor-joining method: a new method for reconstructing phylogenetic trees. **Mol. Biol. Evol.**, v. 4, p. 406-425, 1987.

SALUNKHE, R. B.; PATIL, S. V.; SALUNKE, B. K.; PATIL, C. D.; SONAWANE, A. M. Studies on silver accumulation and nanoparticle synthesis by *Cochliobolus lunatus*. **Applied Biochem. Biotechnol.**, v.165, p. 221-234, 2011.

SARGENT JR, J. F. The national nanotechnology initiative: overview, reauthorization, and appropriations issues: specialist in science and technology policy, **Congressional Research Service**, 2012.

SATHISHKUMAR, M.; SNEHA, K.; YUN, Y. S. Immobilization of silver nanoparticles synthesized using *Curcuma longa tuber* powder and extract on cotton cloth for bactericidal activity. **Bioresource Technol.**, v. 101, p. 7958-7965, 2010.

SCHAEFFER-NOVELLI, Y. **Manguezal: ecossistema entre a terra e o mar**. São Paulo, SP: Caribbean Ecological Research, 1995. 64 p.

SEBASTIANES, F. L. S.; LACAVA, P. T.; FÁVARO, L. C. L.; RODRIGUES, M. B. C.; ARAÚJO, W. L.; AZEVEDO, J. L.; PIZZIRANI-KLEINER, A. A. Genetic transformation of *Diaporthe phaseolorum*, an endophytic fungus found in mangrove forests, mediated by *Agrobacterium tumefaciens*. **Current Genetics**, v. 58, p. 21-33, 2012.

SELVAKUMAR, R.; JOTHI, N. A.; JAYAVIGNESH, V.; KARTHIKASELVI, K.; ANTONY, G. I.; SHARMILA, P. R.; KAVITHA, S.; SWAMINATHAN, K. As(V) removal using carbonized yeast cells containing silver nanoparticles. **Water Research**, v. 45, p. 583-592, 2011.

SHALIGRAM, N. S.; BULE, M.; BHAMBURE, R.; SINGHAL, R. S.; SINGH, S. K.; SZAKACS, G.; PANDEY. A. Biosynthesis of silver nanoparticles using aqueous extract from the compactin producing fungal strain. **Process Biochem.** v. 44, p. 939-943, 2009.

SHELAR, P. S.; REDDY, V. K.; SHELAR, G. S.; REDDY, V. S. Medicinal value of mangroves and its antimicrobial properties - a review. **Continental J. Fisheries and Aquatic Science**, v. 6. n. 1, p. 26-37, 2012.

SINTUBIN, L.; DE WINDT, W.; DICK, K.; MAST, J.; VAN DER HA, D.; VERSTRAETE, W.; Boon, N. Lactic acid bacteria as reducing and capping agent for the fast and efficient production of silver nanoparticles. **Appl. Microbiol. Biotechnol.**, v. 84, p. 741-749, 2009.

SILVA, M. R. O.; ALMEIDA, A. C.; ARRUDA, F. V. F.; GUSMÃO, N. Endophytic fungi from brazilian mangrove plant *Laguncularia racemosa* (L.) Gaertn. (Combretaceae): their antimicrobial potential. **Formatex**, p. 1260-1266, 2011.

SILVER, S. Bacterial silver resistance: molecular biology and uses and misuses of silver compounds. **FEMS Microbiology Reviews**, v. 27, p. 341-353, 2003.

SILVERSTEIN, R.; WEBSTER, F.; KIEMLE, D. **Spectrometric identification of organic compounds**. 7th ed. New York: John Wiley and Sons, 2005.

SONDI, I; SALOPEK-SONDI, B. Silver nanoparticles as antimicrobial agent: a case study on *E. coli* as a model for Gram-negative bacteria. **J. Colloid Interface Sci.**, v. 275, p. 177-182, 2004.

SULAIMAN, G. M.; MOHAMMED, W. H.; MARZOOG, T. R.; AL-AMIERY, A. A. A.; KADHUM, A. A. H.; MOHAMAD, A. B. Green synthesis, antimicrobial and cytotoxic effects of silver nanoparticles using *Eucalyptus chapmaniana* leaves extract. **Asian Pac. J. Trop. Biomed.**, v. 3, n. 1, p. 58-63, 2013.

SUN, X.; LUO, Y. Preparation and size control of silver nanoparticles by a thermal method. **Materials Letters**, v. 59, p. 3847-3850, 2005.

TAMURA, K.; DUDLEY, J.; NEI, M.; KUMAR, S. MEGA4: Molecular Evolutionary Genetics Analysis (MEGA) software version 4.0. **Mol. Biol. Evol.**, v. 24, p.1596-1599, 2007.

TEPASKE, M. R.; GLOER, J. B.; WICKLOW, D. T.; DOWD, P. Three new aflavinines from the sclerotia of *Aspergillus tubingensis*. **Tetrahedron**, v. 45, p. 4961-4968, 1989a.

