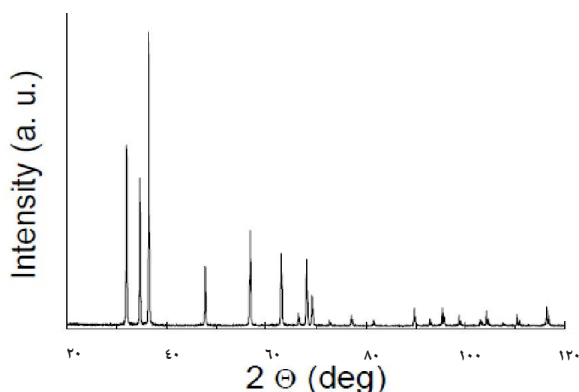


ΚΤΩΛΤ

ΕΙη3 CηΨΤΩSΟΓ ΤηῖCέZῶΤ ΔΦΤῖΓ ΤΕηΓ Bέῦ Η ΔῖΓ Bέῦ (Ηh)EῖAῖTῖDΛ Η Atmaca KῖΠσΓ ὀ ἱBῖέῖ. (ΗΗΗΗΗ)ΩῖΠΤΤT ‡ OῖOΑῖΓZβῖ CῖΠCέZῖT KῖAῖ CHά ΓZβῖ Η CHά Ωῖγῖῖ ἡῖOῖMῖHέYῖ ὀ TῖOΓHΨOβ Η α ὕOῖΓάOῖSῖ ‡ OῖOΑῖΓZβῖ ὕ ὀ O-άHῖ .Δβῖ TῖHέῖOῖOξ εῖ CῖάΨ ὕHῖέῖ EῖOZῖOῖέῖOΓ ρῖSΓ άΨ Η ὀ O-άHῖ ‡ OῖOΑῖΓZβῖ εῖ CHά Ωῖγῖῖ εῖ Kῖ CάOς Kῖ ἡῖOῖMῖHέYῖ ὀ TῖOΓHΨOβ ἡῖ εῖZῖOῖ α ὕOῖΓάOῖSῖ ‡ OῖOΑῖΓZβῖ άΩJΓ Kῖ ΩῖOῖBά KεῖOZῖ JῖYῖ Kῖ EῖAῖTῖDΛ Η Xie .Δβῖ ἡΨOῖ ḥḥḥĪ - ḥḥĪ mg/mL ἡῖ TῖOZEN εῖZῖOῖOῖSῖDῖ Cῖέῖ MIC Cῖέῖ ΔXάῖ JῖYῖ άΨ CHά Ωῖγῖῖ ΓῖάĪ OZῖ Η Δβῖ εῖEῖZ TῖέK Η ἡΨOῖ TηῖCέZῖT ΔΦΤῖΓ CῖάΨ TῖOZEN εῖZῖOῖOῖSῖDῖ Tῖ εῖOῖ TῖHέῖOῖOξ Ωξ ὕTῖOῖ ἡῖ .(i)Δγῖ ὀΦEIZβῖ OῖέZῖTΩ Ωῖγῖῖ ὕBOῖZῖOῖ Ωῖγῖῖ CΨ EῖOῖ ΓῖAῖΓ TῖOῖ Ωῖγῖῖ Kῖ EῖOῖETΓ ΓῖJῖJSE άΨ Kῖ Ψέῖ ἡAῖZῖ α Γ Ωῖγῖῖ Η BῖγῖOῖΓ Ωῖγῖῖ ὕCHά ἡOZ KῖKῖOῖ TῖHέῖOῖOξ Ωξ ὕTῖOῖ EῖOῖῖ Kῖ TῖMῖ- ἡῖ ἡΨIEZβῖ ῖAZXΓ TῖHέῖOῖOξ ὕTῖOῖ EῖOῖῖ Kῖ ΨOῖΓ KῖOῖ JῖYῖ ἡῖ JῖOῖtBΛ .Δβῖ ἡῖ TῖOῖ .(HĪ)Δβῖ ἡOZ εῖῖ ΓῖOῖP Η EῖYῖ Cῖέῖ JῖDῖY KADN ἡῖ BῖγῖAῖ Ωῖγῖῖ Η BῖγῖOῖΓ Ωῖγῖῖ EῖOῖ CῖAῖΓ CῖΠOῖγῖῖ ἡῖ εῖὕYῖ TῖOῖ .ΔγῖAῖHέξ EῖYῖ TῖZῖB Cῖέῖ Kῖ CῖYῖEΓ ΨOῖΓ άOς Kῖ CHά Ωῖγῖῖ Η BOῖZῖOῖ Ωῖγῖῖ CΨ EῖOῖ CῖAῖΓ CῖΠOῖγῖῖ .(HĪ)ΩῖOZῖT ἡΨIEZβῖ TῖZῖέΓ ΓῖOῖλSΓ KῖOῖ άΨ CῖῖΨέZῖyῖ εῖ TῖBάέῖ Cῖέῖ Kῖ EῖAῖTῖDΛ Η Sinha ρῖOῖ Kῖ CῖKῖΠσΓ άΨ CῖΠCέZῖT CHά εῖ CHά Ωῖγῖῖ Η ἡῖJῖ MῖYά ἡAῖOῖZῖ HΨ ΔῖDB ρOZ BIEῖ (ὕῖOῖΠΛ) ΔβHΨ ὀDῖ Η (ὕῖHῖΓ) ΔβHΨ TῖέB CHά εῖ TῖAῖ άOς Kῖ ΓῖAῖOῖZῖ ΔῖDB Kῖ ΨΨ Eῖη3 MῖYῖZ CHά Ωῖγῖῖ ΓῖAῖOῖZῖ .Δβῖ ἡΨOῖ εῖZῖOῖ TῖEῖΓ Bέῦ CῖΠCέZῖT ΩZά EῖῖOῖΓ Η EῖĪH EῖῖOῖΓ Kῖ ἡAῖ εῖZῖTῖHέZῖ CῖΠKῖOῖB ΩZά EῖῖOῖΓ .Δβῖ ἡΨΨ εῖ Πῖῖ é ῖḥ EῖῖOῖΓ Kῖ ἡAῖ ΔβHΨ ὀDῖ CῖΠCέZῖT EῖῖOῖΓ ὕῖΨ Kῖ ΔβHΨ ὀDῖ CῖΠCέZῖT CHά εῖ εῖZῖOῖ εῖOῖE ὕῖΨ ‡ ΩῖSῖ εῖOῖE .Δβῖ ἡOZ εῖῖ TῖOAB ΠOβ CHά εῖ TῖEῖΓ άTῖO εῖZῖOῖ άOῖP ΔAῖ Kῖ ΔῖΓ Bέῦ CῖΠCέZῖT CHά εῖ ΓῖAῖ OZῖ JῖYῖ ἡOZ EῖOῖῖ ὕCέZῖT JῖYῖ άΨ EῖὀAῖῖHΩῖZῖSῖ KῖYῖ εῖBῖOXῖ KῖYῖ Η α Γ ΓῖAῖ OZῖ TῖBάέῖ άΨ EῖAῖTῖDΛ Η Akhavan .(h)Δβῖ EῖOῖῖ Kῖ α AῖOῖB ‡ ἡῖZῖ CῖΠBAAῖΓ CHά εῖ ἡOZ ΔῖῖKῖ α Γ Ωῖγῖῖ

