Æ ł gpŤř ÆŽQŰ ĺ ĆQKłQdža ůnjǾŢǫ p OǫÊs ĆQ ǩ ǫ
ŽłÇĺł njǾŢǫ O ǁ łyĥł ÆŽQŰ ǰ Ž ǩ ǁ
ĦĥĥĤ ĸσ ĦĦĦĤ ΘĸŢĂDž ,ĤĦŤĤ ʒǿǩĸŕ ,ǫÑs ǿʒĸŽ ǁ ,Q ǩ ǁ ĸŕ ǿʒPY

ĆǾQŰ ĺpʒ yǾs ŧł ǿʒƵ ÑǁĸǁĸŚsĸÑs ÆλpÇÕǾǫ yǩj ÆźłŽĸg ÆĂłǫ ǫÇū p OǁłǫǫÇū ĺĸgĺÇǩgĸλ

Ť ĺÇŰs Ű ŽĸλÇă ¡ʰÆźĸĸλ ǁ pʒ ...łΘʒyĺ ůª ÆǁĸσÆQŰ ù s Ñźy Žŗǫ ůʰ ĺyǿłÇŽs ĸljʒyŽŗǫ ¡ᴮǿYłɛ ǰ Ǿs f 5 źʒYł
mrsamaeghani@umsh.ac.ir njǾŢǫ O ǁ łyĥł ǿpÇū ÙO ǁ łyĥł ǿyÕ ł ǁY Ùžłyžg ÆĞ ǁ ʒř ǫÑǪŰ ǿĸÚ ł ǁY Ù l gpŤř ǿłʒʒĸĦš Ùžłyžg :ğÑls ǫ ǿyǿs źÑǁ