THOMPSON, J. D.; HIGGINS, D. G.; GIBSON, T.J. CLUSTAL W: improving the sensitivity of progressive multiple sequence alignment through sequence weighting, position-specific gap penalties and weight matrix choice. **Nucleic Acids Res.**, v. 22, p. 4673-4680, 1994.

TOMA, H. E; BONIFÁCIO, L. S.; ANAISSI, F. J. Da cor à cor inexistente: uma reflexão sobre espectros eletrônicos e efeitos cromáticos. **Quim. Nova**, v. 28, n. 5, p. 897-900, 2005.

TURKEVITCH, J.; STEVENSON, P. C.; HILIER J. A study of the nucleation and growth processes in the synthesis of colloidal gold. **Discuss. Faraday Soc.**, v. 11, p. 55, 1951.

VALDEN, M.; LAI, X.; GOODMAN, D. W. Onset of catalytic activity of gold clusters on titania with the appearance of nonmetallic properties. **Science**, v. 281, p. 1647-1650, 1998.

VIEIRA, B. P.; DIAS, D.; NAKAMURA, E. M.; ARAI, T. I.; HANAZAKI, N. Is there temporal variation on solid waste stranding in mangroves? A case study in ratones mangrove, Florianopolis, Brazil. **Biotemas**, v. 26, n. 1, p. 79-86, 2013.

VIGNESHWARAN, N.; ASHTAPUTRE, N. M.; VARADARAJAN, P. V.; NACHANE, R. P.; BALASUBRAMANYA, R. H. Biological synthesis of silver nanoparticles using the fungus *Aspergillus flavus*. **Colloids Surf. B**, v. 61, p. 1314-1318, 2007.

VIGNESHWARAN, N.; KATHE, A. A.; VARADARAJAN, P.V.; NACHANE, R. P.; BALASUBRAMANYA, R. H. Biomimetics of silver nanoparticles by white rot fungus, *Phaenerochaete chrysosporium*. **Colloids Surf. B.**, v. 53, p. 55-59, 2006.

WARREN, N. G.; SHADOMY, H. J. Yeasts of medical importance. In: BALOWS, A.; HAUSLER JR. W. J.; HERRMANN, K. L.; ISENBERG, H. D.; SHADOMY, H. J. (Ed.). **Manual of clinical microbiology**. 5th ed. Washington: ASM, 1991.

WHITE, R. J.; COOPER, R. Silver sulphadiazine: a review of the evidence. **Wounds U.K.**, p. 52-61, 2005.

WILEY, B. J.; IM, S. H.; LI, ZHI-YUAN.; MCLELLAN, J.; SIEKKINEN, A.; XIA, Y. Maneuvering the surface plasmon resonance of silver nanostructures through shape-controlled synthesis. **J. Phys. Chem. B**, v. 110, p. 15666-15675, 2006.

WORLD HEALTH ORGANIZATION. Prevention of hospital-acquired infections A practical guide 2nd edition. 2002. Disponível em: <<http://www.who.int/csr/resources/publications/whodscscreph200212.pdf>>. Acesso em: 10 jan. 2012.

YANG, XIU-HUA; LING, J.; PENG, J.; CAO, QIU-E.; WANG, L.; DING, ZHONG-TAO; XIONG, J. Catalytic formation of silver nanoparticles by bovine serum albumin protected silver nanoclusters and its application for colorimetric detection of ascorbic acid. **Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy**, v. 106, p. 224-230, 2012.

YEO, M. K.; YOON, J. W. Comparison of the effects of nano-silver antibacterial coatings and silver ions on zebrafish embryogenesis. **Mol. Cell. Toxicol.**, v. 5, p. 23-31, 2009.

YING, G.; LU, H.; PORTER, A. L. The research profiling method applied to nano-enhanced, thin film solar cells. **R&D Management**, v. 40, n. 2, p. 195-208, 2010.

YOON, K-Y.; HOON, B. J.; PARK, J-H.; HWANG, J. Susceptibility constants of *Escherichia coli* and *Bacillus subtilis* to silver and copper nanoparticles. **Sci. Total Environ.**, v. 373, n. 57, p. 2-5, 2007.

ZHAN, J. X.; GUNATHERATH, G. M. K. B.; WIJERATNE, E. M. K.; GUNATILAKA, A. A. L. Asperpyrone D and other metabolites of the plant-associated fungal strain *Aspergillus tubingensis*. **Phytochemistry**, v. 68, p. 368-372, 2007.

ZHANG, M.; ZHANG, K.; DE GUSSEME, B.; VERSTRAETE, W. Biogenic silver nanoparticles (bio-Ag<sub>0</sub>) decrease biofouling of bio-Ag<sub>0</sub>/PES nanocomposite membranes. **Water Research**, v. 46, p. 2077-2087, 2012.

ZHANG, X.; YAN, S.; TYAGI, R. D.; SURAMPALLI, R. Y. Synthesis of nanoparticles by microorganisms and their application in enhancing microbiological reaction rates. **Chemosphere**, v. 82, p. 489-494, 2011.