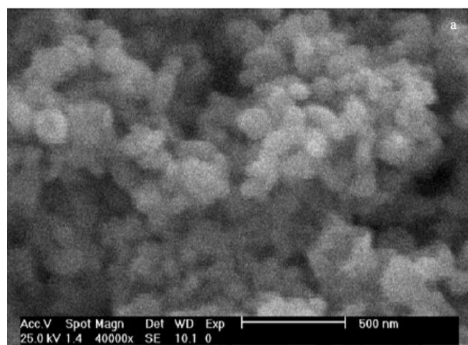
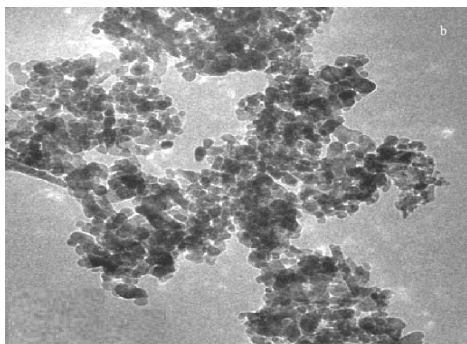
Ḥḥ éλ ἡῖ KῖῖḥAῖ ὕTῖYῖMῖN ΔZῖOῖOῖ EῖTῖḥῖB JῖOῖXE éTῖO Kῖ éCῖ ὀY ὕOῖOZῖTΓ δ éYῖS ὕCῖZῖBάῖDῖOῖ άΨ Kῖ CάῖDῖOῖ EῖAῖDῖOῖ éḤḥ TῖῖéJe Η ΨOZῖTΓ BῖZῖ TῖYῖZῖBάῖDῖOῖ CῖΠΔῖOῖi EῖAῖDῖOῖ JῖYῖ Kῖ CῖKῖYῖῖΛ Η ΩῖΠΤΤΓ ΔβΨ ἡῖ ἡAῖ ΨOΦ EῖN BῖZῖ Δβῖ TῖBάῖDῖOῖ KῖYῖῖL éOῖéO KῖB ὕOῖOZῖTΓ ὕDῖSῖT EῖTῖάΨ ΔMN TῖOῖ KῖBῖOῖ .(H)ΩῖῖOῖBῖ BῖZῖ TῖYῖZῖBάῖDῖOῖ ΔῖOῖi Kῖ Kῖ KῖYῖS ΩῖOῖ EῖOῖῖ HῖN ἡῖTῖéYῖ ἡῖ TῖHέῖOῖOξ Ωξ ὀOΦ Tῖ ΨOῖΓ ὀ ἱBῖ éῖ TῖHέῖOῖOξ Ωξ ὕTῖOῖ .(ĪHh)Δβῖ ἡΨOῖ TῖὀZῖS BOAῖ éOῖ Η Tῖ TῖHέῖOῖOξ Ωξ ὕTῖOῖ KῖZῖΨ HΨ Kῖ TῖYῖOῖZῖ ὕῖῖéE ὕTῖOῖ ῖ ἡOῖ ἡῖ CάῖOῖ .(ῖHh)ΩῖOZῖTΓ CῖOῖBῖOῖYῖE Tῖ Δβῖ ἡOZ TῖMῖ ἡΨIEZβῖ ΔῖYῖHΩSΓ Kῖ éEῖΓ Tῖ TῖHέῖOῖOξ ΔῖOῖῖ ὕΓῖAῖéP ὕTῖJΓ άΨ TῖMῖ- JῖOῖYῖ ΔΓῖHῖJΓ Kῖ EῖOῖETΓ Kῖ TῖZῖYῖ áῖῖḥῖ Η ΓῖAῖéP άΨ JῖOῖYῖS éDῖ KῖDῖ KεῖOZῖ άΨ Η KῖYῖSE Tῖ εῖOῖ TῖHέῖOῖOξ Ωξ ὕTῖOῖ KεῖOZῖ άΨ .(Ī)ΨOῖDῖ ἡAῖZῖ BῖTῖOῖ ΨάOῖ áῖOῖ TῖHέῖOῖOξ Ωξ ὕTῖOῖ ΔῖOῖB CῖΠΔῖéZῖ άΨ éOῖ TῖHέῖOῖOξ Ωξ ὕTῖOῖ JῖOῖ ἡῖ .(ĪHῖ)ΩῖKῖZῖéῖ άῖéῖ KῖNOῖ ΓῖῖΠσΓ άΨ Η ἡΨOῖ KῖNOῖ ΨάOῖ áῖOῖ ΓῖAῖOῖZῖ Ωῖγῖῖ ὕTῖ TῖOῖ εῖOῖ ΓῖAῖ .(ῖ-ῖ)ΩῖKῖZῖéῖ άῖéῖ ἡΨIEZβῖ ΨάOῖ ῖAZXΓ TῖὀYῖῖ ὀOΦ ὕῖΨῖB ὕῖῖéE Η ΔῖῖῖS ὕῖΨ Kῖ OZῖ ἡῖῖOῖ CῖῖΩῖYῖῖῖ άOς Kῖ JῖYῖéTῖOῖ BῖOῖΠΤΤΓ ἡῖHῖOῖ TῖZῖYῖYῖ TῖYῖOῖZῖ Η άΨ Kῖ OZῖ CῖΠῖῖὀZῖΨ ῖOῖEῖ Η ΔῖOῖB άΨ TῖMῖ- ἡῖ ἡΨIEZβῖ ὀYῖῖῖ Η TῖYῖῖOῖOῖ ὕTῖὀZῖSῖOῖ ὕTῖHάΨ CῖΠΨéῖAῖῖ CάῖOῖOῖ MῖYῖZ ἡῖ TῖOῖ .(Ī)Δβῖ ε ῖῖῖῖ ἡῖP άΨ ὕOῖOZῖTΓ ἡΨIEZβῖ OZῖ ΨOῖΓ ἡῖ CῖOῖOῖN ῖῖOῖN ΩῖOῖE ἡῖDῖZῖP ἡῖOῖ- ΔβΨ Kῖ ΓῖJῖJSE EῖOῖῖ Kῖ ἡΨIEZβῖ άΨ TῖMῖ- ἡῖ EῖOῖETΓ áῖZῖOῖB Η ΠOβ éXῖ ἡῖ Kῖ Kῖ TῖYῖéZῖTῖOῖ ΔΓῖHῖJΓ .(ῖ)ΩῖῖΨéῖ ὕῖMῖῖῖOῖ TῖHέῖOῖOξ Ωξ ὕTῖOῖ ΔAῖ Kῖ éOῖ CῖΠῖῖῖB άΨ ε ῖCéZῖTῖOῖ Η ὀΦEIZῖBOῖéZῖTῖOῖ ὕTῖOῖ ὕTῖOῖ TῖOῖ .(Ī)Δβῖ KῖZῖTῖOῖ ε ῖῖῖῖ BῖHῖJΓ CῖΠKῖOῖB δ éZῖyῖ (ῖ)ΩῖῖTῖDB Η ἡΨOῖ άHῖ ὀῖMῖZῖ TῖῖῖBῖ ΓάOῖ Kῖ TῖHέῖOῖOξ Ωξ Kῖ ΩῖBῖOῖ ὕTῖOῖ ἡῖ CῖOῖOῖN ῖῖOῖN TῖῖéῖΓ ΔMN δ Bῖ JῖYῖéTῖOῖ CῖΠΔῖOῖHῖ HῖN ΩZῖOῖ KῖéKῖ Kῖ EῖHéJΓ Η JῖDῖYῖ TῖMῖ- ἡῖ ἡΨIEZβῖ ἡOZ TῖῖéῖΓ ΔΓῖBῖ TῖOῖ ρῖῖéΓ CῖΠEῖῖάῖ ἡῖ CάῖOῖOῖ TῖῖῖῖῖS ΩῖῖῖOῖBά KεῖOZῖ JῖYῖ Kῖ ΨOΦ KῖΠσΓ άΨ CῖYῖῖῖ JῖJῖJSEΓ .Δβῖ CῖΠCέZῖTῖOῖ ὕTῖJΓ άΨ Η ἡΨOῖ ἡῖῖῖ áῖOῖOῖ ΓῖAῖΓ Ωῖγῖῖ OZῖ