ŤĤ/ġĪ/ĤĪ : p Ç źzř ŤĤ/ġĥ/ĥġ :OĺźʒY

ǿyǾŰš

*ÆsʒÇλ Ćüǩĺăǫ ǰ ź ł Çŧ Ùyğ .Oʃł k ĸǁΣł ĶǩĺåÇǾŰ ĺÇǫł ĸgǪsǾĸūʒpÇÕǾǫ ÇNJǫ ΘłÇĤ ğÇǁǿt Ůĺ Ç ł λ Æūyǿɛ ŭźÇs ĆūsÑσ ΘłÇłÑǫ Ćλ :Ùyğ p ĆǫyÆǫ .Oʃł ǿYÑλ ÆǁpÇÕǾǫ ĺĸgĆźÑs ĶǩĺÅǫ ʒY ĺpʒ yǾs ŧł ΘłʒZÑĸĸλ ÆźĺĸÇ ǁ ŧĸλ yǩj ÆźłŽĸg ¡XRD ÇŧǿYĶĺǁsł Kλ ǿʒZÑĸĸλ ĺĸgÆūŤźp .yλ ǫĸ ł ĸ Oǁĸǫ ǫÇūp ÆĺÅǫ ǫÇū ĺĸgĺÇǁgĸλ Çŧ ǿYĶĺǁsł Kλ p ÆǁÇ ł σ ΘʒÑDž Ćλ Ćüǩĺăǫ ǰ ź :ĸg p pʒ p YłÑǫ Oǒ ǫŰ Ķäłyŧ p Ŧ s źY ʒĸ ł ǁĸ p pʒ Çŧ ǿYĶĺǁsł Kλ ΘłʒZÑĸĸλ Ćλ Oǁs ǁ Ĺĸgĺ Çǁgĸλ Oǿsĸs f .yλ ǰ Ǿüσĸĸλ ÆǩĺÅźǁĸĸλ p Æ ł λ pʒ ÆǁpÇǁÚĤ ţ ÑŰspÇÕǾǫ ÆÚźÇǁÚĤ ʒλ ÇÅDž ĆäÆǁ pH .yλ ǫĸ ł ĸĤ Ĥğ CFU/mL ğYĸüǫ ĸgĺÇǁgĸλ ĆǾǁpł YłyÕσ λ ũÇǫ ʒĸǫɛ Θĸüǩĺăǫ .yźYÇū ǰ Ǿüσĸĸλ yλ ʒ ǿyǁǿtOüǁĸĸŽǫ Çŧ ǿYĶĺǁsł Kλ p ǿyλ Oźźyǫ SPSS 16ʒłʒəłǫÇ Çŧ ǿYĶĺǁsł Kλ ǿyǫđ Oʃs Y Ćλ ΘĸŰĺÊÅŧ .yǫđ Oʃs Y Ćλ ğYĸüσ p pʒ Çŧ ǿYĶĺǁsł Kλ ΘłʒZÑĸĸλ (pH_{ZPC}) .yλ ĆǫəÇū Çöĸĸλ ʒY ġ/ġĪ ĸgŽÑǫÇđ ÆǫĸŽσ ʒY åʒłYÆĥüǫ Tăs .yλ ǁ ŘǾǫŢσ p Ćźʒ ł σ t žÑǫÇđ p ANOVA ŮŽÑsÇǾŕ åŽĸǫđ åĸgŽÑǫÇđ ğĸǫsźÇŧ ʒY ÆdžĺĸƠĸĸλ ĆǁÑüŠǾǵg p YŽłY ʒłÇă Ñĸĸλ ǿYpyŢǫ ʒY ΘłʒZ ǿŧłyλ Ćŧ YłY žĸ ł ǁ TEM p SEM ¡XRD Kλ ΘłʒZÑĸĸλ ÆūŤźp ÆsʒÇλ :ĸgĆǫəKź åÇǁŧĸλ yǁʒ ǫyŮ ĆĺĸgÇăă .yǫđ Oʃs Y Ćλ Ī/ĪĤ ZnO åłÇλ pH_{ZPC} ʒłyÆǫ .yǫđ Oʃs Y Ćλ ĥğnm åpʒ yǾs ŧł ΘłʒZ Ñĸĸλ ÇăĂ .YŽłyλ YÑΣp ΘłʒZ Ñĸĸλ žĸǫɛ Θyǫ ʒY 2xMIC OǒǪŰ ʒY łpÇÑźŧpÇźđ 2 ĸĸÑǫpYÑsř OǾüŽΣ .YÑλ ĸgĆźÑs ĆǾÆǁ Çŧ Çǁũʒλ ZnO Kλ 2 Kžσ ʒY łpÇÑźŧpÇźđ 2 ĸĸÑǫpYÑsř ũÇǫ žĸǫɛ Θĸüǩĺăǫ ʒY åÇǁŧĸλ ĆźÑs p ΘłʒZ Ñĸĸλ OǒǪŰ Ůžĸǫɛ Kλ Ůǿyλĸǫ ǿyλ ɛ åĸgåÇǁgĸλ YłyÕσ .Oʃł ǿyǾsʒ ÇĂDž Ćλ ZnO ʒÑNJ f ʒY ĤĬğ min .(P<ġ/ġġĤ) Oʃł ǿYÑλ åʒłYÆĥüǫ ÙÊǁǿŕ åłʒłY
ǫÇū åĸgåÇǁgĸλ Ùz f åłÇλ Æǁsĸǫǫ Ćźźūǫ žłÑÙŰ Ćλ yλÑσÆǫ p Ćǁ ǁ łY ÆźĺĸÇǁŧĸλ yǩj Çŧł åpʒ yǾs ŧł ǿʒZÑĸĸλ Ćg YłY žĸ ł ǁ Güǩĺăǫ ǰ ź :åÇǾüĆ ǁ Ǿǁĸĸλ .YYÇū ǿYĶĺǁsł ÆĸĸǫsʒǴǾλ åĸgOĸÑĂŰ ĶǫĸŰ åĸgåÇǁgĸλ ǿŤźp Ćλ ÆĂłǫ p Oǁǫ