Δ₁β Dē h η₁ Ω₁ ΕΙΓ₁ ΕΛ Η ΚΥΟΒ ΕΛ C₁ΕΩ ΙΛΤ₁Α₁ΰ Ψ₁Ω₁Ε
 .Ω₁Ω₁Ζ₁Τ₁ δ α₁ΙΔ₁Ζ C₁ά₁Ψ₁ Κ₁ΖΙΦ₁Β₁Ε₁ΰ
 Τ₁Σ₁σ₁β C₁ΙΛ₁ά₁Τ₁ Ε₁ Τ₁ς Κ₁η ρΗ₁ η₁ C₁Η₁Κ₁σ₁β ρΗ₁_{ZPC} :pH₁_{ZPC} Ζ₁Φ₁Ψ₁Ε
 η₁ Ε₁Ζ₁Γ₁ά₁ς Ζ₁Ψ₁ Ζ₁Φ₁Ψ₁Ε C₁η₁ΕΩ .Δ₁β₁ η₁ Ψ₁Ο₁Ζ₁Τ₁ Ε₁Ε₁κ Ε₁Ω₁ΕΩ Ο₁Ψ₁ΙΝ
 Κ₁Ω₁Η/Η₁Μ ; (Cerny- MERCK Inc.) Ε₁Π₁ς Ψ₁Δ₁ς Ψ₁Ο₁Α₁Σ₁Γ₁ η₁ Η Δ₁Φ₁Η₁Ε₁Ζ₁Ψ₁ Ε₁Ω₁Η₁ι
 mL α₁Ω₁Γ₁ .Ω₁Ψ₁Ε₁ΰ Ψ₁Ψ₁Ε₁Ζ₁β₁ ρΗ₁ Ψ₁Ω₁Η₁ΰΨ₁Ε₁Ζ₁Ψ₁ Ψ₁Τ₁Ο₁ι Ε₁Ω₁Η₁ι Κ₁Ω
 Η Κ₁Ζ₁Χ₁Υ₁ά Ι₁Η mL Ζ₁Ψ₁ά₁ Ψ₁Ω₁ι Η₁Η₁ α₁Ψ η₁α Δ₁Φ₁Η₁Ε₁Ζ₁Ψ₁ Ψ₁Ο₁Α₁Σ₁Γ₁ η₁ Ι₁Η₁
 Ψ₁Ο₁β Η Ω₁β₁η₁ η₁ Ψ₁Ψ₁Ε₁Ζ₁β₁ Τ₁ Η₁Η₁ Τ₁Ε Η₁ Ψ₁Ψ₁Η₁Ω₁Σ₁Γ₁ α₁Ψ Ψ₁Ι₁Ο₁Α₁Σ₁Γ₁ ρΗ₁
 Ο₁Υ₁Τ₁ η₁ Η₁η₁ g Τ₁Τ₁Ε₁Ν Ε₁Η₁ι₁Φ₁Γ₁ .Ω₁Ψ₁Ε₁ΰ Β₁Φ₁Χ₁Π₁Ε α₁Ο₁ΰΨ₁Τ₁ Κ₁Ζ₁Υ₁Α₁Β₁Ι₁Ο₁Γ₁ Τ₁
 .(Η₁Ι₁)Ω₁Ψ₁Ε₁ΰ Κ₁Ι₁Τ₁Ξ₁ η₁ Ψ₁Ι₁Ζ₁Ψ₁ά₁ η₁ Β₁Η₁Ω₁ Ε₁Λ α₁Ψ C₁Η₁ά Ω₁Φ₁Υ₁Ψ₁ Γ₁ά₁Ι₁
 Ο₁Υ₁Τ₁ Ω₁Ψ₁Ι₁Γ₁ Η Δ₁Φ₁Η₁Ε₁Ζ₁Ψ₁ C₁Ο₁Ζ₁Σ₁Γ₁ Ζ₁Ψ₁ά₁ Ψ₁Υ₁ Μ₁Υ₁Ι₁Ζ₁ Ψ₁Ε₁Ζ₁Ψ₁ α₁Ο₁Χ₁Π₁Γ₁ Κ₁Ω
 Ε₁Π₁Γ₁ Ε₁Ω₁Ζ C₁Ε₁ς₁β₁ η₁ Ω₁Ψ₁ .Ω₁Ζ₁ Κ₁Ζ₁Ε₁ΰ Ε₁Χ₁ α₁Ψ Ω₁Π₁Ι₁Ζ Ε₁Ω₁Η₁ι Κ₁Ω Ψ₁ά₁Ι₁
 Hettich) Ε₁Ψ₁Ε₁Υ₁Ε₁Ζ₁Ι₁β₁ η₁ α₁ς Ψ₁Ι₁Ζ₁Ψ₁ά₁ η₁ Ψ₁Υ₁ Ε₁Λ Τ₁Υ₁Ι₁Μ₁β ρΗ₁ Ψ₁Σ₁Ο₁Γ₁
 Τ₁ (Η₁Ι₁ min Γ₁Ω₁Γ₁ Κ₁Ω Ι₁Η₁Η₁Η₁ rpm α₁Η₁Ψ Τ₁ RotoFix 32 Ψ₁Ω₁Γ₁
 (schott Germany CG-824) Ε₁Ζ₁Γ₁ρΗ₁ Ψ₁Τ₁Ψ₁Ζ₁β₁Ψ₁ η₁ Ψ₁Ψ₁Ε₁Ζ₁β₁η₁
 ρΗ₁_{ZPC} Κ₁σ₁β₁ .Ω₁Ζ₁Ω₁Ζ₁ α₁Η₁Ε₁Ψ₁Ε α₁Τ₁ Ι₁ Ψ₁Ε₁ Ψ₁Ο₁Φ₁ .Ω₁Ψ₁Ε₁ΰ Ε₁Ψ₁Ο₁Φ₁
 .Ω₁Ψ₁Ε₁ΰ Ζ₁Φ₁Ψ₁Ε ρΗ₁ Τ₁Υ₁Ι₁Μ₁β Ε₁Ψ₁Ψ₁Ι₁Γ₁ Ε₁Ω₁ΕΩ α₁Ψ Κ₁Ω₁Η₁Η₁ Ε₁Ψ₁Ψ₁Ι₁Γ₁ Β₁β₁ά η₁η₁
 Η Τ₁Ε₁Φ₁Κ₁Ο₁Ε α₁Π₁ Ψ₁SPSS 16 α₁Η₁ς₁Ι₁Γ₁Ε₁Β₁ς₁ η₁η₁ Ψ₁Ψ₁Ψ₁Ψ₁ Δ₁Υ₁Ε₁Υ₁Ω₁Γ₁ C₁η₁ΕΩ
 Η ANOVA Ψ₁Ε₁Ο₁β₁Ε₁Φ₁ς C₁ά₁Π₁ C₁Ι₁Π₁Ε₁Ο₁Γ₁η₁ Τ₁ς₁Τ₁Ψ₁Ζ₁β₁η₁ α₁Π₁ C₁σ₁β C₁ά₁Π₁ Ψ₁Φ₁Α₁Σ₁Ε Η Κ₁Υ₁ι₁Ξ₁Ε α₁Ψ .Ω₁Ζ₁ Ψ₁Ψ₁Ε₁Ζ₁β₁η₁ Ψ₁Υ₁β₁Π₁Γ₁ (t Ε₁Ο₁Γ₁η₁ C₁η₁ΕΩ
 .Δ₁β₁η₁ Ψ₁Ω₁Ζ₁ Κ₁Ζ₁Ε₁ΰ Ε₁Χ₁ α₁Ψ Η₁η₁Η₁ Ψ₁Π₁Ε₁Ο₁Γ₁η₁ Κ₁Φ₁Α₁ΰ α₁Ψ C₁ά₁Π₁Ψ₁Τ₁Η₁Ω₁Γ₁