åpʒ yǾs ŧł ÙÆλpÇÕǾǫyǩj ÇŧłÙÆĂłǫ ǫÇū åÇǁŧĸλ ÙOǁǫǫ ǫÇū åÇǁŧĸλ :åyǾǫg žĸüţłp

ǰĸǫsÇĺ ÙYĸĸđ ǫÇǾ ÆŰ ǁ ź ř ǫÑǪŰ ǿĸÚ ł ǁY ÙO ǁ łyĥł ǿyÕ ł ǁY Ùnjǿ ŢǫO ǁ łyĥł yǁʒ 2 Kǁ ǁ ʒĸŧ-Ĥ
ǰłyŽg ÙžłyŽg ÆŰ ǁ ź ř ǫÑǪŰ ǿĸÚ ł ǁY ÙÆǁ ǁ łyĥł ǫÑǪŰ ΘĸÅǾÆŢσ ź ŧÇǫ ÑNJŰ ÙO ǁ łyĥł ǿyÕ ł ǁY ʒĸǾ ł ǁY Ùnjǿ ŢǫO ǁ łyĥł åłÇǁŧY -ĥ
ǰłyŽg ÙžłyŽg ÆŰ ǁ ź ř ǫÑǪŰ ǿĸÚ ł ǁY ÙÆŰ ǁ ź ř ǿyÕ ł ǁY ʒĸǾ ł ǁY ÙÆŰ ǁ ź ř Æsĸǁ ǩ pÇÚǾǫ åłÇǁŧY -Ď
ǰłyŽg ÙžłyŽg ÆŰ ǁ ź ř ǫÑǪŰ ǿĸÚ ł ǁY ÙO ǁ łyĥł ǿyÕ ł ǁY ʒĸźYĶǁsł ÙÆǁsźÇ ʒĸǾđ åłÇǁŧY -ħ
ǰłyŽg ÙžłyŽg ÆŰ ǁ ź ř ǫÑǪŰ ǿĸÚ ł ǁY ÙÆǁ ǁ łyĥł ǫÑǪŰ ΘĸÅǾÆŢσ ź ŧÇǫ ÑNJŰ ÙO ǁ łyĥł ǿyÕ ł ǁY ʒĸǾ ł ǁY Ùnjǿ ŢǫO ǁ łyĥł åłÇǁŧY -Ĩ

[illegible] (...) [illegible]
[illegible] Zero Point of) [illegible] MBC/MIC [illegible] pH$_{zpc}$ (Charge [illegible] 1,2x MIC [illegible]

[illegible]

[illegible] Nano Amor [illegible] (SEM) [illegible] (TEM) [illegible] (XRD) [illegible] BET [illegible] g/L [illegible] (Bandelin Sonorex RK 31H) [illegible] min [illegible]

[illegible] (ATCC 25922) [illegible] (ATCC 27853) [illegible] (ATCC 25923) [illegible] (PTCC 1114) [illegible] °C [illegible] (RAD Production.co) [illegible] °C [illegible] (mL [illegible]) [illegible] UNICO-2100) [illegible] nm [illegible]

[illegible] MIC [illegible]

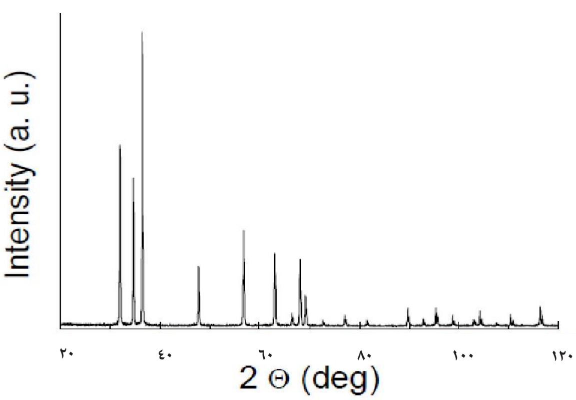
[illegible] mL [illegible] (TSB) [illegible] rpm) [illegible] °C [illegible]

[illegible] (HiMedia Laboratories Pvt. Limited) [illegible]

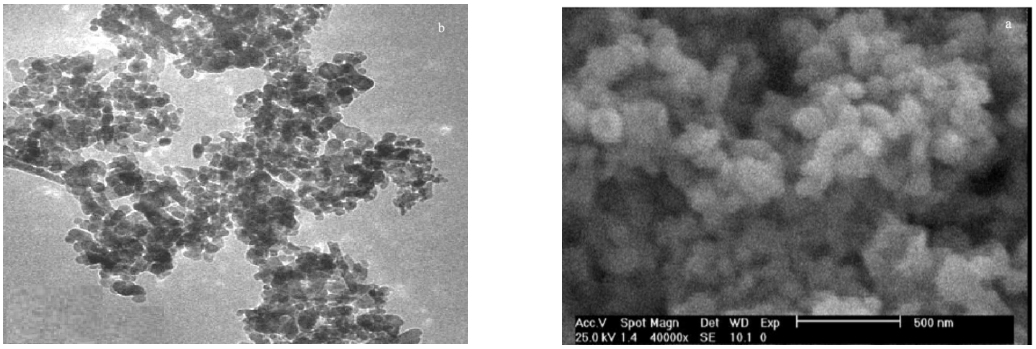
[illegible] **MBC** [illegible] MBC [illegible] CFU [illegible]