C₁Η₁ά Ω₁Φ₁Υ₁Ψ₁η₁ Ψ₁ά₁Ι₁ Ο₁Υ₁Τ₁ XRD Ε₁Υ₁Ο₁Λ₁Ε : Ψ₁Τ₁Η₁Η₁Ψ₁Ψ₁Ο₁Ζ₁
 Ι₁Φ₁Ι₁Σ₁Ε Ζ₁Ψ₁Η₁ α₁Ψ Ψ₁Ψ₁Ε₁Ζ₁β₁η₁ Ψ₁ά₁Ο₁Γ₁

.Ω₁Π₁Ζ₁Υ₁Λ₁ Ψ₁Φ₁Ε₁Ι₁Ζ₁β₁η₁Ο₁Υ₁Ε₁Ζ₁Ψ₁Τ₁ Γ₁ά₁Ι₁ Ο₁Υ₁Τ₁ Ε₁Ο₁Φ₁Υ₁Ζ₁Ι₁Σ₁Β₁Ο₁β₁ Ψ₁Ω₁Γ₁ C₁Η₁Ε₁Κ₁Ω₁Γ₁ Ω₁Ξ Γ₁η₁Ε₁Π₁ Τ₁β₁ά₁ΕΩ α₁Ο₁Χ₁Π₁Γ₁ Κ₁Ω :C₁ά₁Π₁Ψ₁Ψ₁Η₁β₁Υ₁η₁Ψ₁ δ Η₁ά Ε₁Ο₁Φ₁Υ₁Ζ₁Ι₁Σ₁Β₁Ο₁β₁ Τ₁ C₁ά₁Π₁Ψ₁Ψ₁Η₁β₁Υ₁η₁Ψ₁ δ Η₁ά η₁η₁ Γ₁η₁ά₁Ι₁Ο₁Υ₁Τ₁ Ε₁Ο₁Φ₁Υ₁Ζ₁Ι₁Σ₁Β₁Ο₁β₁ C₁Ι₁Π₁Η₁β₁Υ₁η₁Ψ₁ Κ₁Ω₁Ε C₁η₁ΕΩ .Ω₁Ζ₁ Ψ₁Ψ₁Ε₁Ζ₁β₁η₁ Ω₁Π₁ά₁Π₁ Ψ₁Γ₁ Η₁η₁Ι₁ Τ₁Υ₁Ι₁Υ₁Ε₁Ζ₁Ψ₁Τ₁ Ψ₁Ω₁ΕΩ Κ₁Ω η₁α₁ Ψ₁Υ₁Ε₁Ζ₁β₁η₁ Η₁β₁ς₁ C₁Ι₁Π₁Η₁β₁Υ₁η₁Ψ₁ Ψ₁Ε₁Ο₁Φ₁Υ₁Ζ₁Ι₁Σ₁Β₁Ο₁β₁ C₁Η₁Π₁Ρ Γ₁η₁ά₁Ι₁ Ο₁Υ₁Τ₁ Ε₁Ο₁Φ₁Υ₁Ζ₁Ι₁Σ₁Β₁Ο₁β₁ η₁η₁ Ψ₁Ω₁Ζ₁ Κ₁Ω₁Ε C₁Ι₁Π₁Δ₁Χ₁ά₁ α₁Ψ ι Χ₁η₁Γ Ε₁Π₁Γ₁ Ε₁Ε₁φ Ψ₁Φ₁Ψ Γ₁Τ₁Υ₁Ο₁Ζ₁Σ₁Γ₁ Κ₁Ω η₁Η₁ά₁ Κ₁Ζ₁Τ₁ι₁Ζ₁ Η₁β₁Υ₁ Γ₁Ω₁Γ₁ Κ₁Ω Η₁Ψ₁Ψ₁Ψ₁ α₁Η₁Ε₁Ι₁ Β₁η₁ς₁ .Ω₁Ζ₁Ω₁Ζ₁ C₁Υ₁Ψ₁Τ₁Η₁ C₁Ι₁Π₁Η₁β₁Υ₁η₁Ψ₁ Ο₁Υ₁Ν Β₁Γ₁Τ₁Η₁ Γ₁η₁ά₁Ι₁Ο₁Υ₁Τ₁ Τ₁Ε Ω₁Ζ₁ Ψ₁Ψ₁Ψ₁ C₁Ι₁Π₁Η₁β₁Υ₁η₁Ψ₁ Τ₁Ζ₁ς₁ Η₁β₁Υ₁η₁Ψ₁ η₁η₁ Ψ₁Ε₁ Υ₁Π₁Γ₁η₁ Ζ₁Ψ₁Η₁ α₁Ψ Κ₁η₁ Δ₁β₁η₁ Ε₁Η₁Ι₁ Κ₁Ω t Ο₁Ψ₁Ο₁Φ₁Ι₁Ζ₁β₁η₁ C₁η₁ΕΩ) Ζ₁Φ₁Α₁Φ₁Β₁Τ₁ς₁Τ₁Γ₁ Η₁ (Κ₁Υ₁Ο₁β₁ Κ₁β₁ C₁η₁ΕΩ) Ζ₁Φ₁Υ₁Υ₁Π₁Ι₁Ζ₁Ι₁Ν Κ₁Ω (HiMedia Laboratories Pvt. Limited) (α₁ Ψ₁Ω₁Φ₁Τ₁ά₁Ω₁Φ₁ς₁ C₁Ε₁Φ₁Ψ₁Η₁η₁Ω₁Ζ₁ Ψ₁Ι₁Λ₁Ι₁Ε₁Ζ₁Ψ₁Τ₁ Ω₁Ζ₁ά Β₁Ω₁ι C₁Ι₁Π₁Κ₁Π₁Ι₁ Ε₁σ₁Ι₁ Η₁η₁ Η₁Ω₁Π₁Ι₁Ζ Ε₁Ω₁Η₁ι .Ω₁Ζ₁Ω₁Ζ₁ Κ₁ι₁β₁Ι₁Σ₁Γ₁ Τ₁Μ₁ς₁ Ζ₁Φ₁Ψ₁Ι₁Ζ₁Ο₁Γ₁ Η Ζ₁Φ₁Ψ₁Ε C₁η₁ΕΩ :MBC Γ₁η₁ά₁Ι₁Ο₁Υ₁Τ₁ Τ₁Ψ₁Ω₁Π₁η₁Ψ₁ Δ₁Χ₁ά₁ Ψ₁Ψ₁Η₁Ω₁Ρ Ζ₁Φ₁Ψ₁Ε C₁Η₁ά Ε₁Ω Ω₁η₁ς₁ Ψ₁Ω₁Υ₁Ψ₁ Γ₁ά₁Η₁Ω₁Ψ₁ Τ₁Μ₁ς₁ α₁Ψ Κ₁Ω Τ₁Υ₁Π₁Ι₁Κ₁Π₁Ι₁Ο₁Γ₁ η₁η₁ Ψ₁MBC Τ₁Ω Η₁ (Η₁Ι₁)Ω₁Ζ₁Ω₁Ζ₁ Ψ₁Ψ₁Ψ₁Ψ₁ Ψ₁Ω₁Ξ₁Γ₁ Δ₁η₁Ψ₁ Τ₁Ψ₁Ο₁Φ₁ α₁Τ₁Ψ₁ Δ₁η₁Ψ₁ ρ₁Φ₁Σ₁Γ Ζ₁Φ₁Η₁Η₁ .Δ₁ί₁Ε₁Ψ₁ Γ₁ά₁Ο₁κ Τ₁Η₁Α₁Ψ₁ δ α₁Ι₁Δ₁Ζ₁ Τ₁Π₁Ω₁Τ₁ C₁Ι₁Π₁Δ₁Ψ₁ά δ Η₁ά Κ₁Ω Δ₁ι₁Υ₁ς₁ Ε₁ C₁Ι₁Π₁Ι₁Ε₁Ζ₁Ψ₁Τ₁ Ψ₁Ω₁ΕΩ Ω₁Ζ₁ά Ε₁Π₁Ψ₁ α₁Ω₁Γ₁ Κ₁Ω C₁Η₁Κ₁Π₁Ι₁Ο₁Γ₁ Ε₁Ι₁Ι₁/Ι₁Ι₁ Ε₁Π₁Ψ₁ Ψ₁Ο₁ Η₁η₁Η₁Η₁Η₁ η₁η₁ Ε₁Ζ₁η₁Φ₁ Ψ₁Ω₁Π₁Ι₁Ζ₁ Κ₁Π₁Ο₁Γ₁ Ε₁Ε₁κ Ε₁Π₁Γ₁η₁ Κ₁Π₁Ο₁Γ₁ α₁Ψ .Ω₁Ζ₁ Ο₁Ι₁Χ₁Ζ₁ς₁ MBC Ε₁Ω₁Η₁ι Κ₁Ω (Ψ₁Ι₁Ι₁Ε₁Ζ₁Ψ₁Τ₁ Κ₁Ω₁Η₁Η₁ Ψ₁Ω₁ΕΩ α₁Ψ Γ₁η₁ά₁Ι₁ Ο₁Υ₁Τ₁ Τ₁Ω Κ₁Μ₁Ν₁η₁Ο₁Γ₁ α₁Ψ Ψ₁Ι₁Ι₁Ε₁Ζ₁Ψ₁Τ₁ Ε₁Ο₁Φ₁Υ₁Ζ₁Ι₁Σ₁Β₁Ο₁β₁ ι₁Φ₁ς₁ Ψ₁Ε₁Ζ₁Ψ₁ η₁η₁ Ε₁ C₁Ω₁ π₁Ο₁Ε₁Γ₁ CFU δ α₁Ι₁Δ₁Ζ₁ Τ₁Ω Ψ₁Ω₁Π₁Ζ₁ς₁Ω₁ α₁Η₁Ε₁Ι₁ Δ₁η₁Ψ₁ ρ₁Φ₁Σ₁Γ .Ω₁Ζ₁ Ψ₁κ₁Ι₁Ρ Ε₁Π₁Η₁Φ₁Δ₁ς₁ Δ₁η₁Ψ₁ ρ₁Φ₁Σ₁Γ α₁Ψ C₁Ε₁Ζ₁Ψ₁Τ₁ Ω₁Ζ₁ά Τ₁Υ₁Ι₁Σ₁Β₁Ο₁Ε Ζ₁Ψ₁Η₁ α₁Ψ :Γ₁η₁ά₁Ι₁ Ο₁Υ₁Τ₁ Τ₁Ω Ψ₁Ι₁Δ₁Ε α₁Ψ Ψ₁Ι₁Ι₁Ε₁Ζ₁Ψ₁Τ₁ Ψ₁Ε₁Γ₁ Κ₁Ψ₁Π₁Ο₁Γ Τ₁β₁ά₁ΕΩ Δ₁Μ₁Ν Ω₁Π₁ά₁Π₁ Ψ₁Γ Β₁Φ₁ς₁ Δ₁Χ₁ά₁Ω η₁η₁ Ψ₁Ε₁ Υ₁Π₁Γ₁η₁ η₁η₁ Κ₁Α₁Ρ₁Ε₁Γ C₁Η₁Π₁Ρ Ε₁Υ₁Π₁Γ₁η₁ C₁Ι₁Π₁Κ₁Π₁Ι₁Ο₁Γ₁ .Ω₁Ζ₁ Ψ₁Ψ₁Ε₁Ζ₁β₁η₁ Ψ₁Ι₁Ι₁Ε₁Ζ₁Ψ₁Τ₁ Ψ₁Ε₁Γ₁ Ε₁Π₁Γ₁ Τ₁Ω Η<

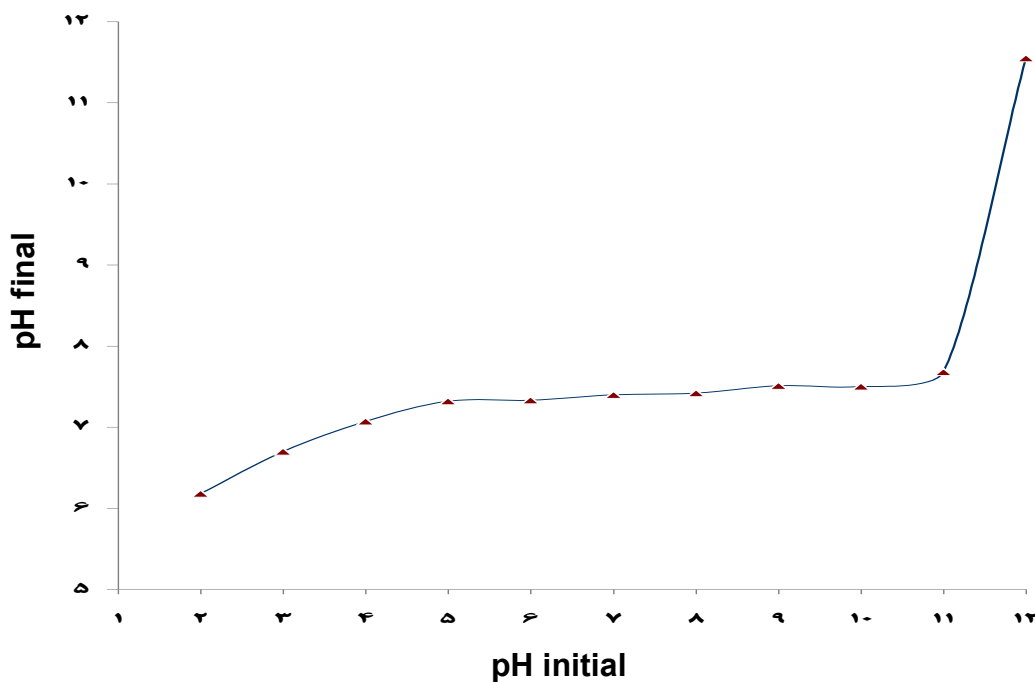


TEM (b) SEM (a) : IJSE JVNth α Ψth ΨICZβth Ψ α OG CH α QΦγth Γth α I O3B ϵ VOλE :O -H ŸKZ

ΤΙΚΖΓΤΥ

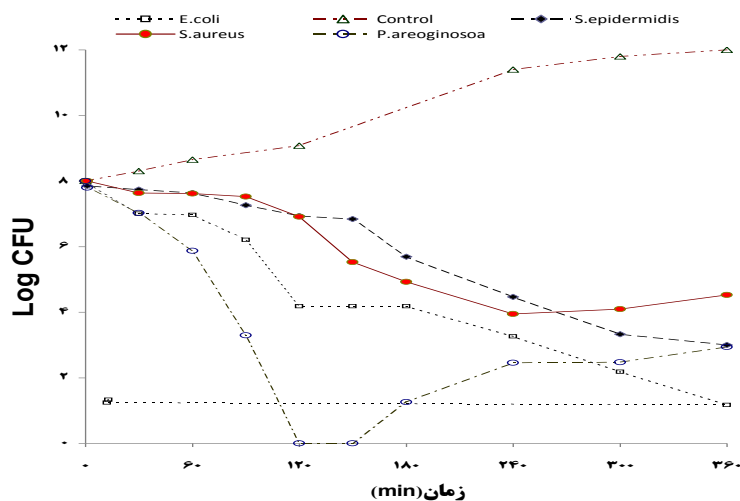
EthΓOΓH Ÿ3 α ŸthηthΩ3th Ÿ θ OλXΓ Πσβ EthΓOΓ ŸŸŸZ Tβ α ϵ Ÿ MYIZ3
 .Δβth ŸΩZ ŸΨ α Hth H ŸHΩN α Ψ CH α QΦγth Γth α I O3B θ OλΦ
 ΔβΨ KŸ Ÿth/Ÿth CH α QΦγth Γth α I O3B pH_{ZPC} ŸŸŸZ Ÿ Tβth ϵ Ÿ
 .Δβth ŸΩΓth
 ϵ ŸΨIΓ (h ŸHΩN) JZOAŸΨ Hth ϵ ŸH ϵ ŸŸOΓ δ H α BIE3th KŸ KNO ϵ TŸ
 KΦAth CH α QΦγth Ÿth α I O3B EOΦγ3I δ BOB ΩZ α ŸΩthŸ α ŸIΓ ΔX α Ÿ
 HthIth/hthIth Hthhth μg/mL KŸIŸOG JVNth α Ψ ΨICZβth Ψ α OG CILC ϵ ZKth
 KŸ πO ϵ Γ ΩZ α ŸΩthŸ α ŸIΓ ΔX α Ÿ JŸ ϵ ZDŸ ETOΓ JVNth α Ψ KŸ Δβth ŸΨOth
 JΦŸth tBŸ .Δβth ŸΨOth ATCC 27853 ŸthOŸŸ ϵ H ϵ Ÿth Ÿ TBOΓHΨOγth
 ΨOth ŸHth/-Ÿthhth μg/mL TILC ϵ ZKth ŸΩthηŸ ΔX α Ÿ ŸthΩP

ŸΨICZβth Ψ α OG Ÿ α I O3B ΓTλXηΓ ϵ XŸ HΨ α Ψ KŸIŸOG MYIZ3
 .Δβth ŸΩZ KŸ α Ÿ ŸΩZ BIE3th CILΔγ ϵ MYIZ3 H IJSE JVNth α Ψ
 H C α OAŸ α IZΦIβ Tβ α ϵ Ÿ C ϵ Ÿ :CH α QΦγth Ÿth α I O3B ΓTλXηΓ
 ŸΨICZβth (XRD) α KŸth KŸZth S ϵ ϵ Ÿth ηth CH α QΦγth Ÿth α I O3B C η Tth
 CH α QΦγth Ÿth α I O3B XRD ϵ VOλE (Ÿth)H ŸŸZ .Δβth ŸΩZ
 QΦγth Γth α I O3B SEM ϵ VOλE (O)H ŸKZ .ΩLTΓT ETO3th Ÿ α
 ΓTŸIŸOG .ΩLTΓT ETO3th Ÿ α IJSE JVNth α Ψ ΨICZβth Ψ α OG CH α
 Γth α I O3B CH α ϵ Ÿ TEM H TηO α T3H ϵ ZKth Ÿ OKβH ϵ KŸ
 C α α Ψ CH α QΦγth Γth α I KŸ ΨΨ ETO3th ŸΨICZβth Ψ α OG CH α QΦγth
 .ΩMγL hth nm ϵ ŸI



KŸIŸOG JVNth α Ψ ΨICZβth Ψ α OG CH α QΦγth Γth α I O3B pH_{ZPC} :h ŸŸZ

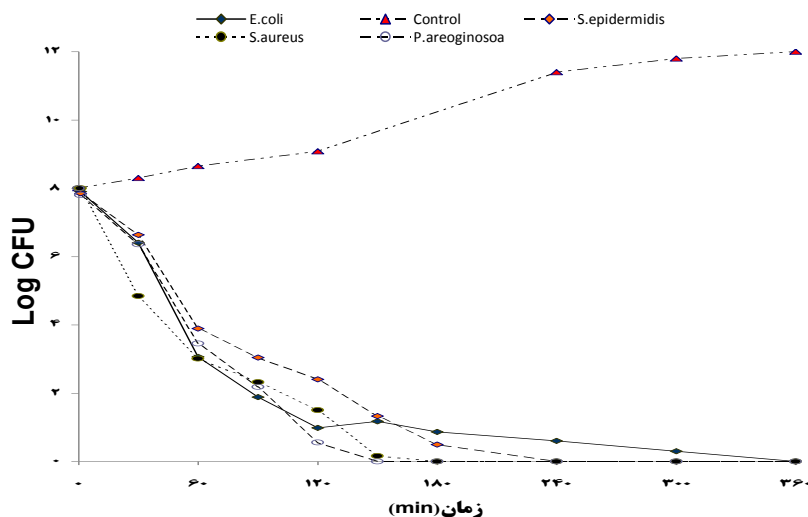
MBC	MIC	باکتری‌ها
۱۲۵۰	۱۲۵۰	اشرشیا کلی ATCC 25922
۲۵۰۰	۶۲۵	استافیلوکوک اپیدرمیدیس PTCC 1114
۵۰۰۰	۱۲۵۰	استافیلوکوک اورئوس ATCC 25923
۳۱۲/۵	۱۵۶/۲۵	پسودوموناس آیروزینوزا ATCC 27853



CH₄ O₂ Γ₁ O₂ E₀γ₁β₀β 1 x MIC Δχ₄ω τ₀ τ₁Δ₀ α₀ Ή₀Δ₀Χ₀Γ₀Π₀Π₀ή α₀Ή₀Δ₀Ε₀Ζ₀Ζ₀Π₀ C₀έ₀ u έ₀Γ₀ E₀Π₀ή T₀Σ₀Π₀: Ή₀Π₀-D Ψ₀Υ₀Ζ₀.
Ω₀Ζ₀ Ή₀Π₀Ε₀Ζ₀β₀ Ή₀ά₀Ι₀Ο₀Ζ₀ E₀Η₀Ω₀ Δ₀η₀ ρ₀Φ₀Σ₀ ή₀ Ή₀έ₀Ζ₀Π₀ C₀έ₀