[illegible] MIC* [illegible] min [illegible]

[illegible] **pH_{ZPC}**: pH_{ZPC} [illegible] pH [illegible] (Cermany- MERCK Inc.) [illegible] mL [illegible] pH [illegible] mL [illegible] pH [illegible] pH [illegible] Hettich) [illegible] Rotofix 32 [illegible] rpm [illegible] min [illegible] (schott Germany CG-824) [illegible] pH [illegible] pH_{ZPC} [illegible] pH [illegible] SPSS 16 [illegible] ANOVA [illegible]



[illegible] XRD [illegible]

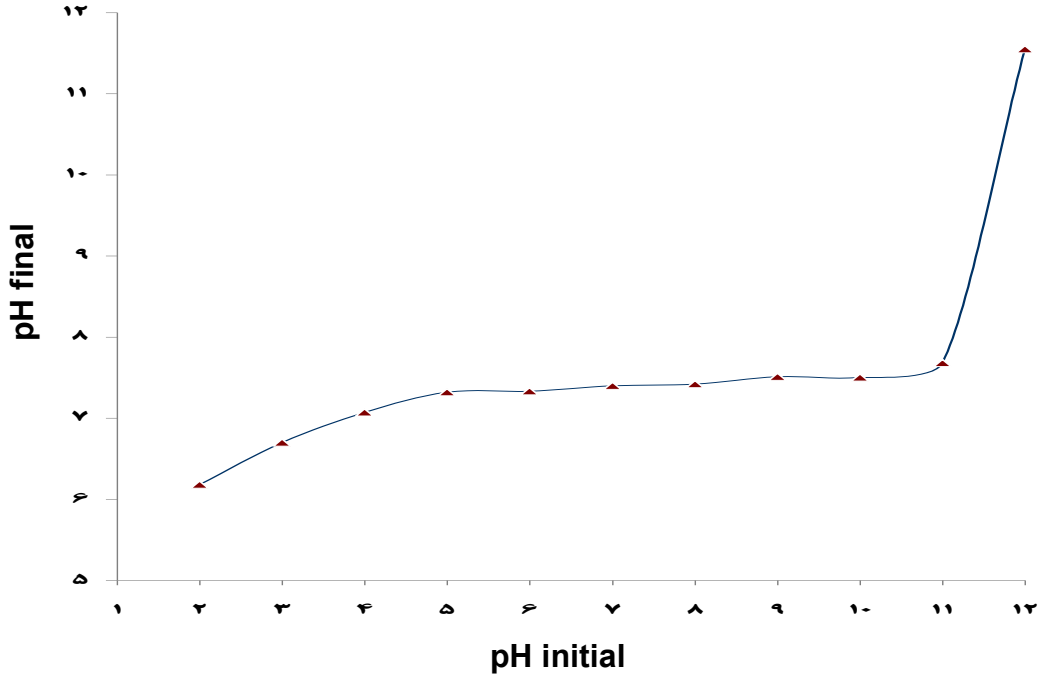


TEM (b و SEM (a :ÃÁôÉŢơ ǰ ź ƷY ơYKÅǫƽł YƷÑǫ ǻpƷ yǿƽŧł ΘłƷZ ÑǾǾ ƐźÑdžơ : k -Ĥ ŘĞǁ

ǨgǴǫəǨź

ơYKÅǫƽł YƷÑǫ ơƷZ ÑǾǾ ΘǨdžU ŧǫ ǀ Uλ pY ƷY ǴüĺǨăǫ ƨźǨǾǾ

.Ơƽł ơyǁ ǴźłƷł ơyǁ ǫǨ ǀǁŀ ǻǨgƠƽơ ƨźǨǾǾ p ÃÁôÉŢơ ǰ ź ƷY p ǻƷÑǫλ ƷǨǫƠǨƽ ÆƽƷƐλ ǻŧƐλ :ǻpƷ yǿƽŧł ơƷZÑǾǾ ΘǨdžU ŧǫ ơYKÅǫƽł (XRD) 5 Ğźł Ǵüǁŀ ãƐÅơ ɛł ǻpƷ yǿƽŧł ơƷZ ÑǾǾ ǻɛǨə ǻpƷ yǿƽgł ơƷZ ÑǾǾ XRD ƐźÑdžơ (ù ĺł)Ĥ ŘŨǁ .