Ε₀τ₀Η₀ά₀Ω₀Π₀ Ή₀Ω₀Π₀έ₀ς₀Ο₀β₀ Ψ₀Τ₀Ζ₀ (ROS) Ο₀ζ₀ω₀ά₀ Ε₀τ₀Π₀ C₀Π₀Κ₀Ο₀υ₀
Ο₀Φ₀Ε₀Ω₀Π₀έ₀ς₀ u έ₀Ζ₀β₀ Κ₀ έ₀Ξ₀Π₀ Ψ₀τ₀Π₀Η₀ά₀Ω₀Π₀ Ή₀Π₀Υ₀Π₀ά₀ Η₀ Ω₀Π₀έ₀ς₀
Τ₀υ₀Ω₀Ζ₀ Β₀υ₀έ₀Ζ₀ Δ₀Π₀Π₀ Ψ₀Υ₀ Γ₀ά₀Ι₀ Ο₀Ζ₀ SEM α₀Υ₀ί α₀Ή₀Ψ₀Ο₀Ζ₀
Ψ₀τ₀Ο₀υ₀ ά₀Π₀Υ₀ C₀Π₀Π₀Π₀Ζ₀Υ₀έ₀ς₀ ω₀Δ₀Ξ₀ ή₀ Τ₀Ζ₀Π₀ Κ₀ Δ₀β₀ Ψ₀Ο₀Ν₀Ο₀Γ₀
Ψ₀έ₀Σ₀Π₀ ά₀Ο₀ς₀ Κ₀ Ψ₀τ₀Ο₀υ₀ ά₀Π₀Υ₀ Ή₀ή₀Ω₀Ζ₀ Ψ₀τ₀Π₀ Κ₀ Η₀ Δ₀β₀ Γ₀ά₀Ι₀Ο₀Ζ₀
Ω₀Π₀Ψ₀Τ₀Τ₀ Ε₀Π₀η₀ SEM Ε₀έ₀ς₀Η₀έ₀Υ₀Ο₀Γ₀ Ζ₀Π₀Π₀ Δ₀Υ₀φ₀Ψ₀ Ή₀Ω₀Π₀η₀ Ψ₀Π₀ί₀
Κ₀ έ₀ς₀ α₀Ή₀ Ε₀Τ₀Ζ₀Τ₀υ₀Ω₀Π₀έ₀ς₀ Η₀ C₀τ₀Ο₀Ι₀Ο₀Γ₀έ₀ς₀ Ή₀ά₀Π₀Φ₀Ι₀β₀ Κ₀ Κ₀Ν₀Ο₀Ε₀ τ₀ Γ₀ά₀Ι₀
Γ₀ά₀Ι₀ Ο₀Ζ₀ E₀Ο₀Π₀γ₀Π₀ς₀Ο₀β₀ α₀Ή₀ Κ₀ Ω₀Π₀Ζ₀ Γ₀ά₀Ι₀ Ε₀Ω₀Ζ₀ Ψ₀Υ₀Π₀ί₀ Β₀Π₀
h Ή₀Η₀Ω₀Ν₀ Κ₀ Κ₀Ν₀Ο₀Ε₀ τ₀ .(Η₀ί₀)Ω₀Π₀Π₀Υ₀ ω₀Δ₀Ξ₀Γ₀ Δ₀Π₀Π₀ Ή₀Γ₀Π₀η₀Π₀ή₀ α₀Ή₀
Ή₀ά₀Ι₀ Ο₀Ζ₀ Τ₀υ₀Ω₀Π₀έ₀ς₀ Δ₀υ₀Π₀Δ₀Γ₀ Δ₀Φ₀Κ₀Τ₀Φ₀ Ή₀Γ₀ά₀Ι₀ Ο₀Ζ₀ Δ₀Χ₀ά₀ω ε₀ Ψ₀ί₀τ₀η₀ τ₀

έ₀ς₀Ε₀Τ₀Π₀ TEM C₀Π₀Π₀ α₀Υ₀ί Ζ₀Π₀Π₀Τ₀Δ₀Π₀ .Ω₀Π₀Ζ₀Π₀ Β₀Χ₀Π₀Γ₀ C₀Η₀έ₀ς₀ Ψ₀Υ₀Ζ₀
Ι₀Ο₀Σ₀Ε₀ Ζ₀Π₀Υ₀ α₀Ή₀Ψ₀Π₀Ε₀Ζ₀β₀ Ψ₀ά₀Ο₀Γ₀ Γ₀ά₀Ι₀Ο₀Ζ₀ Κ₀ Δ₀β₀ ψ₀Ο₀Ξ₀Ο₀Γ₀ Ζ₀Π₀Υ₀
έ₀ς₀Ο₀Ε₀ Θ₀ί₀τ₀ Γ₀ά₀Ι₀ Ή₀ή₀Ω₀Ζ₀ ε₀ Π₀Π₀ .Ω₀ς₀ά₀Π₀ ά₀ς₀έ₀Ι₀ Ο₀Ζ₀ Ή₀Ψ₀Η₀Ω₀Σ₀Γ₀ α₀Ή₀
Υ₀ί₀β₀ Κ₀Ξ₀Φ₀Ζ₀ α₀Ή₀ Η₀ Τ₀Μ₀β₀ Τ₀Υ₀Π₀Φ₀Δ₀Φ₀Ζ₀Ο₀Υ₀Ν₀ί₀Ο₀ί₀ Η₀ C₀ά₀Π₀Φ₀Ι₀β₀ C₀Π₀Π₀Τ₀υ₀Τ₀Υ₀Η₀
Τ₀Δ₀β₀ Θ₀ί₀Ο₀Φ₀ ε₀ Ψ₀ί₀τ₀η₀ Η₀ Ή₀Ω₀Ζ₀ Γ₀Π₀Ψ₀Ο₀Ν₀Ο₀Γ₀ C₀ί₀έ₀ Τ₀Μ₀β₀ Τ₀β₀έ₀Ζ₀β₀Ψ₀
/Ή₀Τ₀Υ₀Η₀ Π₀ο₀β₀ ε₀ Ψ₀ί₀τ₀η₀ Ζ₀Π₀Υ₀έ₀ς₀Τ₀Π₀ Η₀ Ή₀ή₀Ω₀Ζ₀ ε₀ Π₀Π₀ .(Η₀Ι₀)Ψ₀Ο₀Ζ₀Τ₀Τ₀ Τ₀Μ₀β₀
C₀Η₀ά₀ ε₀Δ₀ Ο₀ζ₀ω₀ά₀ C₀Π₀Π₀Ή₀Η₀έ₀ς₀ Ψ₀τ₀Ο₀υ₀ ε₀ Ψ₀ί₀τ₀η₀ τ₀ Ή₀έ₀Δ₀Π₀ Θ₀ί₀Ο₀Λ₀Χ₀Γ₀
Δ₀Φ₀Δ₀β₀ ε₀ Ψ₀ί₀τ₀η₀ C₀ί₀έ₀ Π₀ά₀Ο₀ζ₀ω₀Π₀ Ζ₀Π₀Υ₀έ₀ς₀Β₀Μ₀Γ₀ Ε₀Π₀Ο₀ί₀ Κ₀ Γ₀ά₀Ι₀ Π₀ο₀β₀
Ή₀Π₀υ₀Γ₀ C₀Π₀Π₀Ή₀Η₀έ₀ς₀ ε₀ Ψ₀ί₀τ₀η₀ Ω₀Π₀Ζ₀ .Δ₀β₀ Ή₀Ω₀Ζ₀ έ₀ς₀Ι₀ Γ₀ά₀Ι₀ Ο₀Ζ₀
C₀έ₀ς₀Ψ₀Υ₀Ζ₀ C₀ί₀έ₀ Ή₀Π₀υ₀Γ₀ C₀Π₀Ε₀Τ₀Υ₀Γ₀ Ε₀Π₀Ο₀ί₀ Κ₀ Τ₀Σ₀ο₀β₀ (Ο₀ζ₀ω₀ά₀)



CH₄ O₂ Γ₁ O₂ E₀γ₁β₀β MIC*1 Δχ₄ω τ₀ τ₁Δ₀ α₀ Ή₀Δ₀Χ₀Γ₀Π₀Π₀ή α₀Ή₀Δ₀Ε₀Ζ₀Ζ₀Π₀ C₀έ₀ u έ₀Γ₀ E₀Π₀ή T₀Σ₀Π₀: O-D Ψ₀Υ₀Ζ₀

MYIZ ū 1β ē .ΩΥΨΕΥ ΤΒάΕΩ ΒΛ δ Ηά ΖΥΗ ΤΩ CHά ΩΦγϋΗ
 ε ΛΠū MIC*H ΔΧάω άΨ Τϋ-Ī ŶŪΖ άΨ ἸΩΓ- ΔΒΨ ΚΩ
 έΨΥΨ ΚΩ Δίγζ ἡΩΜτΗΕν- ū ΤΩΓΗΨΟγς CΠCέΖΗΤΩ ΔΦΩΔΝ
 ΚΒ ΔΦΩΔΝ ε ΛΠū ΩΝΗά Η Δβἡ ἸΨΩΩ έΖŷνέβ άΤΦγϋ CΠCέΖΗΤΩ
 ΔΧάω ε ΥήΓΗ ΤΩ .Δβἡ ἸΨΩΩ ΒΛ ΤΩ ΚΥΠΗΓ ΤŷνέΕ έΨΥΨ CέΖΗΤΩ
 ΔΦΩΔΝ ε ΛΠū Δίέβ MIC*h ΚΩ ΓἡάĪΟΖΤ ΕΟΦγΖΤΣΒΟΒ
 ἸέΖΗ CἡέΩ (Ο -Ī ŶŪΖ) Δβἡ ΚΖΓΤΥ ε ΥήΓΗ άΤΦγϋ CΠCέΖΗΤΩ
 ΔΦΩΔΝ ε ΛΠū ΚΖϋΗ .ΩΖ ἸΨΥΕΖβἡ ἸάĪΟΖΤ ΕΗΩΩ Δηŷ ρΦΣΓ ἡἡ
 ἸΨΩΩ CέΕΩΜŷ ΩΝΗά CἡάΨ ΚΦΩ ΚΩ Δίγζ ΤΑŷΤΦΖέΖἡ CΠCέΖΗΤΩ
 ΟΖΤ ΕΟΦγΖΤΣΒΟΒ ΤΩ CΠCέΖΗΤΩ ū ἸΔΕ ΕΠΓἡ ε ΥήΓΗ ΤΩ .Δβἡ
 ε ΛΠū ὶ MIC*h ΔΧάω CἡέΩ ī h ΚΩ ἡ ἡἡ CHά ΩΦγϋΗ ΓἡάĪ
 ‡ ΟŷΟΑΦŷΤΖβἡ CἡέΩ ὶείĪ ἡἡ ΤΑŷΤΦΖέΖἡ CἡέΩ ΤΥΠΕΖŷΤΩ ΔΦΩΔΝ
 έ ἸΗ/Η ἡἡ ū Ο-άΗΗ ‡ ΟŷΟΑΦŷΤΖβἡ CἡέΩ ὶέĪH ἡἡ α ΥΩΦŷάΩΦἡ
 ε ΥήΓΗ έΗἡH ΚΩ έ īī/Ī ἡἡ ἡΩΜτΗΕν- ū ΤΩΓΗΨΟγς CἡέΩ Η
 ΠΤἡάH CάΠ- ὶΦΑΣΕ Η ΚΥἡΞΕ MYIZ ΖΦŷΤΒΛ .Δβἡ ΚΖΓΤΥ
 Δβἡ ἸΨΨ ΕΠηζ ū ἸΔΕ ΕΠΓἡ Η CΠCέΖΗΤΩ ε ΛΠū ΖΦΩ CάΨΤΗŷΓ
 ἸΨΥΕΖβἡ Η ΩΥΠΓ CΠCρΦΣΓ άΨ Κŷ ΖΥΗ ΚΩ ΚΝΟΕ ΤΩ .(P<ḥ/ḥḥ)
 Η ΓἡάĪΟΖΤ ΕΩΖ ΖΦηΖΚΕ ἸΠΔΖΡἡ ΓἡάĪΟΖΤ ΕΟΦγΖΤΣΒΟΒ ἡἡ
 ΨάΨ ΨΟΝΗ ἸάĪΟΖΤ -CέΖŷΤΩ ΨάΟΦέΩ ἸΠΔΖΡἡ ε ΛΠū ΚΞΩΖ άΨ
 έἡ ΩἡΟΕΤΓ ἸάĪ ΟΖΤ ΔΧάω Η ū ἸΔΕ ΕΠΓἡ ε ΥήΓΗ ΖΥἡέΣΤΩ
 ΤΩ ΖΦŷΤΒΛ .(ḥḥ)ΩΥΠΔΖ ΤΥΦ ΤΥ Ūά Βŷ ἡά ΤΕΠΓ ὶΤἡἡ ΖΥΗ
 άΨ Δηŷ ρΦΣΓ άΨ ἸΩΖ Ψἡ- ΕΟΥ ΕἡίΦΓ ὶ ū ἸΔΕ ΕΠΓἡ ε ΥήΓΗ
 ε ΛΠū έΩ ΨΟΦ Κŷ ΩΠΥΤΓ ε ΥήΓΗ ΓἡάĪ ΟΖΤ ΤΥΝ ἸΒΣΖH έἡ
 (ḥḥ)ΕἡάĪŪΔΛ Η Tiwari .ΨάΨ ΒΦΖΥΓ έἡ CΠCέΖΗΤΩ ΔΦΩΔΝ
 ΩΨΟΩ ἸΩΦΒά ΚŷΠΟΓ ΖΥΗ ΤΩ ΤΜΠΗΓ MYIZ ΚΩ ΨΟΦ ΚŷΠΟΓ άΨ ίΦ
 ὶΤἡΟἡ ΕΠΟἡ ΚΩ ἡά ΓἡάĪΟΖΤ ΔΧάω Η ū ἸΔΕ ΕΠΓἡ ε ΥήΓΗ Η
 .ΩΠἸΨέŷ έŷĪ CΠCέΖΗΤΩ ū έΓ έΩ άŶŷέΦΠΕ
 ρΦΣΓ ρΗ ἡἡ ΤŷΠΕ ἡά ΓἡάĪ ΟΖΤ άΨ ΥΠŷ ΤΣσβ άΤΩ ΖΦŷΣΓ
 ρΗ_{ZPC} ἡἡ έΕ ΖΦΥἡς ρΦΣΓ ρΗ έŷĪ Κŷ CάΟς ΚΩ ΩΠἸΨέŷ έŷĪ
 έŷĪ Η ΔἡΓ ΤŪŷέΖŪἡ άΤΩ CἡάΨ ἸάĪ ΟΖΤ Πσβ ὶΩΖΤΩ ἸάĪΟΖΤ
 ΤŪŷέΖŪἡ άΤΩ CἡάΨ ἸάĪ ΟΖΤ Πσβ ΩΖΤΩ Ε- ἡἡ έΕΠΤΩ ρΦΣΓ ρΗ
 ρΗ_{ZPC} ΕἡίΦΓ ΨΟΦ ΚŷΠΟΓ άΨ (ḥĪ) Dimitri .ΨΩΩ ΩΠΗΟΦ ΤΕΠΓ
 ΓάΟκ ΚΩ ἡά CHά ΩΦγϋΗ ΟΖΤ ΕΟŷ ΓΤŷŷέΕ ἡἡ CάΤΦγϋ CἡέΩ ἡά
 ρΗ_{ZPC} ΙΖΣΓ ΖΥΗ MYIZ ū 1β ē .Δβἡ ἸΨέŷ ΚἡΒΣΓ CάΟΕΕ
 ΔΒΨ ΚΩ άΩΩΓ ἡἡ Ε- άΩΩΓ Κŷ Δβἡ ἸΨΩΩ ḥḥ CHά ΩΦγϋΗ ΟΖΤ