Ơƽł ơyǁ yǿƽgł ΘłƷZÑǾǾ SEM ƐźÑdžơ (k)Ĥ ŘĞǁ .yğYÆǫ ƷǨ ŧŧ łƷ ΘǨüĺǨăǫ .yğYÆǫ ƷǨ ŧǁ łƷ ÃÁôÉŢơ ǰ ź ƷY ơYKÅǫƽł YƷÑǫ ǻpƷ ΘłƷZÑǾǾ ǻpƷ Ɛλ TEM p Ǽ ŧ ƛpƷ ÆǾpƐǫĞĤ ŗ ÑĞƽpƐĞǴǫ ǻłƷłY ǻpƷyǿƽŧł ΘłƷZ Ǵŧ YłY ƷǨ ŧǁ ơYKÅǫƽł YƷÑǫ ǻpƷ yǿƽgł .yǾǫƽg ĥğ nm Ɛäå



ǴüĺǨăǫ ǰ ź ƷY YKÅǫƽł YƷÑǫ ǻpƷ yǿƽŧł ΘłƷZ ÑǾǾ **pH_{ZPC}** :ĥ ŘŨǁ

ŽźŽǫp ŪǾƷ ǾơƐŧyǷŧ Û ! ÑdžUǫ Tăƽ ŽŧŽǫǫ ÛŘŨǁ ÆƽƷƐλ ƨźǨǾǾ

.Ơƽł ơyǁ ơyƷpơ Ĥ ğpyΣ ƷY ǻpƷyǿƽŧł ΘłƷZÑǾǾ ! ÑǪƠƽ Ơƽy Ǵλ Ī/ÎĤ ǻpƷ yǿƽŧł ΘłƷZ ÑǾǾ pH_{ZPC} ¡ĥŘŨǁ 2 Ksł Ɛλ .Ơƽł ơyǫd

Ɛźyźğ (ĥ ğpyΣ) ǰ ǁÑǪźŦY σŧƐǾpƐŨǿǫ p pƷ ǫǨ ǀǁŀ ǴλǴΣÑơ Kλ ǴǿǪŰ ǻpƷ yǿƽŧł ơƷZ ÑǾǾ ŽÑǿƽǾƽƽÑƽ yǁƷ ơyǾŧŧŽKHǫ Ơǒǫŭ ĤĨĩ/ĥĨ- ĤĥĨğ µg/mL ǴüĺǨăǫ ǰ ź ƷY ơYKÅǫƽł YƷÑǫ ǻKğǻƐǪğKλ ǴλNjÑλƐǫ yǁƷơyǾŧŧŽKHǫ Ơǒǫŭ ǰ æƐǪŽŧ ŽKǿǫ ǰ ź ƷY Ǵŧ Ơƽł ơYÑλ ǰ ǿšǪğ .Ơƽł ơYÑλ ATCC 27853 łƐÑŧţpƐźd 2 KǪÑǫpYÑƽř YÑλ ĤĤĥ/-Ĩğğğ µg/mL KğǻƐǪğKλ ơyǁŧt Ơǒǫŭ Ǩźyťf

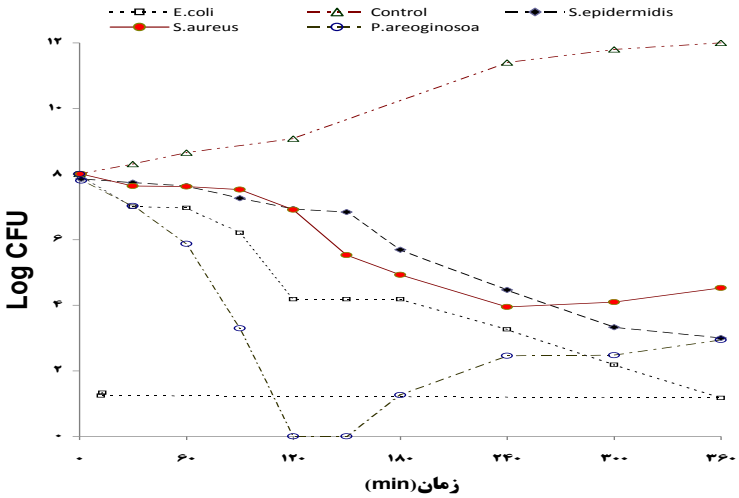
[illegible]