ΓἡάĪ ΟΖΤ ΔΧάω ε ΥήΓΗ ΤΩ .Δβἡ ΚΖΓΤΥ ε ΥήΓΗ CΠCέΖΗΤΩ ΚΦάἡ
 ΤΥΠΕΖŷΤΩ ΩΖά ΚΩŷΤΦΛ ΨΟΝΟΓ CΠCΚΥΟΒ άΨ MIC ΖΦŷΕ άΨ
 ΚΦΗΗ ΔΧάω ΚΩ ΓἡάĪ ΟΖΤ ΤἡŷCέΖŷΤΩ έἡ Τἡάἡἡ ΚΩ Ωηζ ἸΩΠΠΗΓ
 ΨΟΞΟΓ ΖΥΗ Κŷ Δβἡ ΚΖΥἡΗ ΤΥΠΕΖŷΤΩ ΚΦΗΗ ΔΧάω Η ΓἡάĪ ΟΖΤ
 MYIZ ū 1β ē .(ḥĪ)Δβἡ ἸΩΖ έŷĪ ΒΛ ΖΦŷΣΓ έΨΥΨ ρΒΟΕ
 ΕΟΦγΖΤΣΒΟΒ ΤŷΩΠἡἡ Η ΩΖά ΤŷΩΠἡ ΔŷΠΔΓ έἡ ḥ ἸΗΩΝ
 ΖΥΗ .Δβἡ ΒΛ έΩ ΙŷΠΓ ΤΑŷΤΦΖέΖἡ ΚΦάἡ CHά ΩΦγϋΗ ΓἡάĪ ΟΖΤ
 ΟΖΤ MBC Η MIC έΥΠΠΓ ΕΨΩΩ ΒΛ ΚΩ ŪΥΥἡ έŷΕΤΦ ΚΞΦΖ
 Η Ruparella .Δβἡ ŪΥΥἡ ΒΛ ΚΩ ΤΑŷΤΦΖέΖἡ ὶΠΠΓ άΨ ΓἡάĪ
 έἡ ḥΠΔΖΡἡ Κŷ ΩΩΦΒά ΚΞΦΖ ΖΥΗ ΚΩ ΨΟΦ ΚŷΠΟΓ άΨ ΕἡάĪŪΔΛ
 ΠŪŪΔΖ ΨΟΝΗ ΔΑἡ ΚΩ ΕΟΦγΖΤΣΒΟΒ άΨ ΓἡάĪΟΖΤ CέŶŷΩΔΞΕ
 ΚΩ ΚΝΟΕ ΤΩ ΖΥἡέΣΤΩ (ḥĪ)ΩΠΥΥ ε ΥήΓΗ CŶÈΓ Δηŷ ρΦΣΓ άΨ
 ΖŪΔΓ ἡἡ ΤἡŷΟΗέŪΦΓ ΔΦκἡΦ έΩ ΓἡάĪ ΟΖΤ ἸἡἡΩΠἡ ε J
 ΤἡŷCέΖŷΤΩ ΤΥἡἡ ΓἡάĪ ΟΖΤ CέŶŷΩΔΞΕ ΔΦκἡΦ Κŷ Δβἡ
 ΩΠΥΥ άἡἡ έΦΠΕ ΔΣΕ ἡά MIC/MBC έΥΠΠΓ ΚΞΦΖ άΨ Η ἡἡ
 .(ḥḥ)Δβἡ ἸΩΖ έŷĪ ίΦ ΕἡάĪŪΔΛ Η Gan ρΒΟΕ ΨάΟΓ ΖΥΗ Κŷ
 CΠCΚΥΟΒ CHά έΩ CHά ΩΦγϋΗ ΓἡάĪ ΟΖΤ έἡ έΞΠΡ ΚŷΠΟΓ άΨ
 ATCC ἡΩΜτΗΕν- ū ΤΩΓΗΨΟγς ΥΦἡΕΕ ΚΩ ΤΒάέΩ ΨάΟΓ
 ‡ ΟŷΟΑΦŷΤΖβἡ <ATCC 25922 ΤΑŷΤΦΖέΖἡ < 27853
 ATCC ū Ο-άΗΗ ‡ ΟŷΟΑΦŷΤΖβἡ < PTCC 1114 α ΥΩΦŷάΩΦἡ
 CHά ΩΦγϋΗ ΓἡάĪΟΖΤ έἡ έΨΥΨ Γάἡἡ ΚΩ .Δβἡ ἸΨΩΩ 25923
 .Δβἡ ΔἡΓ Βέŷ CΠCέΖΗΤΩ ἡἡ έΖἡΦ ΤΕΠΓ Βέŷ CΠCέΖΗΤΩ έΩ
 ΚΩ ἡέλΣΠΓ ΓἡάĪΟΖΤ ΤἡŷCέΖŷΤΩ ΤΥἡἡ Κŷ Δέŷ ΕἡΟΕΤΓ Τἡἡ
 .(ḥĪ)ΔγΦζ ΚΖΥἡΗ (ΤΕΠΓ Βέŷ ΤΥ ΔἡΓ Βέŷ) ΤἡΟΑΒ ἸάἡΟΥΨ
 ἸάĪΟΖΤ ΔΧάω ε ΥήΓΗ ΤΩ Κŷ ΨΨ ΕΠηζ ΚŷΠΟΓ ΖΥΗ MYIZ ΖΦŷΤΒΛ
 ΨΙΞἡ ΩΖά ΒΩἡ ΚΠΛ έσĪ CΠCέΖΗΤΩ ΚΔΛ CἡέΩ ὶΕΟΦγΖΤΣΒΟΒ άΨ
 άΨ έΖἡΦ ΔΦΔΒ ΚΩ ΩἡΟΕΤΓ ΚΞΦΖ ΖΥΗ .ΩΠΥΤΓ ε ΥήΓΗ ἸΩΖ
 ΨΟΞΟΓ ΖΥΗ ΚΖϋΗ .ΩΖΤΩ ρἡἡΓ ΓἡάĪ ΟΖΤ έΕΠΤΩ CΠCΔΧάω
 ΟΖΤ ΤἡἡέŪΦΓ ΩΞ ΔΦΑΠἡ ὶ ΔΧάω ΤσΦ Κσἡά έŷΕΤΦ ΩἡΟΕΤΔΖ
 ΔΓΠΠΓ ΨΙΞἡ ἸΠΔΖΡἡ έΕΠΤΩ CΠCΔΧάω άΨ ἡἡἡ ὶΩΖΤΩ ΓἡάĪ
 ū έΓ ΕΠΓἡ ΤΒάέΩ Κŷ ΖΥΗ ΚΩ ΚΝΟΕ ΤΩ .ΨάΨ ΨΟΝΗ Cάἡἡἡἡ
 CέΕΠΤΩ ΔΦβἡΥΡ ἡἡ ΤἡŷCέΖŷΤΩ ΔΧάω ὶἡΩΡ ΖΦŷΕ ΚΩ Δίγζ
 έΖΜΩ ΤλΦΧἡἡ ὶΤἡἡ ΕΠΟἡ ΚΩ ΖΥἡέΣΤΩ (ḥḥḥḥ)Δβἡ άΨάΟΦέΩ
 ΚΖΦΠΖ ΤἡἡέŪΦΓ ΩΞ ὶΤἡΟἡ ΤἡŷCέΖŷΤΩ ὶΦγΖΤΣ ΤΒάέΩ CἡέΩ
 ΓἡάĪΟΖΤ ΤŷΩΠἡἡ ΔΦΑΠἡ ΤΒάέΩ ΚŷΠΟΓ ΖΥΗ άΨ .Δβἡ ἸΩΖ

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Antimicrobial Efficacy of Zinc Oxide Nanoparticles Suspension Against Gram Negative and Gram Positive Bacteria

Edris Hoseinzadeh¹, *Mohammad Reza Samargandi², Mohammad Yosef Alikhani³, Ghodratollah Roshanaei⁴, Ghorban Asgari²

¹Department of Environmental Health Engineering, School of Public Health, Lorestan University of Medical Sciences, Khorramabad, Iran

²Department of Environmental Health Engineering, School of Public Health, Hamadan University of Medical Sciences, Hamedan, Iran

³Department of Microbiology, Faculty of Medicine, Hamadan University of Medical Sciences, Hamedan, Iran

⁴Department of Biostatistics, School of Public Health, Hamadan University of Medical Sciences, Hamedan, Iran

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ABSTRACT

Background and Objectives: Along with the rapid development of human life, controlling harmful effects of microorganisms would be unavoidable. The objective of this study was to evaluate antibacterial efficacy of zinc oxide nanoparticles on different microbial strains.

Material and Methods: This experimental study was done using gram negative and gram positive bacteria in nutrient media. Nanoparticle characterization was determined using X-ray diffraction (XRD), scanning and transmission electron microscopy (SEM and TEM). Bacterial sensitivity to nanoparticles was tested using a disk diffusion test and minimum inhibitory concentration (MIC). Time-kill studies and other tests were carried out using 10⁸ CFU/mL of bacteria at baseline. A point of zero charge, pH_{ZPC}, of nanoparticle was investigated using the batch equilibration method. Obtained data were managed by SPSS Ver.16 and were analyzed through the Pearson, analysis of variance (ANOVA) and Student's independent t-tests. 0.05 was selected as significant level for all tests.

Results: Characterization results from XRD, SEM, and TEM showed that particles are in nano range and they do not contain any discernible crystalline impurity. The average ZnO nanoparticles diameter was 20 nm. The pH_{ZPC} for ZnO was found to be 7.51. The *P. aeruginosa* strain exhibited larger diameter inhibition zone (DIZ) to ZnO nanoparticle compared with other strains. Population of *P. aeruginosa* for 2 x MIC concentration was reduced to zero in the presence of nano ZnO within 150 min. The bacterial CFU had significant difference with contact time, nanoparticles loading, and bacterial strain ($P < 0.001$).

Conclusion: This study demonstrated that antibacterial activity of ZnO can be a candidates for the elimination of gram negative and gram positive bacteria, particularly in nosocomial infection agent control.

Keyword: Gram negative bacteria, Gram positive bacteria, Antimicrobial effect, ZnO

*Corresponding Author: mrsamarghani@umsha.ac.ir

Tel: +98 811 8380025 Fax: +98 811 8380509