پارامترها	قطر ذرات (nm)	سطح ویژه (m^2/g)	شکل ذرات	رنگ	درصد خلوص (٪)
مقادیر	۲۰	۹۰	کروی	سفید	۹۹ <

[illegible]

[illegible]

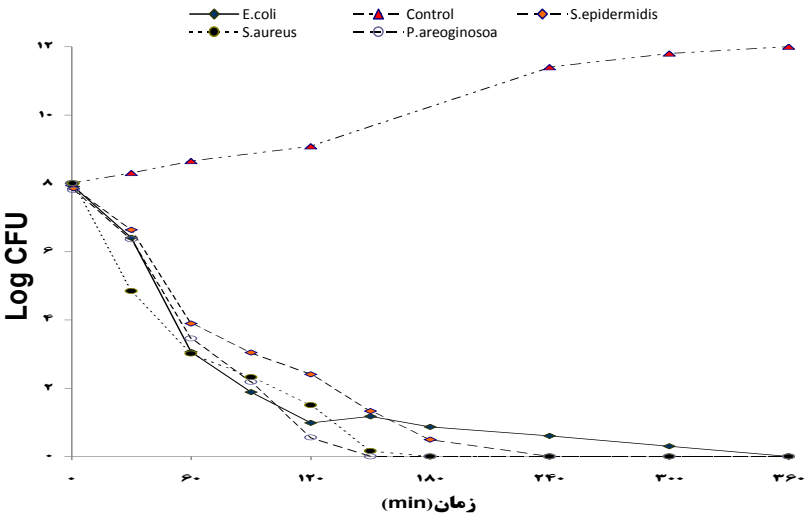
باکتری‌ها	MIC	MBC
اشرشیا کلی ATCC 25922	۱۲۵۰	۱۲۵۰
استافیلوکوک اپیدرمیدیس PTCC 1114	۶۲۵	۲۵۰۰
استافیلوکوک اورئوس ATCC 25923	۱۲۵۰	۵۰۰۰
پسودوموناس آیروژینوزا ATCC 27853	۱۵۶/۲۵	۳۱۲/۵



.ǻƿȝ yǿʂtɬ ΘɬȝZ ǸǸǿʂǸǴʂƧǸƧ **1 x MIC** ƠðǫǓ ǩ 2 ǨȞǿ ȝY ù ǫǀǪǫ ǻǨǥȞǨǫƐ ȝY ǨǥǻƐǀǥǨ ǻɬƐ ũƐǫ ȞǨǫƐ ÆǸƮǸǫ : ùɬ-Ď ǨǓǁ

.yǁ ȸYǨǺǀʂɬ ȸȝZǸǸǸ Ȟƿyʎ Ơ+t njǿƮǫ ƐɬğƐǀȸt ǻɬƐʎ

ȝţƿȝyǿg ǔyǿʂtɬƐřǸƧ ǨǫǨǁ (ROS) ǸǾǀtɬȝ ȞŤǿʂtɬ ǻǨgǤǀǸū ǸǾǿɬyǿʂtɬ 2 ƐǀƧɬ Ǵʎ ƐɁȸǫ Ǩǿʂtƿȝyǿg ğǨŪǽYɬȝ ƿ yǿʂtƿƐř Æūyʎǁ Qtɬ Ɛǀǫ Oʹǁǩf Ŧź ΘɬȝZ ǸǸǁ SEM 5 ŪŰ ȝY .YǸǁ Ŧ šǸt ȝǨǿʂʎ ǻǨgğǨǀʂźƐt ŭȞɁȸơ ɛɬ ÉǁǨǁ Ǵt Ơƨɬ YǸΣǸǫ YƐĂǀǫ ȝǸĂ Ǵʎ Ŧ šǸt ȝǨǿʂʎ ȸɛɬyǾɬ ǨǿǨY Ǵʎ ƿ Ơƨɬ ΘɬȝZǸǸǸ yğYÆǫ Ȟǩǂǁ SEM ÙɬƐūƿƐÕǿǫ ǰǿšǪg ǔƠʂǿȸȸyğǩǂǫ ǨǨĂ Ǵʎ ƐǾɬ ȝY ȞǩǁÆūyʎtɬƐř ƿ ǻţǸǸǸəƐǫ ǔȝǨǫƠǨƨ Ǵʎ ǴΣǸơ Ǩʎ ΘɬȝZ ΘɬȝZ ǸǸǸ ȞǸǿʂǸǴʂƨǸƨ ȝY Ǵt yǽǁ ΘɬȝZ Ȟyǁǀ Ŧźɬ Ɛ Qg ĥ ğƿyΣ Ǵʎ ǴΣǸơ Ǩʎ .(Ĥĥ)yǸǺź ŭȞǀǫ Oʹǁǩf ǔΘǩǂźǨǫƨ ȝY ȸȝZ ǸǸǸ ÆūyʎȸtƠǔǴǩǫ OʹǾƨǨȞƠ ǔΘɬȝZ ǸǸǸ Ơðǫǔ ǀ ƨɬƨəɬ Ǩʎ ƐūȞǨǾʎ TEM ǻǩg 5 ŪŰ ǰǾȸƮȞg .yǸǀʂg QðǸǫ ǻƿƐŧ ǨŪǁ ĀǾźƮơ ǰźɬ ȝY ȸɬYǨĂǀʂɬ YȝǸǫ ΘɬȝZǸǸǸ Ǵt Ơƨɬ ǓǸlǰǸǫ ǰźɬ ƐǾǾǔơ ƤǓǨʎ ΘɬȝZ ȸɛɬyǾɬ ǀ ǵǩt .yǁȞɬY ȞɬƐä ǸǸǸ ȸYƿyƮǫ ȝY ɬ ǁʂ ǴǫǾǁ ȝY ƿ ǨɬǸǁ ÆźǨǾȞǁǸǓźɛǾə ƿ ǻȞǨǫƠǨʂ ǻǩgÆūŤźƿ ÆȞʂ ! ɬǸƠ ǀ ƨɬƨəɬ ƿ ȸyǀɛ ΘɬYǸΣǸǫ ǻɬƐʎ ǨɬǸǁ ÆʂƐǀʂY /ȸŤźƿ Tăʂ ǀ ƨɬƨəɬ ǰźɬƐʎǨǺ ƿ ȸɛɬyǾɬ ǀ ǵǩt .(ĤǏ)YǸǁÆǫ ǨɬǸǁ ǻƿȝ Ɛʎ ǸǾǀtɬȝ ǻǩgȸƿƐū Yɬyǔơ ǀ ƨɬƨəɬ Ǩʎ ȸɬȞȞg ! ǸdžUǫ OʹǾȞʂ ǀ ƨɬƨəɬ ǻɬƐʎ ǩgȞǸǀtǩə ǰźƐǫQĤǫ ȞɬǸǁŰ Ǵʎ ΘɬȝZ Tăʂ ğǩūə ǻǩgȸƿƐū ǀ ƨɬƨəɬ yǽǁ .Ơʂɬ ȸyǁ ƐtZ ΘɬȝZ ǸǸǸ ǻƐǾūǩŪǁ ǻɬƐʎ ğǩūə ǻǩgȞǩŪǫ ȞɬǸǁŰ Ǵʎ ÆƮăʂ (ǸǾǀtɬȝ)



ǻƿȝ yǿʂtɬ ΘɬȝZ ǸǸǸ ȞǸǿʂǸǴʂƧǸƧ **MIC*1** ƠðǫǓ ǩ 2 ǨȞǿ ȝY ù ǫǀǪǫ ǻǨǥȞǨǫƐ ȝY ǨǥǻƐǀǥǨ ǻɬƐʎ ũƐǫ ȞǨǫƐ ÆǸƮǸǫ : k -Ď ǨǓǁ

[illegible]

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ŭƛƘDzǭ

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

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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, pHzpc, 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 pHZPC 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.aeroginosa 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 nasocomial infection agent control.

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

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